FINAL REPORT

Innovation Policies in Singapore, and Applicability to New Zealand

Submitted to

Ministry of Economic Development
Wellington

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1. INTRODUCTION AND EXECUTIVE SUMMARY

1.1. INTRODUCTION

The Ministry of Economic Development is interested to learn more about growth and innovation policies in Singapore, and their potential applicability to New Zealand. The Ministry has engaged us to:

- Briefly provide a framework for thinking about the costs and benefits of government policies that are aimed at stimulating innovation;
- Describe and critically evaluate growth and innovation policies in Singapore; and
- Comment on the applicability of those policies to New Zealand.

Policies that facilitate innovation are critical to dynamic efficiency and economic growth. It is interesting to note that there has been an increasing focus on innovation as a source of future growth across OECD nations.[1]

The scope of our description and analysis (in other words, what is meant by "growth and innovation policies") is defined by the New Zealand Government's Growth and Innovation Framework. Section 2 of this report briefly describes that Framework.

In trying to draw lessons for New Zealand, it is important to understand the context (economic, political, historical and institutional) in which Singapore's growth and innovation policies have been designed and operated. Section 3 of this report briefly addresses these issues. This discussion includes a section (3.5) introducing at a high level the broad types of innovation policies pursued by Singapore, and summarising the framework developed in Appendix A to this report for thinking about the costs and benefits of those policies.

Section 4 more fully describes, and to a limited extent evaluates, Singapore's growth and innovation policies, and their implementation. In section 5 of this report, we step back and provide a more holistic evaluation of the impact of these policies.

Having analysed Singapore's growth and innovation policies and implementation, we then turn in section 6 to consider whether or not any of those policies might be worth considering further for application in New Zealand.

[1] A brief description of this increased focus by OECD countries on innovation is given in Appendix A.

We conclude in section 7. The final sections of this report list references, useful Singaporean websites and Singaporean contacts.

Appendix A contains a brief review of the economics literature on certain areas related to growth and innovation, with the objective of providing a framework for thinking about the costs and benefits of government policies that are aimed at stimulating innovation. It is not a thorough literature review, but is somewhat higher level and largely conceptual.

Appendices B to H provide a variety of supporting information to the text of this report.

1.2. EXECUTIVE SUMMARY

Singapore is a republic with a parliamentary system of government. Since achieving self-government in 1959, Singapore has been governed continuously by the People's Action Party (PAP), providing it with an impressive level of political stability. The institutions of Singapore (e.g., the bureaucracy and the recognition and enforcement of property rights) are generally regarded as being of very high quality.

Geographically, Singapore is extremely well placed on trade routes and adjacent to very large markets. This is of course in stark contrast to New Zealand.

Singapore's economic model has always involved a relatively high degree of active government strategy and intervention. The explanation for this approach lies largely in the circumstances facing the new government in 1959:

- An undeveloped economy;
- A small domestic market;
- Unemployment;
- Ethnic conflict;
- Limited social services and poor housing; and
- Defence insecurity.

In short, there was a real sense of survival risk, and a belief that massive investment was required, both for economic and security reasons. Combined with a Confucian culture emphasising subordination of the individual interest to the collective good, these circumstances and concerns drove Singapore's economic strategy, and created an alignment of interests among its people.

A key focus of the economic strategy has been the subsidised attraction of investment by multinational companies, and later in the period the lower employment cost of foreign workers. As the economy grew, labour became limiting, and immigration policy became a key economic growth tool.

Other key types of innovation policies pursued by Singapore are:

- Public and subsidised private venture capital financing;
- Public and subsidised private investment in R&D;
- A strong commitment to education, including subsidisation of training schemes for employees and regulation of tertiary-level enrolments to line up with expectations of demand; and
- The facilitation of clusters (specific focuses have included biotechnology and environmental technology; electronics and manufacturing technology; and information technology).

One of the strengths of the self-titled "Singapore Inc." has been the effective integration of policies and execution across multiple agencies. This has been assisted by the endowment of the political and administrative systems in a few key persons. At the most senior levels, a core of politicians and civil servants in the various ministries and statutory boards manage Singapore Inc.

Most of Singapore's innovation policies could be argued to address "market failures", such as:

- Information externalities;
- Information asymmetries; and
- Transactions costs.

However, there are also costs to government intervention ("government failure"), such as:

- The "picking winners" problem (e.g., risks of lobbying and capture; government employees are likely to have less experience, poorer information and poorer incentives than private sector investors; and crowding out of private investment); and
- Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money.

Unfortunately there are very few publicly available critical studies of the efficacy of Singapore's individual growth and innovation policies. If the relevant government agencies have carried out such studies, they are generally not publicly released.

Methodologically it is also quite difficult to identify the impact of specific government policies on national economic growth.

Accordingly, our evaluation of Singapore's innovation policies is by necessity based on specific case studies, generic literature, general observation and broader studies of Singapore's economic performance.

Singapore's economic growth rate has clearly been spectacular. However, income at the start of the period was very low and the other "Asian Tigers" (Hong Kong, South Korea and Taiwan) also grew spectacularly, each of which has had its own idiosyncratic economic model. While economic policy is multidimensional and difficult to place on a continuum, it is probably reasonable to characterise South Korea as having had the most active government involvement among the four Tigers, with Hong Kong at the other extreme. Singapore would be towards the South Korea end of the continuum.

In general, the key drivers of economic growth vary depending on the "maturity" of an economy. While capital and labour accumulation will tend to drive growth of undeveloped economies, productivity gains and innovation are more important for developed economies.

While measurements of total factor productivity growth are difficult and controversial (and possibly particularly so in respect of Singapore), the general view is that Singapore's productivity growth has been disappointing, particularly compared to that of Hong Kong. The efficiency of Singapore's microeconomic environment has also been questioned, and evidence of innovation and entrepreneurship in Singapore is mixed. There is certainly a perception in Singapore that the level of innovation and entrepreneurship is a concern.

Against the background of these outcomes, the role of Singapore's more "active" growth and innovation policies is contentious, and it is not possible at this stage to rigorously justify any strong claims about the effect of those policies. It may be argued that the Singaporean specific growth and innovation policies assisted in the efficient accumulation of capital and labour, which in turn resulted in significant growth for an economy starting from a low base in the 1960s. However, the evidence on the efficacy of these policies in promoting productivity improvements is mixed.

Less contentious is the positive role of the following factors in Singapore's growth:

- Institutional quality;
- Relatively low barriers to trade and foreign investment;
- Prudent monetary and fiscal policies;
- Low corporate tax rates;

- A strong commitment to education; and
- Geography.

From the point of view of innovation and dynamic efficiency, we would particularly highlight from this list institutional quality and openness of the economy to trade and investment:

- Institutional quality includes the clear specification and enforcement of property rights. Combined with Singapore's relative political and economic policy stability (compared to countries such as New Zealand), this institutional quality would provide investors with a relatively high level of certainty; and
- As discussed in section 5, we hypothesise that Singapore's openness and dependence on foreign capital and labour imposes an efficiency discipline on economic policy. The openness also enhances the flow of new ideas into Singapore.

Despite the ambiguity of the efficacy of Singapore's more active innovation policies in promoting innovation and productivity gains, our study has identified a set of interesting policies in respect of which there is merit in considering their application in New Zealand. Unfortunately it is very difficult to assess the effectiveness of these policies based purely on the Singaporean experience. A more thorough comparative institutional public policy analysis is required for each one, and this would benefit from a wider sample of countries that have tried them.

2. THE GROWTH AND INNOVATION FRAMEWORK

In an effort to improve New Zealand's growth rate, the New Zealand Government has developed a "Growth and Innovation Framework,"[2] which consists of two key planks:

- Strengthening the "foundations" of the economy, including ensuring that there is a stable macroeconomic framework, and an open, competitive economy; and
- Building effective innovation.

This second plank is broken down into four areas, and we briefly outline these below.

2.1. ENHANCING THE INNOVATION FRAMEWORK

The focus of this area is on research and development, and commercialisation of ideas. Examples of specific government policies are:

- The establishment of the Venture Investment Fund, which is a venture capital fund;
- Improved tax treatment of R&D expenditure;
- Increased funding of basic research;
- Funding of grants to support private sector R&D; and
- The establishment of an incubator development programme.

2.2. DEVELOPING SKILLS AND TALENT

The GIF identifies three key ways to address "the talent issue".

Growing More Talent and Industry Training

The focus here is on improving the primary, secondary and tertiary education sectors, and the skill levels and adaptability of workers.

2 See New Zealand Government (2002).

Attracting Overseas Talent to Live and Work in New Zealand

The focus here is on redirecting immigration policy towards people with specialist and in-demand skills, and branding New Zealand as technologically advanced, innovative, creative and successful.

Utilising Overseas Kiwis

The "World Class New Zealanders" strategy involves initiatives such as:

- Building a network of talented New Zealanders currently based overseas; and
- Using that network to establish business exchange programmes and mentoring for young New Zealand entrepreneurs and emerging talent.

2.3. INCREASING GLOBAL CONNECTEDNESS

Increased global connectedness is seen as critical in order to increase exports and access to skilled people, capital, ideas and knowledge. The three methods identified by the GIF to increase global connectedness are discussed below.

Attracting Foreign Direct Investment

The GIF signals a more active foreign direct investment regime. At page 45, the GIF states:

> *Realistically this promotional activity can not rely on providing large financial inducements to individual companies. Indeed, New Zealand is unlikely to win a bidding war with other countries or regions in terms of attracting particular companies. We need to attract investment on the basis of the existence of clusters in New Zealand that are already operating at world-class levels.*

Having stated that, we do note however that the GIF refers to Government funding of up to $1.6 million for Ericsson Synergy.

More Aggressive Export Promotion

The Government believes that New Zealand's export sector occupies a lower share of GDP than most other small OECD countries, and has taken a series of initiatives to assist export growth, including:

- Increasing TradeNZ funding;
- Establishing the Export Credit Office to assist those exporters required to provide medium- or long-term finance to their buyers, or those dealing with countries with a high risk of economic instability; and
- Advancing open trade agreements.

Brand NZ

The Government believes that New Zealand needs to complement its "clean green" image with that of a technologically advanced, creative and successful country. The Government has committed resources in conjunction with events such as the America's Cup and The Lord of the Rings trilogy with the stated purpose of contributing to this, and is working with the private sector to develop a Brand New Zealand programme.

2.4. FOCUSSING GOVERNMENT RESOURCES

While not exclusive, the Government has chosen to focus its strategies on three sectors:[3]

- Biotechnology;
- ICT; and
- Creative industries.

[3] Section 2.2.4 of the GIF Framework states, "…government will more aggressively focus its policy intervention in relation to innovation and growth. In the first instance biotechnology, ICT and the creative industries have been chosen as the areas for particular emphasis, because of their extensive influence on so many parts of the economy." (New Zealand Government (2002:49).

3. CONTEXT FOR INNOVATION POLICIES IN SINGAPORE

3.1. INTRODUCTION

In trying to draw lessons for New Zealand, it is important to understand the context (economic, political, historical and institutional) in which Singapore's growth and innovation policies have been designed and operate. This section briefly addresses these issues.

3.2. GEOGRAPHY

Singapore is strategically located astride trade routes within Southeast Asia, and more extensively, among Europe, the Far East, and Australasia. For many years after the British "founding," Singapore's main businesses were based on its free port. Besides trade, they included finance and insurance, shipping, and ship repair. Even today, the oil refining industry processes crude from the Middle East on the way to markets in the Far East, and the ship-repair industry maintains and repairs vessels on their return voyage.

The country's land area is 685 square kilometres (up from 641 square kilometres in 1992 because of land reclamation). By contrast with Hong Kong, the island is relatively flat, and is almost all economically usable. However, the government has deliberately set aside substantial areas for water catchment and military use.

As a city-state, Singapore enjoys substantial advantages from concentration, such as economies of scale and information flows. The business and financial centre is less than thirty minutes' drive from industrial zones and the international airport. Singapore's total population is 4.2 million, of whom 3.4 million are residents. The population density is 6075 per square kilometre. Coupled with a high per capita income, this density supports a vibrant and sophisticated, albeit relatively small, domestic economy.

3.3. GOVERNMENT AND INSTITUTIONS

Singapore is a republic with a parliamentary system of government. A written constitution provides for the organs of state, the executive, legislature and judiciary. The Head of State is an elected President who appoints the cabinet headed by a Prime Minister. The cabinet is collectively responsible to Parliament.

Since achieving self-government in 1959, Singapore has been governed continuously by the People's Action Party (PAP). This has provided a relatively high degree of political stability. The PAP government inherited a colonial legacy of a clean administration and civil service, law and order, and widespread use of the English language. However, it also inherited unemployment (13.2% in 1959),[4] labour unrest, and ethnic conflict all of which were exploited by an underground Communist movement. Further, the colonial administration provided limited social services and especially poor housing.

Initially, Singapore sought integration with Malaya to achieve economies of scale in a larger market. The PAP government pressed hard for "merger," and indeed, in 1963, Singapore joined Malaya, Sarawak, and Sabah to form the new Federation of Malaysia. However, integration was short-lived as acute political differences arose between the federal administration in Kuala Lumpur and the Singapore government. In 1965, Singapore had to leave the federation.

Just two years later, Singapore suffered another severe shock. In 1967, the British Government announced that it would withdraw from bases in Singapore. In that year, British military expenditures accounted for 12.7% of GDP (Rodan 1989: 87). Hence, the British decision posed both economic as well as security challenges. The same year, the Singapore Government introduced compulsory military service for all able-bodied male citizens.

Singapore is a small city-state and lacks natural resources to the extent of even having to import water. Consequently, the government has always considered that it has to work hard on its institutions and processes to build a pro-growth environment based on a strategy of policy-induced competitive advantage.

> *[T]he separation of Singapore from Malaysia constituted more than a collapse of economic strategy. Rather, as leaders of a small, independent city-state, the PAP suddenly felt the need to explain and justify the political existence of Singapore. What emerged out of this was a coherent set of arguments which focused on the threat to, and requirements of, Singapore's political and economic survival. This 'ideology of survival' … insisted on the inseparability of economic and political survival and the necessary subservience of all other considerations* **(**Rodan 1989: 88).

And:

> *With the viability of the economy in doubt due to small size of the domestic market, the government played a pioneering role in areas where the initial capital requirement exceeded the capacity of the private sector or where the project was viewed too experimental in nature.* IMF (2000: 9)[5]

4 Rodan (1989: 74).

5 Referring to a study by Krause (1990).

While such government intervention might seem to violate the neo-classical economic model, the PAP viewed it as essential to survival. Faced with internal and external threats, both domestic and foreign capital might well prefer safer investments outside Singapore. Without sustained investment, Singapore would have fallen prey to the domestic leftist threat or an external power.

From the beginning, the government's priorities were education and human resources, economic development, and internal and external security. The 1961-64 State Development Plan provided M$508 million for economic development and M$350 for social development (see Table 1).[6]

Table 1: 1961-64 State Development Plan (Unit: M$ million)

Item	Amount
Economic development, of which:	508
• Economic Development Board	100
Social development, of which:	350
• Housing	153.6
• Education	94.0
Public administration	17.5

Source: Rodan (1989: 64-66)

Initially, the government followed a socialistic economic model with detailed formal planning and targeted industrialization. The 1961-64 plan, extended to 1965, was the one and only development plan implemented as the second plan for 1966-70 was aborted with post-Malaysia, British military withdrawal changing the premises upon which the plan was drawn.

Instead of relying on World Bank and other external resources, Singapore's strategy involved the following triangulation:

- The Economic Development Board (EDB) attracting FDI for jobs;
- The Housing and Development Board (HDB) building subsidised, low-cost public homes; and
- The Central Provident Fund (CPF) financing first public sector deficits and then CPF members' purchase of homes.

6 The government of Singapore maintained the Singapore dollar on a fixed 1:1 parity with the Malayan (then Malaysian) dollar until 1973.

The role of the EDB is discussed in section 4 of this report.

A central feature of the Singapore economy is the CPF, a national defined contribution plan established in 1955. All employed persons and their employers are required to contribute a percentage of earnings to the CPF. Foreigners do not have to contribute to the CPF, which stems from the policy of keeping their wage costs down. Under the Income Tax Act, only those working in Singapore for less than a year pay a flat income tax rate, with the rest paying the same as Singapore nationals on a progressive tax schedule.[7]

Being mandated to invest in government bonds and securities, the CPF became a major source of public finance. In later years, the government increased the CPF contribution rate, for various reasons, including raising funds to finance development expenditure, regulation of domestic demand, and raising the cost of labour (as discussed in section 3.4 of this report).[8] Since the government has been running budget surpluses, the Government Investment Corporation of Singapore has invested the CPF money, including overseas.

The single largest item in the 1961-64 State Development Plan, and hence indirect beneficiary of CPF funds, was housing (Table 1). In thirty-two years (1927-59), the colonial government had built only 23,000 housing units. The PAP government was extremely dissatisfied with this performance and established the HDB in February 1960. Within just two years (1961-63), the new HDB built 29,635 units, exceeding its target of 26,521 units by 12%.

The Singapore government has continued to intervene in the economy. The outcome is a hybrid model encompassing a visible, interventionist hand of the government in a generally market supporting way. The hybrid model encompasses Singapore as a developmental state driven by the self-proclaimed "Singapore Inc." ensemble of ministries, statutory boards, and government-linked companies (Low 2001; Low 2002a).[9]

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7 Taxation and the policies of the CPF interact and have varied over time. The CPF has been a defined contribution scheme wherein employed Singaporean residents have contributed of the order of 20% of their wage income and employers 20% (16% more recently) up to some limit. The income tax rate increases with income from 2% to approximately 28% where the 20% rate is reached at S$200,000. Foreign workers pay the income tax but neither they nor their employer (on foreign workers' behalves) make a contribution to the CPF. The corporate tax rate applied to interest and dividends has been 22%; tax imputation was implemented until a date in the 1990s. Implications of these policies are that corporate investment would be encouraged by a low corporate tax rate, and tax wise it has been cheaper to employ foreign rather than domestic workers.

8 In September 1968, the CPF contribution was raised from 5% for employer and employee to 6.5% each. Subsequently, the contribution rate was progressively raised to a peak of 25% in July 1984.

9 Most agencies of the Singapore government are established by statute, and hence are labelled "statutory boards".

Singapore Inc. is overseen by economic and related ministries – Education, Finance, Law, Information, Communications and the Arts (formerly Communications), Manpower (formerly Labour), Trade and Industry – and driven by their subordinate statutory boards.

The statutory boards include the Economic Development Board (EDB), Jurong Town Corporation (JTC), and the Monetary Authority of Singapore (MAS). Historically, the EDB focused on attracting multinational companies (MNCs) to establish manufacturing bases in Singapore in a "pragmatically strategic manner" (Schein 1997: 23). The JTC supported the EDB by developing industrial real estate for immediate occupation, while the MAS ensured macroeconomic stability and promoted Singapore as a financial centre.

From the earliest days, the ministries and statutory boards have acted in concert, either directly or indirectly. For instance, the principal mission of the EDB is to promote investment. Yet it has also played a role in human resources development and raising productivity.[10]The CPF-HDB nexus illustrates the indirect collaboration of two statutory boards.

The government-linked companies include those formed to take over British military facilities (Keppel Group and Sembawang Group), greenfield entities established to pursue particular industrial objectives (DBS Bank, Singapore Airlines, Neptune Orient Lines, Singapore Technologies Group, National Iron and Steel, and Intraco), and more recently, companies resulting from partial privatisation of infrastructural functions (Singapore Telecommunications, Singapore Mass Rapid Transit Corporation, and Singapore Power).

Singapore's legal framework is largely based on English common law, as clearly confirmed when Parliament passed the Application of English Law Act in 1993.[11] The Penal Code and Evidence Act are derived from 19th century Indian law, while the Companies Act relies heavily on Australian legislation.

Judicial power is vested in the Supreme Court, consisting of a chief justice and an unspecified number of other judges, all appointed by the president, on the advice of the prime minister. The judiciary is the chief guardian of the Constitution. A separate system of *shariah* courts enforces family laws specific to the Muslim community.

The attorney general, assisted by the solicitor general, is the principal legal advisor to the government, serves as the public prosecutor, and is responsible for drafting all legislation.

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10 Overall economic strategy in Singapore is undertaken by the Cabinet. Agencies including the EDB take direction from the Cabinet and respective Ministries. The "planners" of economic policy are located in the ministries, while the "executers" are located in the agencies.

11 No. 35 of 1993, now *Laws of Singapore*, Chapter 7A, 1994 Revised Edition.

As emphasized by Chief Justice Yong Pung How, the fair and transparent legal framework is a key comfort to foreign investors and businesses: [12]

> *We inherited from the British a legal system that is familiar to most, if not all, international businessmen and corporations. What the law in Singapore is, is readily ascertainable. Contractual and property rights are recognized and given binding legal effect. Access to the courts is open to all.*

Singapore generally follows international conventions on labour laws. However, under amendments to the Industrial Relations Act in 1968, unions are barred from negotiating promotions, transfers, replacements, retrenchment, dismissal, and work assignments. [13]

The labour movement is closely aligned with the government, to the extent that a cabinet minister is the chief executive of the umbrella labour organization, the National Trades Union Congress (NTUC). The "symbiotic relationship" between the labour movement and government is a party practice rather than a legal link. It ensures an industrial relations system that promotes business and investment based on tripartitism and collaboration, by contrast with the usual adversarial approach.

At the time of writing, Singapore does not have a general competition law. Rather, competition policy is applied to particular sectors – telecommunications, media, banking and insurance, and energy – by their respective sector regulators. The government has indicated that it will promulgate competition law and establish a competition authority by 2005, in part, owing to pressure from partners in bilateral trade agreements (Low 2003a and Low 2003b).

In 2002, the Intellectual Property Office of Singapore (IPOS) was established to replace the Registry of Patents and Trademarks. The government has systematically revised intellectual property laws to conform with Trade-related Intellectual Property Rights (TRIPS). It plans further revisions and increased enforcement to meet commitments made pursuant to the free trade agreement with the United States.

3.4. ECONOMY AND ECONOMIC POLICY

As discussed earlier, Singapore's economic growth was historically based on trade. However, from the mid-1950s, a succession of expert reports advised that Singapore shift its strategy to emphasize industrialization, and that it needed a sufficiently large domestic market (IBRD 1955; Lyle 1959; IBRD 1963).

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12 Speech, Fourth Inter-Pacific Bar Association Annual Conference Dinner.

13 Industrial Relations Act, Laws of Singapore, Chapter 136 clause 17(2), 1999 Revised Edition.

The PAP government was convinced that industrialization was the solution to the employment of a growing population and the key to future economic growth. Accordingly, it sought merger with Malaya to create the domestic market. Upon Singapore's joining the new Federation of Malaysia, it followed federal policy and initiated a policy of industrialization through import substitution buttressed with protection against imports through tariffs and quotas.[14]

Meanwhile, United Nations expert Albert Winsemius advised Singapore to take aggressive steps to attract investment:

> *The Report [concluded] … in view of Singapore's relatively late start in the effort to attract industrial capital, combined with its high wage levels, state intervention was essential if Singapore was to compete successfully with other countries in the region for investment* (Rodan 1989: 64)

The Singapore Government's State Development Plan for 1961-64 was largely based on the Winsemius Report (Rodan 1989: 64-65). It established the Economic Development Board (EDB) with M$100 million, with the mission to finance industry and develop fully equipped industrial estates ready for immediate occupation.

However, in August 1965, when Singapore was expelled from the federation of Malaysia, the import-substitution strategy came undone. The second development plan, for 1966-70, had to be aborted. Shorn of a large domestic market, the Singapore Government needed another way to resolve festering unemployment.

The Government quickly decided on an export orientation. But domestic businesses were geared to exporting primary products, and regional markets such as Malaysia were raising barriers against imports. Hence, the government focused on attracting foreign multinational companies (MNCs) to manufacture in Singapore and export to global markets. The EDB began to aggressively promote Singapore as a low labour-cost base for MNCs.[15]

Fortuitously, the Singapore government's renewed outward orientation coincided with a boom in international trade from 1965-73. The economy forged ahead, with real GDP per capita growing at 10.7% annually, despite the additional shock of the British military withdrawal. During this period, the government enacted legislation and reformed the trade union movement to ensure peaceful industrial relations. These moves were buttressed by a policy of deliberate wage restraint. Following the OPEC oil shock, economic growth continued, albeit at the slower rate of 5.8% between 1973-79.

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14 The following analysis draws heavily on Hughes (1993).

15 Without a domestic market, an export- and outward-oriented economy means a free and competitive trade policy and promotion in commensurate. Beside multilateral trade liberalization at the World Trade Organisation (WTO) level, Singapore has actively supported regional efforts in ASEAN, APEC and others beside its own bilateral free trade agreements initiated since the early 1990s.

By the mid-1970s, the government had to confront the new problems of excessive domestic demand and labour shortages.[16] The government responded by sharply increasing CPF contribution rates to control domestic consumption, and allowing the large-scale import of foreign workers to address the demand for labour.[17] Even in 1973, foreign workers constituted over 12% of Singapore's workforce (Deyo 1981: 44).

For the long-term horizon, the government shifted the emphasis of industrial policy towards upgrading the workforce, more capital-intensive methods, and higher technology. This culminated, in 1979, with the "high-wage" policy to shift the economy away from labour-intensive businesses and drive a "second industrial revolution" (Rodan 1989: 142). Then Minister for Trade and Industry Goh Chok Tong remarked:[18]

> *"[foreign labour] helps to sustain low-skilled, low productivity and labour intensive industries. These industries in turn can afford to pay only low wages which in turn, cause them to depend on more imported labour to keep their wage cost down."*

In 1985, a real estate slump and stock exchange crisis coincided with the lingering effects of international recession to spark Singapore's first economic recession. The Government quickly empanelled the Economic Committee chaired by then Minister of State for Trade and Industry Lee Hsien Loong. Upon the Committee's recommendations, the government relaxed the high-wage policy, instituted a temporary cut in CPF contributions, and depreciated the Singapore dollar. The recession was quickly overcome, and the economy continued on a high growth trend.

Table 2 provides a simple time-line of the development of the Singapore economy and the government's economic policy.

16 The unemployment rate was 8.9% in 1966, and fell to 4.0% by 1974.

17 All employees and their employers are required by law to contribute specified percentages of the employee's earnings to individual accounts with the Central Provident Fund (CPF). The CPF was established in 1955.

18 "Cheap Labour 'Shake Out'," *Straits Times*, June 9, 1979.

Table 2: Timeline of Singapore Economy and Economic Policy

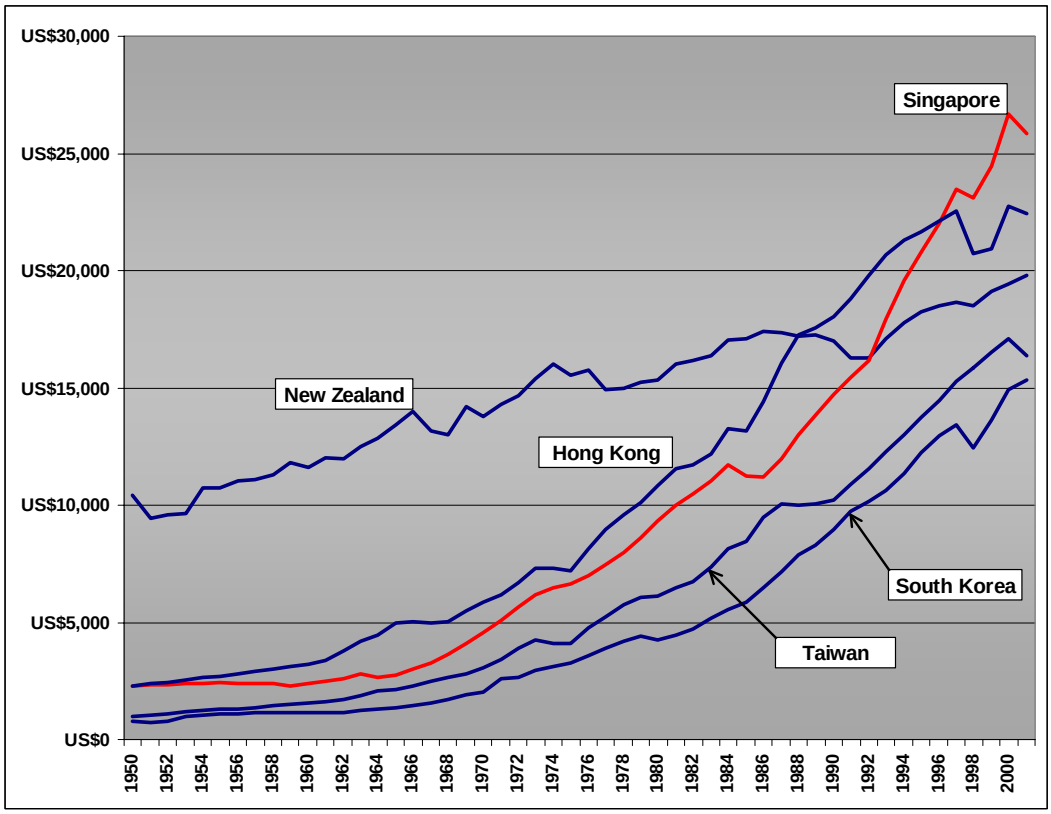
	1965-73	1974-85	1986-97	1998-onward
Economic issue	Expulsion from Malaysia; British military withdrawal	Oil and commodity price shocks; labour shortages	High labour costs; over-investment in real estate	Asian Financial Crisis; challenge from China; economic maturity; high land costs
Economic policy	Promotion of investment; promotion of labour-intensive manufacturing; wage restraint	Emphasizing capital-intensive industry; importing foreign workers; high-wage policy	Emphasizing services as second engine of growth; regionalisation	Emphasizing knowledge-based economy; domestic entrepreneurship

Between the major economic recessions of 1985 and 2002, the Singapore economy grew annually at an average rate of 8.1 percent.[19] Per capita GNI (gross national income) more than doubled to S$36,909, placing Singapore on a par with France and Germany.[20] The dramatic growth in Singapore's real income is shown in Figure 1, shown alongside New Zealand's performance and the other Asian tiger economies.

19 Source: Singapore Department of Statistics.

20 Source: Singapore Department of Statistics. According to World Bank (2003), Germany per capita income in 2001 (US PPP dollars) was $25,350, France $23,990, and Singapore $22,680. New Zealand was $19,160.

Figure 1: Real Income Per Capita, New Zealand and the Four Tigers (1999 US$ PPP)[21]



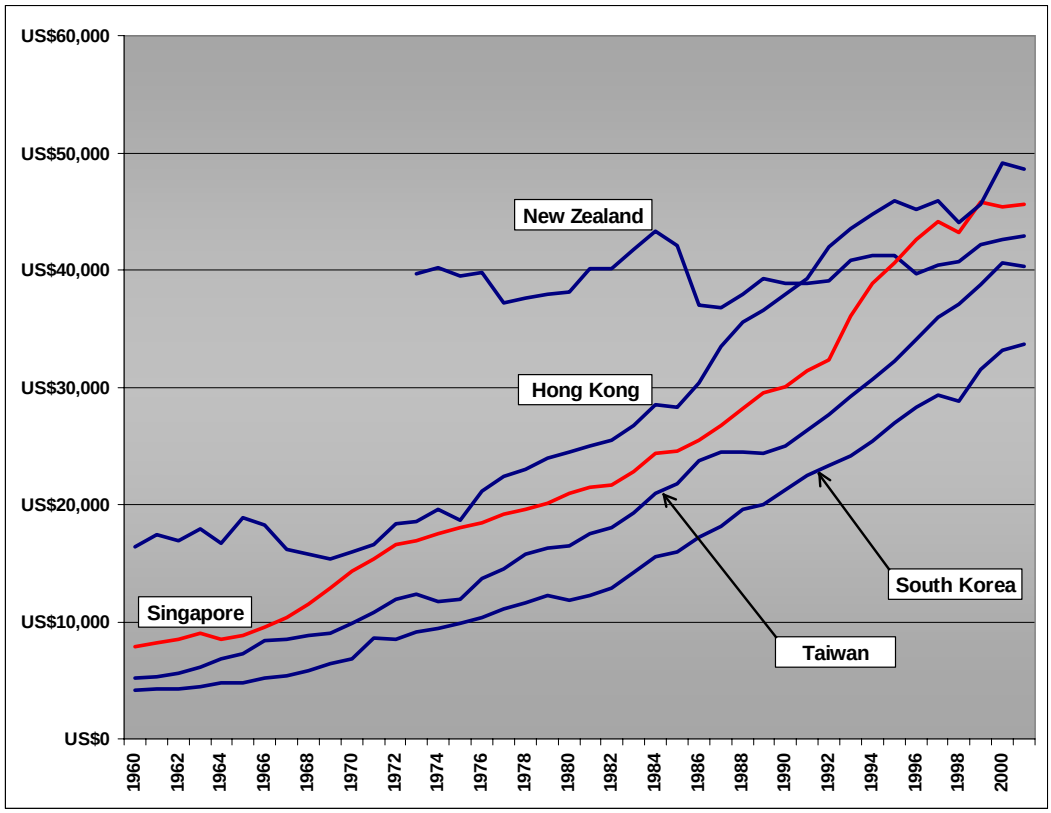
Source: Groningen Growth and Development Centre webpage (http://www.eco.rug.nl/ggdc/index-dseries.html#top)

At the macroeconomic level, the Singapore economy is characterized by an extremely high savings rate and level of exports (see Table 4). The high savings rate results from compulsory contributions to the CPF, amounting to a total of up to 36% of an employee's earnings (Young 1992; Toh and Ng 2002). The CPF is mandated to invest in government securities and consequently, the high savings have been commandeered by the government to support public housing and other national initiatives.[22]

21 Data used to produce this chart is available in Appendix E.

22 The CPF financed Singapore's public housing program. In the 1960s and 1970s, the Housing Development Board (HDB) was the largest borrower from the government's development fund (Low and Aw 1997).

Figure 2: Real Income Per Worker, New Zealand and the Four Tigers (1999 US$ PPP)



Source: Groningen Growth and Development Centre webpage (http://www.eco.rug.nl/ggdc/index-dseries.html#top)

Table 3: Gross Domestic Savings 2001

	Singapore		New Zealand	
		Ranking		Ranking
GDS (US$ billion)	39.3	27	11.4	44
GDS (as % GDP)	45.8	1	23.3	30

Source: International Management Development (2002), *World Competitiveness Yearbook 2002*.

The government sector has also earned more than it spent on an operating basis. Besides taxes, it earns income from land sales and investments. The contractionary effect of budget surpluses has been mitigated by the extent of public-sector investments in infrastructure, housing, and education.

Since 1985, the structure of Singapore's economy has shifted towards services and manufacturing, and away from wholesale and retail trade, transport, and construction. A major engine of growth has been the financial and telecommunications sectors, driven by the liberalization of both industries with the goal of establishing Singapore as a regional financial and communications hub. This was a key recommendation of the 1986 Economic Committee.

Within manufacturing, there has been a shift towards higher value-added products in electronics (2002: 42.2% of total manufacturing output) and chemicals (2002: 15.2% of total manufacturing output) and away from more labour-intensive items such as apparel, textiles, and consumer electronics.[23]

Exports grew from S$50,179 million to S$223,901 million between 1985-2002. While exports to all markets have risen, Singapore has experienced a re-balancing away from relatively distant markets in the Organisation for Economic Cooperation and Development (OECD) to markets within the Asian region. For instance, in 1987, the United States and Europe accounted for 38% of Singapore's exports, while Asia accounted for 52%. By 2002, the share of the United States and Europe had fallen to 29%, while Asia's had increased to 64% (see Table 4).[24] The shift may in part be attributed to the growth of services exports. Exports of services have a relatively stronger regional orientation than exports of manufactured products.

23 Sources: Ministry of Trade & Industry (2002), *Economic Survey of Singapore 2002*. EDB.; Economic Development Board.

24 As Singapore is a major entrepot centre, it is important to distinguish between exports and "net domestic exports", i.e., exports originating from within Singapore. Table 5 reports Singapore's gross exports.

Table 4: Singapore – Exports at Current Prices (Unit: S$ billion)

	1987		1992		1997		2002	
United States	14.674	24%	21.779	21%	34.117	18%	32.935	15%
Asia	31.301	52%	54.786	53%	111.045	60%	142.285	64%
Japan	5.449	9%	7.857	8%	13.125	7%	15.99	7%
Malaysia	8.56	14%	12.925	13%	32.405	17%	39.002	17%
Brunei, Philippines, Thailand	4.139	7%	8.839	9%	14.981	8%	16.466	7%
China (incl. Hong Kong)	5.362	9%	9.892	10%	23.886	13%	32.76	15%
Europe	8.727	14%	18.326	18%	28.62	15%	31.316	14%
Total	60.266		103.351		185.613		223.901	

Source: *Economic Survey of Singapore*, *Statistical Appendix*, 2002.

For its size, Singapore has a relatively high market share of world exports (see Table 5). See Appendix D for a brief literature review on distance as a barrier to trade.

Table 5: Shares in World Exports 2000 and Changes 1985-2000 (Unit: %)

20 Economies with Largest Export Market Share, 2000		20 Winner Economies based on Export Market Share Gains, 1985-2000	
US	13.2	China	4.5
Germany	8.2	US	1.8
Japan	7.7	Korea	1.2
China	6.1	Mexico	1.1
France	4.8	Malaysia	0.9
Canada	4.7	Ireland	0.8
UK	4.5	Thailand	0.8
Italy	3.5	Taiwan	0.7
Netherlands	3.1	Singapore	0.6
Taiwan	2.7	Spain	0.5
Mexico	2.6	Philippines	0.4
Korea	2.5	Hungary	0.2
Belgium/Lux	2.4	Vietnam	0.1 and less
Spain	1.8	India	
Malaysia	1.7	Israel	
Switzerland	1.6	Poland	
Singapore	1.5	Turkey	
Sweden	1.4	Czech Republic	
Ireland	1.3	Chile	
Thailand	1.1	Portugal	

Source: UNCTAD (2002, 144).

Against this impressive record, Singapore's growth has been criticized for relying relatively heavily on expansion of capital and labour inputs, and being relatively weak in productivity growth (Young 1992). We discuss this issue in detail in section 5 of this report.

The IMF (2000) points to three indicators of weakness in the Singaporean microeconomic environment:

- Locally controlled companies are found to be less efficient than foreign-controlled companies;
- Price-average cost margins in Singapore are much higher than those in Hong Kong and the OECD; and
- Export market shares have been declining.

What underlies these indicators? The IMF observes:

> *Various indicators of competitiveness – including the microeconomic competitiveness indicator of the World Economic Forum – confirm Singapore's macroeconomic strengths, but have also revealed a relative weakness in the microeconomic environment viewed critical for innovation and productivity growth…One likely cause of the weakness in (sic) microeconomic environment is the very high degree of government involvement in (sic) Singapore economy … Although the [Government Linked Corporations] have been expected to operate on a competitive basis in both domestic and international markets … their overwhelming market power is likely to have crowded out local private enterprises and thus prevented the development of a large and dynamic network of local corporations, contributing to the widely perceived lack of corporate dynamism in Singapore.* IMF (2000, 5-11)

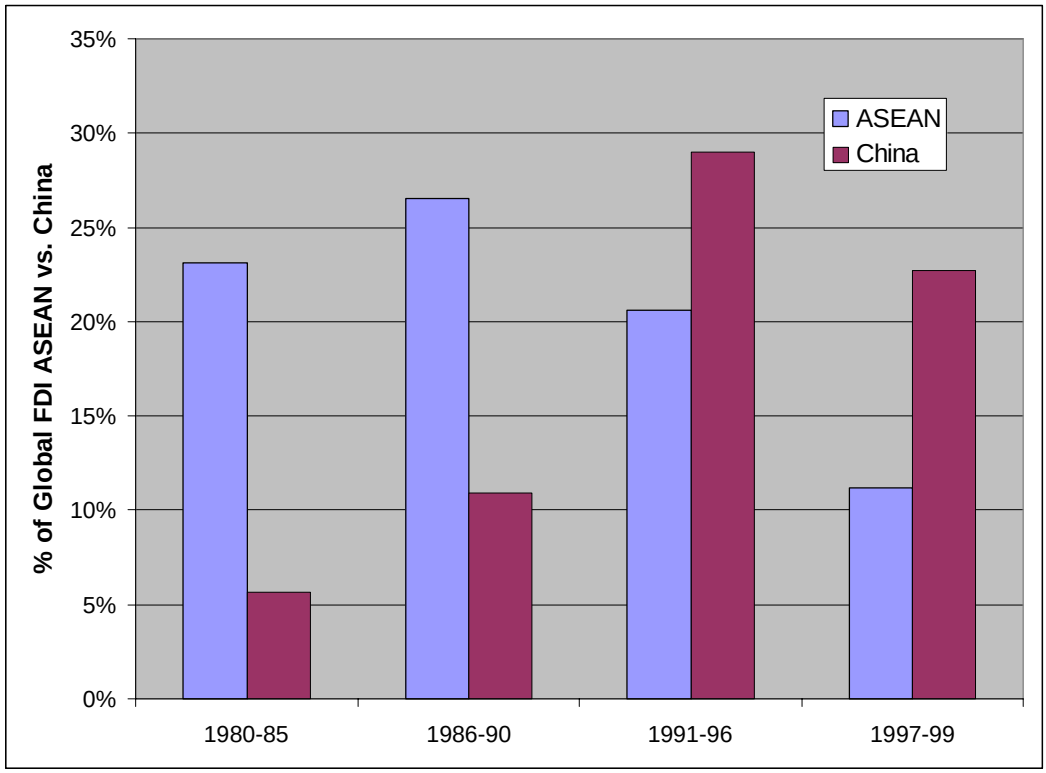
As noted earlier, the Singapore Government has indicated that it will promulgate competition law and establish a competition authority by 2005. Against the background of the policies described in section 4 of this report, it will be interesting to see how this competition policy works. From an economics perspective, the objective of competition policy is to encourage dynamic efficiency by exposing firms to pressure to innovate and invest. Selective government interventions have the potential to undermine competitive processes.

A particular structural weakness impeding the transition to a "knowledge-based economy" is the relatively low educational attainment of the population. For instance, in 2001, the average years of schooling was only 8.7, albeit a substantial gain over the average of 5.7 years in 1985. More crucial is the lack of entrepreneurship and intellectual capital epitomised as creativity and innovativeness, not merely an educated, literate and productive workforce.

The Asian financial crisis of 1997-98 revealed another limitation on Singapore's future economic growth. Singapore had sought to develop closer economic ties with the neighbouring ASEAN region, and especially Thailand, Malaysia, and Indonesia through such initiatives as the "Growth Triangle" encompassing Johor in Malaysia and Riau Islands in Indonesia. The goal was for businesses to re-locate low-end activities and resource-dependent operations to resource rich countries, and allowing their Singapore entities to focus on higher value-added functions.

However, the crisis disproportionately affected Singapore's ASEAN neighbours: several of the larger, more sheltered economies responded with protectionist policies. China avoided the crisis. It had overtaken ASEAN and became the primary recipient of foreign direct investment in Asia: see Figure 3.

Figure 3: Percentage of Global FDI Share ASEAN vs. China



Source: Hafiz Mirza (2001), *Reviving FDI Inflows in Southeast Asia*[25]

Partly in response to the crisis, the government expanded its definition of Singapore's economic hinterland to a seven-hour radius that includes Northeast and South Asia and Australasia. It is also pursuing bilateral trade arrangements with the OECD economies and a broader "ASEAN Plus Three" free trade area including China, Japan and Korea.

Nevertheless, it should be noted that the Asian financial crisis affected Singapore with much less severity than many (not all) other East Asian countries. The IMF (2000) attributes this resilience to the strength of Singapore's economic fundamentals and policy management.

25 Available from: http://www.gapresearch.org/finance/Reviving%20FDI%20Inflows%20in%20Southeast%20Asia.pdf

3.5. Overview of Singapore's Innovation Policies and an Economic Framework

Sections 3.3 and 3.4 of this report provided an overview of the driving factors and economic history of modern (i.e., post-independence) Singapore. The purpose of this section is to:

- Provide a brief introduction to the broad types of innovation policies pursued by Singapore, which are described and analysed in more detail in sections 4 and 5 of this report; and
- Summarise the economic framework developed in Appendix A to this report for thinking about the costs and benefits of those policies.

The economics literature tends to focus on pieces of the "innovation system" in isolation. However, there are some articles that address the linkages between those pieces. These articles are also reviewed in 0, and we summarise them at the end of this section.

3.5.1. Foreign Direct Investment

Overview of Policy

A key plank of Singapore's strategy has been to attract investment by multinational companies, and to leverage the benefits of that investment into the domestic economy. Subsidies have played an important role in this strategy.

Economic Framework

Governments around the world actively pursue foreign direct investment (FDI), so Singapore is not unique in this respect. FDI can stimulate innovation in the host country through information spillovers. Foreign companies may bring knowledge about production processes and industrial organisation that spillover to employees, suppliers and local customers, and raise the stock of human capital. These spillovers may justify government subsidisation, without which the private rate of foreign investment may be suboptimal. Furthermore, government intervention may help to mitigate information asymmetries and uncertainties faced by companies in entering a foreign country. By targeting assistance and attracting leading companies in a particular industry, information barriers to other companies in the industry may be lowered and, depending on the success of the first company, a domino effect of new investment by other foreign firms may be induced.

Empirical studies show that the benefits of spillovers to the host country are greatest when the technology of the foreign entrant is within sufficient "reach" of the host country population, facilitating absorption and use of the new information. Information industries, such at ICT, tend to generate greater spillovers, which implies government policy will be most efficiently targeted at some industries, rather than applied indiscriminately. However, targeting would involve the government in "picking winners", and there is some empirical evidence showing that government assistance for FDI seems to systematically attract entry by firms offering few beneficial spillovers to the host region.

3.5.2. Venture Capital

Overview of Policy

Singapore has attempted to stimulate venture capital financing through public venture capital co-investment and encouragement of private venture capital investment through tax incentives.

Economic Framework

In principle, markets may fail to deliver efficient levels of venture capital because of information asymmetries and economies of scale in monitoring investments. Public assistance for venture capital markets may raise welfare if there is a credible signalling effect of public funding, and market failures elsewhere (e.g. sub optimal investment in R&D) may be efficiently reduced by raising the funding of the activity via venture capital. However, there is no clear evidence that market failure in venture capital is actually occurring. The very low success rate of applicants for venture capital may reflect the rarity of good ideas and the true costs and risks of funding new ventures.

Overseas, governments have intervened in venture capital markets, but the performance of these schemes has been quite mixed, with no clear evidence of success. Governments cannot be expected to make good fund managers: venture capital requires hard-nosed decisions to quickly withdraw funding to unsuccessful businesses, and government officials do not generally have the necessary incentives or expertise to manage such investments.

The U.S. experience, where venture capital markets are well established but tightly regulated, does suggest a role for government in the regulation of the venture capital market e.g. rules about the divesting shares.

3.5.3. R&D

Overview of Policy

Singapore's R&D policies include public financing of research institutes; private sector R&D incentives, (e.g., via the tax system); and publicly funded secondment of research scientists and engineers from research institutes to local firms.

Economic Framework

Government assistance for R&D can be justified on the grounds of spillovers of knowledge from the innovating firm. These spillovers may reduce private investment in R&D below a social optimum, implying a role for government. However, market responses to spillovers, such as inter-firm cooperation, mergers, and clustering are also effective in internalising spillovers. We have not uncovered literature that quantifies the relative merits of the two approaches. The empirical literature generally finds the long run benefits of assistance for R&D are very large and justify government intervention.

3.5.4. Education

Overview of Policy

Education has always been a priority for Singapore. As well as government investment in primary, secondary and tertiary education, there is a strong commitment to subsidisation of training schemes for employees; regulation of tertiary-level enrolments to line up with demand-side expectations; and university partnerships with selected international institutions.

Economic Framework

Although difficult to estimate, studies of the returns to education indicate that increases in levels of education raise economic growth. However, there is some evidence that the returns to education have already been exhausted at current levels of public funding in developed economies, with the costs of additional public education expenditure not compensated for by further increases in the national output.

Firms which fund employee training raise the value of their employees to other firms. In the event that an employee leaves the firm, he or she will take with them the knowledge gained. To the extent the knowledge gained is usefully applied in the new firm, the investment made by the firm departed will spill over to the new firm. Given on-the-job training is usually funded by the firm, this may lead to under-provision of investment training. Microeconomic evidence indicates positive effects of on-the-job training on wages; however, no studies have been carried out which empirically relate on-the-job training to economic growth.

From the limited literature we have located on the optimum mix of graduates, the high social value of R&D implies value in funding policies which, firstly, increase the supply of scientists and engineers and, secondly, raise the responsiveness of graduates in these fields to demand conditions in labour markets. Increasing the supply of scientists and engineers strongly complements subsidies on R&D by strengthening the relationship between R&D subsidies and the supply of suitably qualified labour.

3.5.5. Immigration

Overview of Policy

Immigration policy has also been a key strategic lever for the Singapore Government. Immigration policy has focussed on workers with relevant skill sets, as opposed to family unification.

Economic Framework

The literature on migration finds a positive relationship between the level of human capital in migrants and economic growth. Migration is a low-cost source of human capital relative to natural increase, which incurs the substantial cost of child rearing and primary education. Migrants also arrive with different ideas, which the literature suggests is in itself valuable. However, a positive economic value of migration to the host country rests on the successful assimilation of migrants.

3.5.6. Clusters

Overview of Policy

The Singapore Government has attempted to facilitate the development of clusters. Specific focuses have included biotechnology and environmental technology; electronics and manufacturing technology; and information technology.

Economic Framework

Clusters lower transport costs, help internalise knowledge spillovers, and place firms close to relevant customer and labour markets. However, empirical evidence on the value of government-sponsored technology clusters is mixed, with a number of studies showing both superior and inferior innovation performance of firms in government-sponsored technology parks. The case for government intervention is also difficult to justify theoretically, with no apparent market failure. That is, there is no reason to expect clusters will not successfully form as and where the mix of the above benefits are sufficient to justify the costs of relocating.

3.5.7. Fostering Linkages

Innovation is not produced by merely having adequate levels of each input into the innovation process. Linkages and interaction between different factors and different parts of the economy are essential. Innovation primarily occurs through clusters of competing companies which are supported by a common innovation infrastructure (which includes an educated population, supply of risk capital, basic research investment).

The linkage between researching companies and the common innovation infrastructure is central to the production of innovation, and it is here that universities have been identified as having a key role. Universities are an important conduit between basic and commercial research and infrastructure. Government policy interventions of value may include placing pressure on universities to conduct relevant research and to produce high-quality students with specific technical skills. Another role for government may be in fostering linkages between venture capitalists, for their expertise in commercialising innovation, and industry and universities.

3.6. CULTURE

This report notes at several points the Singapore government's lack of transparency. In addition, the political and administrative systems have been endowed in a few key persons. At the most senior levels, a core of politicians and civil servants in the various ministries and statutory boards manage Singapore Inc. Upon retirement, key persons "retire" into government-linked companies. This practice ensures tight control, smooth execution, and a seamless interface to foreign investors and trading partners.

This practice has been continually reinforced by emphasis on "Asian values," and specifically, Confucian ethics. Confucianism emphasizes subordination of the individual interest to the collective good. Lee Kuan Yew, Singapore's founding and longest-serving Prime Minister, stressed the importance of:

> *[A] well-ordered society so that everybody can have maximum enjoyment of his freedoms. This freedom can only exist in an ordered state and not in a natural state of contention and anarchy* (Zakaria, 1994:111).

In the traditional Confucian ethic, individuals must pursue personal self-cultivation (*xiu shen*) within the confines of the family (*qi jia*). Further, if the individual cares for his country (*zhi guo*), then society will be peaceful and harmonious (*ping tian xia*) (Riegel 2000).

The collectivist culture supported the leadership with the speed, flexibility and power to inform and deliver jobs, homes and security to Singaporeans. That these were indeed delivered time after time, crisis after crisis, formed an implicit political compact between voters and the PAP government, which has been returned continuously to power since independence.

However, at a more critical time, these very success factors may forestall effective performance in a globalised, knowledge-based world. A knowledge-based economy, especially one emphasizing entrepreneurship, depends on critical and independent thinking across the board and at all levels. The culture of obedience and stability does not fit easily with the relatively new desire for a creative and enterprising culture.

These concerns also apply to the leadership itself. How far can the leadership think "out of the box" when "group thinking in the same pool" seems pervasive? Since independence, the leadership has effectively "delivered the goods". However, is it locked in to a set of institutions and policies that have become difficult to change except on an incremental basis? Can Singapore truly re-engineer and steadily make the wholesale changes that might be necessary for the transition to a knowledge-based economy?

3.7. CASE STUDY: SUZHOU INDUSTRIAL PARK

Over time, Singapore has increased its emphasis on foreign economic policy. The twinning of economic policy with foreign policy is demonstrated by an increased emphasis on trade agreements, discussed later in this report, and by the regionalisation policy promulgated in 1993 to encourage Singapore companies and people to tap the region, in which the Suzhou Industrial Park was a flagship project.

On 26 February 1994, Chinese Vice Premier Li Lanqing and Singapore Senior Minister Lee Kuan Yew signed an agreement to establish the China-Singapore Suzhou Industrial Park Development Company Limited (CSSD), to develop the Suzhou Industrial Park (SIP).[26] CSSD, with a registered capital of US$100 million, was a joint venture between a Singapore consortium including government-linked companies such as EDB Investments, JTC International, Keppel Corporation, and Temasek Holdings holding the majority 65 percent share, and a Chinese consortium with the minority share.

Within three months, ground was broken on the new development. At the suggestion of then Chinese paramount leader, Deng Xiaoping, the SIP was intended to promote a model of good municipal management and social order for the whole of China. Alongside the SIP, the Singapore Government initiated a project for "software transfer" to train Chinese officials in the arts of economic, social, and civic administration.

Despite Beijing's endorsement, protracted differences arose between the joint venture partners. A particular vexation for the Singaporean leadership was Suzhou's continued promotion of an earlier-established rival park, the Taiwanese-owned Suzhou New District. Far from giving preferential treatment to the SIP, municipal authorities applied lessons learnt from SIP to offer investors the same benefits in the New District at a lower price than the SIP.

26 China-Singapore Suzhou Industrial Park Development Co. Ltd, http://www.cssd.com.cn/.

On a visit in December 1998, Senior Minister Lee Kuan Yew lectured Suzhou officials over their "bureaucratic shenanigans," telling them, "This matter has to be clarified because our credibility is at stake and the credibility of the Chinese Government as well in endorsing the SIP at the very highest level".[27]

In June 1999, just five years after the initial joint venture agreement, the Singapore consortium decided to cut its losses. Having invested US$131 million and undertaken to guarantee an additional US$65 million in loans, it unilaterally agreed to transfer a 30 percent share to the Chinese consortium on January 1, 2001. The Singaporeans agreed to continue the development of just 8 square kilometres of the Industrial Park, or 11% of the originally planned area, and to sell power and water-treatment plants to the Chinese consortium.

The Suzhou failure not only wounded pride, but also cast doubt on Singapore's effectiveness as a broker or partner for regional business and investment. European businesses had been wooed to ride on Singapore partners through the "Singapore unlimited" regionalisation strategy. However, at the signing of the revised agreement, Suzhou mayor Chen Deming remarked, "When you or your joint-venture partner decide to invest in China you must take into account our cultural differences".[28] Singapore Inc. was revealed to be less than savvy outside the sheltered and sanitized home terrain.

The common thinking underlying Singapore Inc. had yielded advantages of quick and integrated collective action. However, in the unfamiliar environment of central China, this common thinking translated into "groupthink" and strategic inflexibility.

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27 David Lague, "China "shenanigans" over city plan miffs Lee," *Sydney Morning Herald*, March 21, 1998.

28 Ben Dolven, "Suzhou project: Wounded pride," *Far Eastern Economic Review*, July 8, 1999.

4. SPECIFIC INNOVATION POLICIES IN SINGAPORE

4.1. INTRODUCTION

In this section, we discuss Singapore's growth and innovation policies under the following subject headings:

- Industry assistance;
- Skills and talent;
- Global connections;
- Branding; and
- Sectoral initiatives.

Our discussion is a mixture of description and analysis. We interweave the discussion with references to relevant economic literature and with our own analysis. In section 5 of this report, we step back and provide a more holistic evaluation of the impact of Singapore's growth and innovation policies.

We note at this point that there are very few publicly available critical studies of the efficacy of Singapore's individual growth and innovation policies. If the relevant government agencies have carried out such studies, they are generally not publicly released. Accordingly, our evaluation is by necessity based on specific case studies, generic literature, general observation and broader studies of Singapore's economic performance.

While this section considers the various agencies and their functions separately, it is important to bear in mind that one of the strengths of "Singapore Inc." is the effective integration of policies and execution across multiple agencies. Effective integration may well be a key policy advantage of small countries.

4.2. INDUSTRY ASSISTANCE

4.2.1. Economic Development Board (EDB)

The EDB was established in August 1961 with a budget of M$100 million. It has been the international spearhead of "Singapore Inc.," driving the growth of manufacturing and internationally traded services. It has also played the role of "national incubator" of economic promotion agencies. The EDB and its "alumni" have spawned many other specialized statutory boards, including International Enterprise Singapore (formerly the Trade Development Board) and the Agency for Science, Technology and Research (formerly the National Science and Technology Board).

The EDB is a statutory board legislated under an act of parliament. This organizational form provides management and financial autonomy, but is subject to public accountability through the parent Ministry of Trade and Industry.

Following Singapore's expulsion from Malaysia, the EDB shifted to emphasis to inward investment by multinational companies, opening its first overseas offices in Hong Kong and New York. The attention to foreign investors was driven by immediate concerns – racial unrest, separation from Malaysia, and the British military withdrawal undermined the economic and investment climate in Singapore. In the region, instability in Indonesia and the Vietnam War contributed to the overall sense of insecurity.

The idea was that foreign capital would promote manufactured exports, and investment from the United States and other international powers would tie them more closely to Singapore, thus strengthening national security.

Table 6 illustrates the significance of foreign direct investment to Singapore's economy.

Table 6: Shares of Foreign Affiliates in Exports of Selected Host Economies for all Industries and Manufacturing, Selected Years, %

	Selected years	All industries	Manufacturing
Singapore	1994	Na	35
	1999	Na	38
Hong Kong	1985	Na	10
	1997	Na	5
Malaysia	1985	26	18
	1995	45	49
Korea	1999	Na	15
Taiwan	1985	17	18
	1994	16	17

Source: UNCTAD (2002, 154).

Foreign investment in Singapore and New Zealand is illustrated in Table 7.

Table 7: Inward Foreign Direct Investment (Unit: US$ million)

	Singapore	New Zealand
1980	6,203	23,362
1985	13,016	2,043
1990	28,565	7,930
1995	59,582	26,182
2000	95,714	25,069
2001	104,323	20,408

Source: UNCTAD (2002, Annex B, pp 303-6).

More recently, the EDB has also branched into what may be termed innovation policies. This reflects the more general shift in emphasis by the Singapore government towards domestic entrepreneurship, described elsewhere in this report.

The EDB pioneered the concept of "one-stop investment facilitation," encompassing coordination of investment incentives, financing including co-investment, human resources and immigration, and industrial and commercial real estate. This comprehensive approach continues to be one of Singapore's key competitive advantages in attracting inward foreign investment, as it reduces transaction costs for investors.

We now describe various programmes and schemes administered by the EDB. Generally, these offer three types of incentives – favourable tax treatment, grants and cost-sharing, and co-investment. The most important tax incentive is "Pioneer Status," which provides exemption from corporate tax for up to 10 years (presently the corporate tax rate is 22%). This is available for activities that introduce substantially more advanced technology or skills into the industry, consistent with the technology spillover effect described in section A.6.1 of this report.

Also consistent with this effect is the Development and Expansion Incentive, which provides a concessionary 10% corporate tax rate for up to 10 years. This is available for new projects, expansion, or upgrading that yield "significant economic spin-offs for Singapore".

Local Industry Upgrading Programme

In 1986, the EDB initiated the Local Industry Upgrading Programme (LIUP) to upgrade, strengthen and expand the pool of local suppliers of parts and services to MNCs (multinational corporations). By meeting the increasing requirements of MNCs, Singapore enterprises would upgrade their business operations and become more internationally competitive.

The LIUP envisages three phases. The first phase is improvement of overall operational efficiency such as production planning and inventory control, plant layout, financial and management control techniques. The second phase introduces and transfers new products or processes. Finally, local enterprises progress to joint product and process R&D with MNC partners.

A key element is the LIUP manager, an employee of a participating MNC, whose salary is paid by EDB (Wong 1999). The manager identifies the weaknesses in the local supplier and recommends various upgrading measures. The participating MNC may assist through vendor development programs or quality training programs. LIUP managers meet regularly to pool their knowledge of local supplier problems and possible solutions. From these meetings, the EDB learns how to better customize industry assistance programmes.

In the case of the hard disk drive industry, a considerable number of the LIUP managers crossed over to their local "clients," thus reinforcing the transfer of technology and skills to local industry (Wong 1999: 26-27).

Accordingly, it can be seen that the rationale for the LIUP scheme is to assist the FDI technology spillover process.

Innovation Development Scheme

As the EDB focused efforts towards new knowledge-driven clusters and promoted Singapore as a global hub for business and investment, it developed new schemes. Established in 1996, the Innovation Development Scheme encourages manufacturing and services businesses to undertake innovation projects in Singapore.

The Scheme covers up to 30% of qualifying costs of product or process innovations that: (i) promise significant improvements in productivity or generate tangible outcomes such as additional investments, introduction of new services or adoption of new technology; and (ii) will make a significant contribution to the relevant industry or cluster.

The grants are subject to limits for each category of expense: manpower (50%), equipment and materials (30%), local professional services (50%), foreign professional services (30%), and intellectual property rights (30%).

The EDB's Patent Application Fund Plus supports up to 50% of the cost of filing a patent up to limits of S$5,000 and S$25,000 over two stages of filing.[29]

International Headquarters Scheme

The International Headquarters scheme seeks to attract foreign companies to establish regional or global headquarters in Singapore.[30] Businesses that meet specific minimum investment requirements may receive concessionary tax rates of 0-15% (compared with the standard 22% corporate rate) on qualifying income.

In 1998, Caltex Petroleum (then a joint venture between Chevron Corporation and Texaco Inc) moved its global corporate headquarters from Dallas, Texas, to Singapore and became the first recipient of EDB's Global Headquarters Award. By 2001, about 60% of the 6,000 international companies in Singapore had regional operations and headquarters responsibilities, with annual spending increasing 10-fold in eight years to exceed S$7.5 billion. At total of 220 companies had received EDB's headquarters awards.

The demand to locate regional headquarters in Singapore undoubtedly depends on regional conditions. The need for a regional base increases with the extent of business and investment in the region. Singapore's relative attractiveness as a headquarters location depends on its reputation for a clean and stable government and legal system, effective infrastructure, and comfortable living conditions as compared with other regional locations.

Furthermore, Singapore is well situated geographically. All of ASEAN is within a 3-hour flying radius, and a 7-hour flying radius includes Australasia, Northeast Asia (China, Japan and Korea), and South Asia (India, Pakistan and Sri Lanka). Singapore's airport boasts of the largest number of airlines calling in Southeast Asia, although Bangkok and Kuala Lumpur airports pose some competition.[31]

The EDB aims to attract another 280 world-class regional and international headquarters by 2010.

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29 Until 2002, this was administered by the Intellectual Property Office of Singapore (IPOS) as the Patent Application Fund.

30 This was established in 2003 to rationalize the Global, Operational, Business, and Manufacturing headquarters schemes.

31 See section Appendix D for a brief literature review on distance as a barrier to trade.

Enterprise 21

In 1999, the Government launched the Technopreneurship 21 (T21) initiative, chaired by Deputy Prime Minister Tony Tan.[32] The inter-ministry initiative aimed to revise government regulations, education, and facilities, and provide financing in order to encourage and nurture private-sector technology-based innovation and entrepreneurship. Now renamed "Enterprise 21," the T21 initiative encompassed several schemes.

The US$1 billion Technopreneurship Investment Fund aimed, through co-investment, to establish Singapore as a major centre for venture capital. As of early 2002, the venture capital industry in Singapore had grown to a value of S$13 billion managed by over a hundred firms.[33]

The Technopreneur Investment Incentive encourages investment in new technology-based enterprises by permitting investors in approved start-ups to offset certificates for capital losses incurred against their taxable income. Each start-up was allowed to issue up to S$3 million worth of such certificates. This scheme involved a major departure from Singapore's tax regime, which provided for taxation of income only and not capital gains (and hence, did not allow deduction of capital losses).

The Start-up Enterprise Development Scheme (SEEDS) provides equity financing for start-ups involved in the development of new or better products, processes and applications in the manufacturing and services sectors. Drawing on a S$50 million fund, the scheme matches third party private-sector cash investments, dollar for dollar, up to a maximum of S$300,000. To date, the scheme has financed over 60 start-ups.

The Technopreneur Home Office (THO) Scheme allows approved technopreneurs to set up new businesses in their homes. The Housing Development Board and the Urban Redevelopment Authority, respectively the regulators of public and private housing, did not allow businesses to be registered or operated from residential premises. Eventually, four years later, in June 2003, the rules were relaxed to allow all but a limited list of businesses to be set up at home.

Tax Incentives

From the beginning, one of the EDB's key industry promotion tools was tax incentives. Consistent with the intent to stimulate incremental investment rather than simply substitute for private-sector funds, the EDB considers three sets of factors in awarding tax incentives:

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32 http://www.sedb.com/edbcorp/programmetechno21.jsp.

33 Speech by Dr Tony Tan Keng Yam, Deputy Prime Minister and Minister for Defence, at the opening ceremony of Bizworld, Tuesday, 19 March 2002, at Anglo Chinese School (Independent).

- Knowledge intensity - utilization/development of new innovations and new technology;

- Tradability - the extent to which the product(s) or service(s) can be exported. The company should either have ventured into the international market or have concrete plans to do so; and

- Value-added per worker - calculated by taking factors such as land rental, remuneration, profit, interest cost, and dividing by the number of workers.

Table 8 provides details of the various tax incentives.

Table 8: Tax Incentives

Tax Incentive	Qualifying Activities	Minimum Requirements	Tax Concessions
Economic Expansion Incentives (Relief from Income Tax) Act:[34]			
Pioneer Status	Eligible manufacturing and service activities.	The project introduces technology know-how or skills into an industry which is substantially more advanced than that of the average level prevailing in that industry. There are no companies in Singapore performing similar activity.	Exemption from corporate tax (presently 22%) on profits arising from pioneer activities. Tax relief period is 5-10 years.
Development & Expansion Incentive	Eligible manufacturing and service activities.	Companies must engage in new projects or expand or upgrade its operations in Singapore. The new project or expansion/upgrading must generate significant economic spin-offs for Singapore.	Corporate tax rate of 13% for up to 10 years with provision for extension.

34 *Laws of Singapore*, Chapter 86. The Act was originally passed in 1967, and most recently revised in 2001.

Tax Incentive	Qualifying Activities	Minimum Requirements	Tax Concessions
Investment Allowance	Eligible manufacturing and service activities; approved projects for reducing consumption of water.	Qualifying period of up to 5 years within which specified investments must be made.	Exemption of taxable income of an amount equal to a specified proportion (up to 50%) of new investment in productive equipment.
Approved Foreign Loan Scheme	Eligible manufacturing and service activities.	Minimum loan of S$200,000 from foreign lender for purchase of productive equipment. Tax relief should not result in an increase in tax liability in the foreign country.	Full or partial exemption of withholding tax on interest payments.
Approved Royalties	Eligible manufacturing and service activities.	Tax relief should not result in an increase in tax liability in the foreign country.	Full or partial exemption of withholding tax on royalty payments.
Overseas Investment Incentive	Investment by eligible companies in approved overseas projects	Companies must be at least 50% owned by Singapore citizens or Singapore permanent residents, and incorporated and resident in Singapore for tax purposes.	Losses incurred from the sale of shares, up to 100% of equity invested, can be set off against the investor's other taxable income.
Technopreneur Investment Incentive (TII) Scheme	Eligible start-up company in the initial stage of developing or exploiting new technology	Unlisted company in its initial years of existence.	Deduction from taxable income for losses incurred.

Tax Incentive	Qualifying Activities	Minimum Requirements	Tax Concessions
Income Tax Act[35]			
Venture Capital Fund Incentive	Approved venture capital fund investments.	The venture capital fund must invest a certain percentage of its subscribed funds in Singapore and seed-stage and/or restart projects in Singapore.	Exemption of corporate tax on net gains from disposal of approved investments and other income from approved overseas investments for up to 10 years.
Operational Headquarters	Eligible headquarters operations.	The Operational Headquarters must provide approved headquarters services to related companies.	Income arising from the provision in Singapore of approved services will be taxed at 10%. Incentive period will be up to 10 years with provision for extension.
Double Deduction for R&D Expenses	Eligible manufacturing and service activities.	Operating expenses (excluding depreciation) for R&D activities. The R&D project must be carried out in Singapore.	Double deduction of qualifying R&D expenses against income.

Evaluation

The EDB does appear to have been successful in attracting MNCs into Singapore. However, in the 1980s and 1990s, given Singapore's favourable geography and institutions, might the MNCs have invested anyway? And have the benefits to Singapore's population exceeded the costs (e.g., the efficiency costs of raising tax and the opportunity cost of that tax revenue)? The EDB has analysed the performance of its various programmes, but these studies are confidential and have not been published for public scrutiny (Hughes 1993: 16-22).

35 *Laws of Singapore*, Chapter 134. The Act was originally passed as Ordinance 39 of 1947.

Certainly many of the EDB's schemes can be conceptually justified by reference to the technology spillover and capital market imperfections described in section 3 of this report. However, many of them do involve the EDB attempting to "pick winners," which poses risks for taxpayers. Government employees are likely to have less experience, poorer information and poorer incentives than private investors, as well as potentially conflicting objectives. Furthermore, these interventions open the government up to lobbying, which can be expected to result in allocation of subsidies to the most organised and well-resourced players.

'EDB schemes have been criticized for requiring substantial documentation and other justification, and hence being less accessible to the small and medium enterprises that need the incentives most. The director of a manufacturing firm noted that his company engaged an executive, whose primary function was to apply for government incentives.

Some of the EDB's interventions would not be necessary in less tightly-regulated societies. For example, the Technopreneur Home Office Scheme, a rather pale imitation of Hewlett-Packard's famous garage, was really a band-aid over rigid rules imposed by Singapore's housing regulators.

However, several studies sponsored by the Information Storage Industry Center at the University of California, San Diego, concluded that the government and the EDB in particular played a major role in attracting the hard disk drive industry to Singapore and then developing the cluster of local enterprises around it (Wong 1999; McKendrick et al. 2000). We elaborate on this industry in the case study below.

Further, an overall review of the EDB after thirty years concluded:

> *"Balancing on the razor's edge constantly requires sound judgment. Ultimately, this has been the Economic Development Board's great strength. Backed by stable macroeconomic and open trade policies, it has tried to evaluate and follow market trends rather than to change them. Operating at the margin, its professionalism has enabled it to provide leadership while avoiding major mistakes. Where mistakes have been made, they have been corrected quickly."* (Hughes 1993: 25)

Case Study: LIUP and the Hard Disk Drive (HDD) Industry

Wong (1999) argues that the development of the hard disk drive (HDD) industry in Singapore reflects the effectiveness of the EDB's careful planning and aggressive marketing. In the mid-1980s, Singapore quickly became the world's single most important regional hub for HDD assembly. Between 1986–96, Singapore accounted for more than 40% of the global shipment of HDD units (Wong, 1999).[36]

While no single factor completely accounts for the successful development of the HDD industry in Singapore, Wong's view is that government policies, specifically the EDB's initiatives, played a crucial role in nurturing the industry.

In 1982, Seagate launched the first HDD assembly operation in Singapore. At that time, Seagate sought to relocate component production and eventually its entire drive assembly from Santa Cruz to Asia. Singapore was chosen over Korea and Hong Kong. Apart from the availability of English speaking skilled labour and the presence of experienced US-trained engineers, a major factor was the EDB's intervention.

EDB officers received senior Seagate executives at the airport and introduced them to CEOs of companies with manufacturing plants in Singapore. The EDB was also instrumental in introducing Seagate to local entrepreneurs who could manufacture components for the disk drive. This resulted in a reduction in the cost of final assembly. The EDB made a quick and generous offer of investment incentives.

Subsequently, the EDB paved the way for a smooth relocation for other HDD majors. The EDB introduced a key local manager to Conner and granted pioneer status. Conner was able to start up production quickly, and within two years, the Singapore plant was producing almost 80% of Conner's global output. In the case of CDC, Korea required a joint venture arrangement, while the EDB welcomed 100% CDC ownership, offered tax incentives, and introduced competent local suppliers. CDC chose Singapore and achieved a fast production ramp up.

The growth of HDD assembly activities in Singapore sparked off the rapid development of local supporting industries. More than 100 local companies are significant suppliers to the HDD industry (Wong, 1999).

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36 In recent years, the hard disk drive manufacturers have shifted their low-end operations to Penang, China, and other regional locations, thus reducing their employment in Singapore. Significantly, however, they have retained significant high value-added activities in Singapore. In June 2003, Seagate announced a further S$200 million investment tripling its production capacity in Singapore. Additionally, regionalisation by MNC hard-disk manufacturers has given opportunities for supporting Singaporean businesses to expand overseas with their MNC clients.

MMI Holdings (MMI) is an example of a local supplier that has successfully developed into a world-class player. It was formed in 1989 with Conner as the first customer. By adapting the latest process technologies and delivering good quality at low cost, MMI's turnover grew from S$4.7million in 1990 to S$346 million in 2002. The company invested in CAD/CAM technologies, rapid prototyping techniques and advanced supply chain management practices.

In 1994, Conner experienced contamination problems with its drives. MMI was the only supplier that was willing to take up the challenge of solving the problems by producing extruded base-plates. Through joint R&D, MMI achieved a breakthrough and managed to diversify its customer base to include MKE and Toshiba, while retaining its strong position with Conner (which was subsequently acquired by Seagate).

By 1999, MMI secured 16% of the world market share of base-plate manufacturing for hard disk drives. It now has manufacturing facilities in Singapore, China, Malaysia and Thailand. MMI benefited from the EDB's incentives and assistance for local suppliers. As the first company in Singapore to carry out magnesium casting and machining, it received pioneer status for this project.

The EDB has co-invested with MMI in two ventures – Metal Components Engineering Pte Ltd and Integrated Magnesium Technologies Pte Ltd. The former will enhance MMI's competitiveness by vertically integrating its manufacturing value chain. In addition, MMI will develop new capabilities in magnesium die casting with Integrated Magnesium Technologies. This will help MMI's diversification into other markets.

All the major HDD manufacturers in Singapore participate in the LIUP. A comparative analysis of suppliers to the HDD industry found that a relatively higher proportion of Singapore supplier firms evaluated public policy favourably as compared with those in Penang (Wong 1999: Annex Tables 16-19).[37] Further, the Singapore suppliers evidenced a greater commitment to technological upgrading. In particular, 8 of 13 had established some collaborative relationship with a local university or public R&D institute as compared with only 2 of 15 in Penang (Wong 1999: Annex Table 16).

Finally, McKendrick et al. (2000: 271-3) emphasized Singapore's institutional infrastructure, and indirectly EDB's "one-stop" facilitating role, in developing the HDD industry:

37 See, also, Kok (1993).

> *Our conversations with managers provided many interesting details about why the United States did not hold on to manufacturing longer than it did, and the reasons were not limited to factor costs. Singapore's infrastructure far surpasses that in many American cities. The US regulatory environment can also be cumbersome; and while this sometimes reflects the benefits of checks and balances and worthy concerns such as environmental protection, it may also reflect political deadlock and bureaucratic inefficiencies. For example, American HDD firms can start up within six months in Singapore, faster than many municipal governments take to approve a building application. For industries such as disk drives, in which start-ups and expansions must move quickly if firms are to be successful, such reactions are too slow and inflexible.*

4.2.2. Agency for Science, Technology and Research (A*STAR)

A*STAR's mission is to foster world-class scientific research and develop talent for a knowledge-based economy. Its predecessor, the National Science and Technology Board (NSTB) was established in 1991 to execute the National Technology Plan (1991-95). The Singapore Government views vigorous research and development as essential both to attracting and retaining multinational investors as well as a knowledge base for domestic enterprises (NSTB 1996: 16).

Broadly, the Plan committed S$2 billion to develop a technology infrastructure, including the development of national research institutes and a Science Park, encourage private sector R&D through grants and assistance, and lead manpower development. The Plan included specific targets for national expenditure on R&D, the private-sector contribution to R&D, and the proportion of research scientists and engineers in the workforce (see Table 9).

Table 9: National Technology Plan Targets and Accomplishments

Measure	Target for 1995	Actual 1994	Target for 2000	Actual 2001
R&D intensity (percentage of GDP)	2%	1.12%	1.6%	2.1%
Private sector share of R&D	50%	62.7%	63%	62.5%
Research Scientists & Engineers per 10,000 labour force	40	47.7	65	88*
-- of whom percentage with graduate qualifications	no target	47%	60%	39%

Sources: NSTB (1996); A*STAR (2001); *authors' calculations.

In 1996, the government promulgated a successor National Science and Technology Plan committing S$4 billion over a five-year period (NSTB 1996). The broad objectives of the Plan were to provide scientific and engineering manpower, create a conducive environment for R&D, strengthen Singapore's technological capability, and foster innovation and commercialisation. The 1996 Plan raised the input targets for R&D (see Table 9).

The Plan charted a division of responsibility between the private sector, which would focus on the development, innovation, adaptation, and acquisition of a first tier of near-term technologies, and the public sector (national research institutes and universities), which would focus on the second and third tiers of technologies that would yield economic return only in the medium and long term. Boldly, it declared:

> *by the year 2000, in industry clusters where there is already a significant competitive and technological edge, Singapore should aim to achieve leadership or near-leadership in the key technologies supporting these clusters. Examples … are the data storage and IC packaging technologies.*

With regard to manpower, the 1996 Plan emphasized both development of local talent through scholarships and promotion and aggressive recruitment of foreign nationals. As for the technological capability, the Plan called for further investment in the national research institutes and strengthening linkages between the institutes and the universities and industry. Specifically, funds were allocated to appoint 20 international researchers as Temasek Professors to establish laboratories in Singapore universities. The research institutes were directed to recover a specified percentage of their budgets from industry.

In October 2000, Minister of Trade and Industry George Yeo announced the S&T 2005 Plan, with a total budget of S$7 billion.[38] The Plan outlined five key strategies:

- Focus and strengthen R&D capabilities in niche areas;
- Further encourage private sector research and development;
- Establish a system for effective technology transfer and intellectual property management;
- Recruit global talent and nurture local talent; and
- Develop strong international relationships and networks.

38 Speech by George Yeo, Minister for Trade and Industry, at the Official Opening of the Institute of Materials Research and Engineering (IMRE) Building, 25 October 2000.

Significantly, by contrast with its two predecessors, the S&T 2005 Plan was announced by Minister Yeo at the opening ceremony of a research institute building, rather than in a published document. Consequently, there was no public review of the outcomes of the preceding plan or detailed statement of the new targets, if any. We are not aware of any independent analysis of the efficacy of the previous plans.

Subsequently, the NSTB announced a new focus on "development, nurturing and deployment of research and development manpower". The NSTB was re-structured into two research councils – the Biomedical Research Council (BMRC) and the Science and Engineering Research Council (SERC) – that would co-ordinate and manage public sector R&D.[39]

The NSTB retained S$5 billion of the total S$7 billion budget to fund public sector R&D and development of graduate research manpower. The NSTB transferred a budget of about S$2 billion and the roles of supporting private sector R&D, "technopreneurship," and venture financing to the EDB.[40] In January 2002, the re-organization was completed with the re-naming to A*STAR.[41]

A*STAR and the EDB are key members of a multi-agency initiative to upgrade the technology of local manufacturers. Under this initiative, A*STAR assigns scientists and engineers from its research institutes to approved companies for up to two years. These contribute technical expertise and help businesses build up in-house R&D capability and sharpen their competitiveness. During the attachment, the company pays just 30% of the scientist/engineer's compensation. As of May 2003, a total of 32 scientists had been attached to 25 companies.[42]

'A*STAR hopes that local manufacturers will hire the scientists on a permanent basis and so, strengthen the transfer of technology and capability to industry. From a policy perspective, this mechanism may transfer technology more effectively than licensing or other forms of "disembodied" transfer. The movement of personnel transfers both scientific knowledge as well as the tacit skills that contribute to increasing the "absorptive capacity" of the receiving companies for new technology (Cohen and Levinthal 1990).

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39 Press Briefing: NSTB Chairman Unveils Board's New Focus & Orientation, February 15, 2001.

40 Significantly, in what might be viewed as a reflection of the difficulties in stimulating innovation and entrepreneurship, the Government launched the Technopreneurship 21 (T21) initiative in 1999, even before the second technology plan had been completed. Please refer to our discussion of "Enterprise 21" in Section 4.2.1 above.

41 Curiously, however, the A*STAR includes an entity to commercialise intellectual property, Exploit Technologies Pte Ltd. Exploit's function seems more aligned with the EDB's role.

42 A*STAR Press Release: "Local Enterprises Get Help To Chart Technology Roadmaps For Growth," 29 May 2003.

Evaluation

The first and second national technology plans expressed targets in terms of inputs rather than outputs. Singapore's focus on R&D intensity could be justified by empirical studies linking total factor productivity (TFP) growth and R&D intensity at the national level among OECD countries (Bassanini, Scarpetta and Visco 2000), and at the business level in various countries (Griliches, 1986; Hall and Mairesse, 1995; Wakelin, 2001).

The proportion of research scientists and engineers and the absolute volume of R&D in the economy may relate to the capacity of businesses to absorb new technology. The absorptive capacity of an organization for new technology depends on its involvement in relevant research (Cohen and Levinthal 1990). The presence of trained engineers was a factor in attracting hard-disk drive manufacturers to locate in Singapore (Wong 1999). Most R&D conducted by MNCs in Singapore solves manufacturing-related problems (Amsden et al. 2001).

With regard to outputs, the Ministry of Trade and Industry has studied the macroeconomic return to R&D in Singapore. Between 1978-2001, an additional S$1 spent on R&D generated an increase in GDP of S$0.26 in the short run (one year) and S$0.68 in the long run. At the national level, the internal rate of return on R&D was 20%, which substantially exceeds domestic interest rates (Toh and Choo 2002). However, on another measure – patents, Singapore lags Taiwan and Korea (see Table 10). Nevertheless, Singapore has improved on this measure dramatically in the last 20 years.

Table 10: U.S. Utility Patents Granted per Million Population

2000			1980		
Rank	Country	Per million pop	Rank	Country	Per million pop
1	US	308.7	1	Switzerland	189.7
2	Japan	246.6	2	US	165.9
3	Taiwan	210.3	3	Japan	101.3
4	Switzerland	182.1	4	Sweden	94.4
5	Sweden	177.2	5	Germany	85.1
12	Korea	70.1			
19	Singapore	54.3	18	New Zealand	15.2
23	New Zealand	28.0	26	Singapore	2.4

Source: WEF, 2002.

Finally, is government R&D funding well targeted? Table 11 reports the various measures of the return from R&D at the business level. The data suggest that government funding has been targeted well. However, it does not address the question of whether government R&D funding simply crowds out private-sector expenditure, particularly on a selective basis.

Table 11: Singapore: Returns to Business-Level R&D, 1996-2001

	Short-run Contribution to Business Value-added (%)	Long-run Contribution to Business Value-added (%)	Internal Rate of Return
Businesses with substantial government R&D funding	0.043	0.141	19.8%
Those without	0.039	0.127	13.5%

Source: Toh and Choo (2002)

4.2.3. Standards, Productivity, and Innovation Board (SPRING)

SPRING is the successor to the Productivity and Standards Board (PSB), which in turn succeeded the National Productivity Board. The National Productivity Board started as the National Productivity Council in the late 1970s. The mission of SPRING is to raise productivity and so enhance Singapore's competitiveness and economic growth. More particularly, SPRING is dedicated to achieve an average TFP growth of 2% annually for the next 10 years.

Singapore has always been concerned about productivity. However, the views famously expressed by Alwyn Young and Paul Krugman in the early 1990s about Singapore's poor total factor productivity growth (see section 6 of this report) led to a new focus on SME productivity.

The Government's key concern is that the low value added and productivity growth among small and medium-sized enterprises (SMEs) has held back the entire nation's growth (see Table 12). Referring to Table 13, Singapore's SMEs are relatively passive by contrast with Taiwan's more dynamic SMEs, which operate in a larger domestic economy (Lee-Tsao and Low 1989; Toh and Ng 2002). They have been characterized as being bound by a subcontracting mind-set.

It may be argued that SMEs face a shortage of investment funding. However, the EDB's 1989 SME Masterplan and PSB's SME21, and earlier small industry financing schemes, had low take up rates. This is due to the culture and practice of family-owned businesses, which are reluctant to show their books and accounts to satisfy banks and government agencies.

Top university graduates prefer careers in MNCs, Government-linked companies, and the government to being entrepreneurs (Lee-Tsao and Low 1989). An extreme view is that, given its small domestic market and limited abilities, absorption of entrepreneurial talents in GLCs and MNCs and the parochial culture of local entrepreneurs, Singapore SMEs would do no better in the new economy than they did in the old economy unless the government's prodding and schemes work (Lian 2001).

Table 12: Domestic Enterprises

	Value Added per Worker (S$ '000)						
	1994	1995	1996	1997	1998	1999	2000
SMEs	49.5	50.6	52.2	50.5	47.3	51.0	55.5
Large domestic enterprises	98.2	101.2	101.1	104.8	102.6	114.9	129.9

Source: SPRING

Table 13: SMEs in Taiwan and Singapore in Terms of Relative Base

	Population	SMEs '000	SMEs per 1000 people	People per SME
Taiwan	20	743	37.1	26.9
Singapore	3	69	23.0	43.5

Source: Hall (1995)

Institutionally, the EDB has provided a one-stop service for MNCs and larger local enterprises. SPRING aims to serve the same role for SMEs with three key thrusts:[43]

- Broad-based assistance;
- Enterprise upgrading; and
- Domestic cluster development.

SPRING mentors SMEs to map out strategic directions and implement best practices, and assists them with business development and technology enhancement. It administers a number of schemes to provide financial assistance to SMEs, defined as businesses with at least 30% local equity, and whose parent group fixed assets do not exceed S$15 million, and parent group employment does not exceed 200.

43 SPRING has assumed the responsibilities of the EDB's Small Enterprise Bureau.

The Local Enterprise Finance Scheme (LEFS) supports SMEs in expansion and development of new capabilities through loans of up to S$15 million at fixed interest rates. The LEFS started as small industry finance after the first oil-induced recession in the mid-1970s and gradually gained momentum as SMEs came into focus with the passing years. The loans may be used to expand or upgrade factory premises or machinery, or augment working capital, or factor receivables. The scheme is administered through approved private-sector financial institutions from funds provided by the Government. The rationale for using the banks is that they have better expertise in credit checks and monitoring. The Micro Loan Programme offers similar financing of up to S$50,000 to very small local enterprises (with no more than 10 employees).

In September 2002, SPRING established the Loan Insurance Scheme (LIS) to complement the LEFS. Participating financial institutions use their own funds and have discretion over the interest rates. The government subsidizes the premium for credit risk insurance. The scheme was launched with capacity for S$30 million of loans annually for five years. With the subsidy and more flexibility to package loan facilities according to each borrower's risk profile, SPRING envisaged that 1,500 SMEs would receive financing through the scheme.

The Local Enterprise Technical Assistance Scheme (LETAS) supports SMEs in engaging consultants to advise on modernising and upgrading their operations. The scheme subsidizes up to 70% of the cost of the consultancy fees. It is administered jointly with various other agencies with functional responsibility for particular sectors of the economy – the Building and Construction Authority, the EDB, International Enterprise Singapore, JTC Corporation, Ministry of Community Development and Sports, and Singapore Tourism Board.

A particular LETAS initiative targets the application of information technology (IT) to upgrade local enterprises. LETAS subsidizes consultancies for IT implementation and e-commerce.[44] Another LETAS initiative promotes business-format franchising as a way to grow a successful business. LETAS subsidizes consultancies to develop franchise systems.

SPRING promotes knowledge and skills learning as a continuous, lifelong process. The Industry Capability Upgrading Programme Consultancy Assistance Scheme subsidizes up to 90% of consultancy fees to prepare a 3-year plan that results in at least 50% of the workers in the industry acquiring certifiable skills through new or enhanced training courses.

44 In April 2001, Infocomm Development Authority of Singapore (IDA) transferred responsibility for the Local Enterprise Computerisation Programme to SPRING, which merged it into LETAS.

Launched in 1993, the OJT 2000 plan promoted structured on-the-job training (OJT). By 2000, the plan succeeded in raising company participation from 20% to over 60%, with over 300,000 workers trained. The successor plan, OJT 21, was launched to encompass both theory and practice in training, and encourage companies to certify their OJT courses through the National Skills Recognition System or other certifying agencies. The Skills Development Fund (SDF) subsidizes training in broad-based skills at S$2.50 per trainee hour and critical high-end skills at S$6-10 per trainee hour.[45]

In 1998, the Critical Enabling Skills Training (CREST) scheme was launched to prepare the workforce for a knowledge-based economy. It emphasizes seven core skills:

- Learning to learn;
- Literacy;
- Listening and oral communication;
- Problem-solving and creativity;
- Personal effectiveness;
- Group effectiveness; and
- Organisational effectiveness and leadership.

The SDF subsidizes 90% of approved CREST course fees for company-sponsored employees subject to a cap of $10 per trainee hour. As of March 2003, over 2,200 organizations had implemented CREST with over 178,000 training places.

SPRING actively seeks opportunities to organize SMEs into groups for greater efficiency. Broadly, the opportunities are to undertake activities such as bulk purchasing and training on a joint basis through a single management company, organizing SMEs in close proximity to share facilities, and organizing SMEs in related trades to conduct joint advertising and promotion.

45 We elaborate on the Skills Development Fund below in section 4.3.

Evaluation

While there may be some conceptual justification for financial assistance to SMEs (capital market imperfections), in some degree, SPRING exists simply to level the playing field towards local enterprises that are too small to warrant EDB's attention. Indeed, Alwyn Young (1994) observed that the EDB and other government incentives were all geared to pander to multinational corporations while SMEs were almost second-class citizens.[46]

We discuss the rationale for promotion and subsidization of worker training below in section 5.3.

4.3. SKILLS AND TALENT

In a country with no natural resources, the foundations for growth have been human resources, capital, and increasing productivity. The Singapore Government has multiplied the human resources contribution to economic growth through education and a very focused foreign labour policy. Historically, the Government has allocated the largest shares of the national budget to education and defence (see Table 14). In the transition from labour and capital intensive activities to a knowledge-based economy, education has become a key imperative.

Table 14: Singapore: Budget Allocation

	1997	1998	1999	2000	2001	2002	2003
Budget (S$billion)	23.90	27.20	29.20	29.00	28.05	28.33	29.92
Percent to education	19.7	21.0	19.5	20.7	22.4	24.0	21.9

Source: Ministry of Finance

4.3.1. Education

The Ministry of Education oversees Singapore's national educational system, which consists of three tiers:

- Free, compulsory primary education for up to 7 years leading to a common national examination, the Primary School Leaving Examination;
- Free, non-compulsory secondary education for up to 5 years, in an academic stream that leads to the Singapore-Cambridge General Certificate of Education at the 'Ordinary' level or a technical stream that leads to the Certificate at the 'Normal' level; and then

46 See Lee and Low (1989), chapter 3 on State Entrepreneurship, pp 143-75 and Low (2002).

- Highly subsidized tertiary education at a university (following two years of pre-university education), polytechnic, or technical institute.

The medium of instruction is English for most subjects. The Singapore Government has continued the colonial practice of subjecting school-leavers to a national examination administered by the Cambridge University Local Examinations Syndicate. With this international qualification, they can apply to tertiary institutions worldwide.

The government has invested heavily to enhance the quality of the school system, through recruitment of more teachers and improvement of the physical and ICT infrastructure. It has further set a target of developing Singapore's universities into world-class institutions in part through collaborations with selected international institutions including MIT, Georgia Institute of Technology, Technical University of Eindhoven and Technical University of Munich.[47]

The two comprehensive universities – National University of Singapore and Nanyang Technological University – play a major role in the public-sector R&D effort in conjunction with A*STAR research institutes. The National University aims to the status of a leading North American public research institution. In January 2000, a third institution – the Singapore Management University – was established. The new university explicitly adopted a North American educational model.[48]

In technical education at the tertiary level, five polytechnics offer diploma programmes in a range of disciplines from engineering to business and media.[49] Republic Polytechnic admitted its first batch of students in 2003. The Institute of Technical Education provides tertiary-level vocational education. It comprises 10 regional centres that provide both full-time education and part-time training in support of continuing education and training initiatives of other ministries.

The government has always been very clear as to the objective of education. Tertiary-level enrolments have been carefully regulated to ensure a balanced mix of graduates, in line with demand-side estimates based on projected GDP and productivity growth.

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47 Certainly, funding collaborations with leading international institutions is merely the first step towards establishing world-class universities. The strategic intent is that through joint activities, Singapore universities will learn institutional practices as well as directly benefiting from research and teaching collaboration.

48 We are not aware of any published analysis which indicates the reasons for this decision on direction in terms of the educational model. However, the Prime Minister has spoken of transforming Singapore into the "Boston of Asia". From this it seems that the Singapore Cabinet holds the view that the US model of higher education is the one to emulate (see http://www.bc.edu/bc_org/avp/soe/cihe/newsletter/News19/text4.html).

49 In the 1980s, the EDB responded to a perceived gap in the educational system by establishing three specialized technical institutes (the German Singapore Institute, French Singapore Institute and the Japan Singapore Institute) to provide training in electronics and engineering. Subsequently, these were merged into Nanyang Polytechnic.

In particular, the Singapore Government has always exhibited a bias towards science and engineering education. A committee chaired by Minister of State Ng Eng Hen reiterated the need for this slant in order to avoid shortages of technical manpower experienced by other developed countries, and also to ensure a resilience in supply (technically-trained persons could more easily switch to non-technical jobs than vice versa) (Ministry of Education 2003).

Training and Continuing Education

From early on, the Singapore Government recognized that a major structural weakness was the relatively low educational attainment of the population. The Ministry of Manpower (which succeeded the Ministry of Labour) oversees training and continuing education to serve the individual worker. The Ministry's programmes initially targeted the less well-educated workers, but following the Asian Financial Crisis, which introduced "white-collar unemployment," the Ministry has also sought to help the better educated.

As of 2002, 19% of the workforce had primary education or less, and a further 42% had secondary education or less (see Table 15). The Basic Education for Skills Training (BEST) scheme gives working adults a primary-school education in English language and mathematics. The next level of continuing education is Worker Improvement through Secondary Education (WISE), which educates working adults up to the equivalent of secondary school in English and mathematics. BEST and WISE are administered by the Institute of Technical Education.

Table 15: Singapore: Educational Profile of Employed Persons (%)

	1996	1997	1998	1999	2000	2001	2002
Primary and below	24.8	23.4	22.3	21.7	24.9	19.8	19.1
Lower Secondary	14.0	16.0	15.2	15.4	12.9	14.1	13.9
Secondary	30.7	28.7	28.5	27.9	25.3	28.1	28.2
Post secondary	11.6	10.1	10.0	9.8	9.9	10.5	11.1
Diploma	7.4	9.2	9.9	10.3	11.9	10.6	9.8
Degree	11.6	12.7	14.1	14.8	15.1	17.0	17.8

Source: SPRING

Table 16: New Zealand: Educational Profile of Employed Persons (2001)

Highest Qualification	% of Employed Persons
No Qualification	21.0%
Secondary	40.1%
Vocational	24.2%
Degree	14.7%

Source: 2001 Census, Statistics New Zealand.

Several initiatives address changes in the labour market arising from structural changes in the economy as a whole. The Skills Redevelopment Programme was established by the EDB and the National Trades Union Congress (NTUC) in 1996. It subsidizes training at up to a maximum of 90% of the course fee subject to a cap of S$10 per hour and also pays the employer S$6.10 per hour during the employee's absence. The Programme pays higher subsidies for workers over 40 years old who do not have tertiary education.

The Programme extends to unemployed persons, providing a similar subsidy for course fees and an hourly training allowance. Upon completion of the training, the trainees must accept offers of employment arranged by the training sponsor and remain with the same employer for at least 6 months. The Programme includes over 900 approved courses provided by 100 training institutions in occupations and fields ranging from childcare to chemicals and tourism. It is managed by the NTUC.

The Ministry of Manpower supports special initiatives to place workers in industries and functions that are subject to labour shortages. At the time of writing, these included aerospace and call centres. More generally, the three-year National Information Technology Literacy Programme**,** established in 2001, equips Singaporeans with basic ICT skills, and so enhances their employability and quality of life. It is managed by the Infocommunications Development Authority (IDA).

While the Skills Redevelopment Programme focuses on lower-income workers, the Strategic Manpower Conversion Programme targets the higher end of the workforce. It subsidizes course fees and pays allowances to encourage employers to convert new hires and existing employees to functions in short supply. This Programme also extends to unemployed persons.

At the time of writing, Programmes had been established for logistics, social services, info-communications and e-learning, and internationalisation. In 2000, the Ministry of Manpower and IDA launched the Programme for info-communications to convert 300 professionals to jobs in programming, systems analysis, networking, database administration, and consultancy. The Programme subsidized 50% of course fees up to S$4,000 and provided a $40 daily training allowance.[50] In 2003, the Ministry and International Enterprise Singapore launched a Programme in international business to train 400 executives over three years.[51]

The Self-Employment Training Programme aims to equip individuals with the background and basic skills to start and run a business. The introductory courses explain the issues and risks involved in starting a business. The following courses teach general business skills. The Programme is managed by the Singapore National Employers Federation.

The Ministry finances SPRING initiatives BEST, WISE, and CREST and its own skills Redevelopment Programme from the Skills Development Fund (SDF). The SDF was established in 1979 to fund worker upgrading and is financed by a levy on the earnings of low-wage employees. Currently, the levy is 1% of the earnings of workers whose monthly earnings are S$1,500 or less.[52] Table 17 sets out some brief budgetary information for the SDF.

Table 17: Skills Development Fund Annual Income and Expenditure

	1998/1999	1999/2000	2000/2001	2001/2002
Annual Income (S$ million)	38.8	33.9	46.2	65.5
Annual Expenditure (S$ million)	50.5	62.3	71.2	78.1

Source: Skills Development Fund Annual Reports.

The preference of the Singapore Government is that the private sector "champions" or takes charge of programmes, to take advantage of the private sector's superior information and to improve the image and marketing of the programmes.

50 "MOM and IDA to Launch Pilot Phase of Strategic Manpower Conversion Programme in Infocomm Sector," Press Release, 26 April 2000.

51 Speech by Mr Tharman Shanmugaratnam, Senior Minister of State for Trade and Industry and Education, at the launch of the Strategic Manpower Conversion Programme for Internationalisation, on 29th January 2003.

52 When the SDF was first established, the levy was set at 4%. With the 1985 recession, the levy was lowered to 2% in April 1985, further to 1% in April 1986. For the period October 1979 to March 1995, the skills development levy ceiling is at S$750, the minimum contribution is S$2.

Evaluation

Many empirical analyses have demonstrated the economic value of primary and secondary education.[53] Moreover, the government provides free primary and secondary education to school age children. Accordingly, it is regarded as fair to subsidize primary and secondary education for adults.

Further, employers may not invest sufficiently in worker education and training to the extent that they cannot appropriate the full marginal returns from the investment. Until very recently, Singapore has experienced very low unemployment, and consequently, employers have complained of "job-hopping" by workers. A worker switching employers would take along the previous employer's investment in her or his human capital to the new employer.

Accordingly, government intervention may be justified. It is worth noting that the subsidies for the redevelopment and conversion programmes are tied to the trainees completing six months' of employment after training. Hence, these programmes certainly yield better value for money than pure welfare schemes.

In practice, the participation of smaller businesses in the various worker training programmes is relatively low compared with larger enterprises. Hence, in effect, smaller businesses subsidize the training costs of larger enterprises through the SDF.

4.3.2. Immigration

Consistent with Singapore's origin in colonial times, the present government views the purpose of immigration as to augment the domestic supply of human resources, and particularly, skills and talent in short supply. By contrast with other developed countries, Singapore immigration policy accords relatively little regard to family re-unification. For instance, a man who marries a Singapore woman does not automatically gain right of entry.

Table 18 contrasts the desired national skills profile (as based on the projected industrial structure) and the actual situation. The desired profile consists of 65% in the skilled category, comprising 25% with degrees, 20% with diplomas and 20% with post secondary certification. The imbalance can be met by increasing the educational level of local workers or by importing foreign talent.

53 See Psacharopolous, George, (1994), "Returns to Investment in Education: A Global Update," *World Development*, Vol 22, No 9, pp 1325-43 and Psacharopolous, George and Patronis, Harry, Anthony, (2002), "Returns to Investment in Education: A Further Update," *World Bank Policy research Working Paper 2881*, September.

Table 18: National Skills Profile

Skills profile	1988	1998	Desired profile, 2008-2013 years
Skilled (post-secondary education)	19	34	65
Semi-skilled (secondary education)	31	28	20
Unskilled (less than secondary education)	50	38	15
Total	100	100	100

Source: Report on Labour Force Survey of Singapore; MOM, 1999, p 11.

Employment of foreign workers on a short-term basis is an effective safety valve that can be switched on or off according to macroeconomic conditions. In 1999, the Ministry of Manpower revealed that the workforce included 450,000 foreigners on work permits and 80,000 with employment passes, representing 28% of the total workforce.[54]

In 1992, the EDB launched the Singapore International Manpower Programme to attract foreign professionals and managers. The 1996-2000 National Science and Technology Plan even set out explicit targets for the recruitment of foreign nationals to augment the domestic supply.

However, following the Asian financial crisis, in 1998 the government revised its immigration policy to be more selective, targeting particular groups such as technopreneurs. It formed the Committee on Singapore Talent Recruitment to develop and implement strategies to attract and retain foreign talent.

Immigration policy distinguishes among highly skilled, professional, and tertiary-qualified foreigners according to their monthly income, qualifications, and skills. They are assigned to four grades of employment pass. Depending on the grade, the incoming foreigner may be accompanied by spouse, children, and even parents and in-laws. See Table 19.

54 *Business Times* 26 July 1998; *Straits Times* 20 May 1999; MOM 1999.

Table 19: Foreign Workers

P	Professionals, managers, administrators, investors, entrepreneurs , world class artistes, musicians Privilege: Dependants passes for spouse, children; long term passes for parents, parents-in-law P1: Those earning over S$7000 monthly[55] P2: Those earning over S$3500 up to S$7000 monthly
Q	Skilled workers, technicians, specialised skills Q1: Monthly income over S$2500; at least five O levels or full NTC2 certificate Privilege: Dependants passes for spouse, children Q2: Those not meeting Q1 income and educational requirements for exceptional; cases. Holders not allowed dependants passes for spouse, children
R	Semiskilled and unskilled R1: Those with NTC3 practical certificates or suitable qualifications; employers pay monthly FWL S$100 R2: Unskilled, employers pay full FWL for two-year work permit holders R pass holders cannot bring in immediate family, subject to security bond and medical examination for two-year work permit holders

Source: Ministry of Manpower; Low (2002a and 2002b)

In the aftermath of the Asian financial crisis, Government-linked companies, including DBS Bank, Chartered Semiconductor, Neptune Orient Lines, and the Singapore Exchange made headlines by recruiting foreign talent to head their organizations. Large compensation packages, lucrative by local standards, were justified as being necessary to match international norms.

The recruitment of foreign talent extends to generous scholarships for foreign undergraduate and graduate students at the universities. The government directly recruits middle school students from China to continue their education in Singapore. Government-linked companies including Singapore Airlines offer undergraduate scholarships in India as part of the larger national effort to recruit foreign talent. All foreign students in universities and polytechnics qualify for loans to cover tuition and living expenses.

55 Equivalent to approximately NZ$6,800.

By contrast to the welcoming approach to professional and educated foreigners, the government tightly regulates the import of skilled and semiskilled foreign workers. The system combines a levy on the foreign worker's earnings and industry quotas on employment of foreign workers. Work permits for foreign skilled or unskilled workers are tied to a specific employer and occupation and generally are valid for two years only. There are special arrangements for foreign construction and domestic workers.

In January 1999, in response to the Asian financial crisis, the government reduced the foreign worker levy for skilled workers to reduce business costs and persuade businesses to remain in Singapore. The government lowered the foreign worker levy still further for particular sectors.[56]

Evaluation

The Ministry of Trade and Industry analysed the contribution of the foreign workforce to Singapore's growth (Tan et al., 2001). Table 20 reports the shares of GDP growth attributable to foreigners holding employment passes and work permits. In the period 1991-2000, foreigners on employment passes began to be admitted in substantial numbers, rising to 80,000 by 1999. Accordingly, their contribution to GDP growth increased sharply to almost 37%. However, the contribution of foreign work permit holders remained very low.

Table 20: Growth Contribution

		% of GDP Growth Attributable to Each Factor				
	GDP growth (%)	Capital	Local labour force	No. of employment pass holders	No. of work permit holders	TFP
1986/Q1 to 1990/Q4	8.46	13.0%	15.4%	5.3%	1.9%	64.4%[57]
1991/Q1 to 2000/Q4	7.79	26.5%	14.1%	36.9%	3.8%	18.8%
1986/Q1 to 2001/Q2	7.82	22.3%	15.1%	27.5%	3.2%	31.9

Source: Tan et al. (2001)

56 The 2003 Budget extended the reduced levy until the end of 2003.

57 To explain: of 8.46% pa growth in GDP, 5.44% (=64.4% × 8.46%) is attributable to growth in total factor productivity.

In 1999, Singapore admitted 450,000 work permit holders, representing about 25% of the workforce. They present the recurring issue of whether the admission of foreign unskilled and low-skilled workers has retarded the economy's shift to more capital-intensive modes of production and delivery, and to higher-valued added activities.

Moreover, the increase in the contribution of (highly skilled) employment-pass holders in 1991-2000 coincided with the observed drop in the contribution of TFP to GDP growth from over 64% to under 19%. This presents another issue: did "foreign talent" with the immediate and requisite skills substitute for a longer-run TFP increase?

There is also some concern in Singapore about a "brain drain". In 1999, Prime Minister Goh Chok Tong raised the issue of building "heartware" in more avenues for citizens to participate in the nation's affairs, which he expanded in 2000 by describing the new divide in society as "cosmopolitans" (those who are English-speaking, skilled and globally oriented) and "heartlanders" (those living in public (HDB) housing and domestically grounded).[58] He alluded to the "cosmopolitans" as being "quitters" when they migrate, while "heartlanders" are basically "stayers".

4.4. GLOBAL CONNECTIONS

Singapore's first move to establish a global people network was a joint initiative with the private sector. The Singapore International Foundation was established in 1991 with the mission: "To enable Singaporeans everywhere to think globally, feel Singaporean, be responsible world citizens and foster friendships for Singapore".

The Foundation supports relief work, development projects, and volunteer work by Singaporeans in foreign countries. Youth projects have included providing healthcare and school development in the ASEAN region, China and India. Experienced professional volunteers teach English, mathematics, ICT literacy, and vocational skills as volunteers in ASEAN countries.

The Foundation also aims to foster a sense of national identity and kinship among Singaporeans around the world by drawing them into a network of joint projects, dialogue, and sharing of ideas. The Foundation supports 85 overseas Singapore clubs and also works with Singapore Student Associations in foreign countries. While the Foundation is private, it receives over 90% of its funding from the government.

58 Singapore Government Press Release, 4 October 1999 and 19 March 2000, respectively.

Subsequently, the Singapore Government established Contact Singapore, an international network of contacts for foreign talent and overseas Singaporeans interested in working or studying in Singapore. Previously undertaken by the EDB, this outreach role includes general overseas marketing and promotion of opportunities in Singapore.

Just as the EDB provides a one-stop service for foreign investors, Contact Singapore provides a one-stop centre for people, providing information on immigration, housing, education, taxation, and other aspects of work and life in Singapore. By contrast with other agencies, Contact Singapore does not have the remit to provide financial incentives.

For Singapore employers and educational institutions, Contact Singapore provides recruitment and promotion services through its overseas offices. Its larger responsibility for promoting the "Singaporean overseas network" overlaps with the mission of the Singapore International Foundation.

Assessment

Over 10 years after the foundation of the Singapore International Foundation, the overseas Singaporean network seems weak. One possible reason is that many Singaporeans emigrate because of dissatisfaction with particular aspects of the country – the stringent educational system, compulsory military service, "top-down" nature of government, and the high cost of living. These emigrants would rather assimilate quickly into their new homes, than maintain a distinctive Singaporean identity.

4.5. BRANDING

Singapore does not explicitly project an international brand. In 1997, Deputy Prime Minister Tony Tan launched a "Singapore Inc." website as the virtual point of entry for foreign businesses and investors.[59] Besides that, the closest to a broad-based national effort are the promotions of the Singapore Tourist Board and Singapore Airlines. Singapore lacks large-scale businesses or organizations with wide international footprints such as Nokia, Nestle, Coca Cola, or the International Committee for the Red Cross.

The Tourist Board advertises Singapore throughout the world. However, it emphasizes the diverse cultures and good-value shopping, neither of which relate to the transition to a knowledge-based economy. The Board itself does not even seem to have decided on a national icon, be it the Merlion, the city skyline, or the new Esplanade on the Bay.

59 Speech by Dr Tony Tan Keng Yam, Deputy Prime Minister and Minister for Defence, at the Launch of the Singapore Inc website held on Tuesday, 11 March 1997 at 9.00am at the NCB Auditorium.

Singapore Airlines is hailed internationally for providing a consistently high standard of service. However, it has built this reputation on "the Singapore girl" which may be perceived as being sexist and does not contribute to the image of growth and innovation.

The most widely sold technological product originating from Singapore is probably Creative Technology's soundcard.[60] However, Creative soundcards are not widely associated with Singapore in the same way as say, Nokia mobile phones are associated with Finland.

"Singapore Inc." has projected itself selectively, and quite possibly, more cost-effectively through business channels. One notable mechanism is the international panels that provide strategic counsel to various sectors and agencies. For instance, the EDB's International Advisory Council includes the Chief Executive Officer of Agilent Technologies Inc., the Chairman of the Board of Asahi Glass Co. Ltd, the Chairman of the Board of Executive Directors of BASF Aktiengesellschaft, and the Chief Executive Officer of Rolls-Royce Plc.

The Singapore Government's International Academic Advisory Panel includes the Vice Chancellor of the University of Cambridge, the Provost of MIT, a Managing Director of Sutter Hill Ventures, and the Chairman of the Executive Committee of the Lockheed Martin Corporation.

Regular meetings of these panels provide an opportunity for Singapore Government leaders to learn from international business and academic leaders, as well as a hospitable environment for these persons to interact among themselves.

Within Singapore, there is a concerted effort to celebrate and recognize enterprise and innovation. Beginning in 1995, the EDB has annually recognized the "Enterprise 50" list of the most enterprising and promising homegrown businesses. More than 50 of the Enterprise 50 companies have since matured to public listings, and some have expanded successfully into international markets. Various groups, including the Association of Small and Medium Enterprises with the Rotary Club, Ernst and Young, and Business Times with DHL confer awards for the Entrepreneur of the Year.

Several government agencies together with Cap Gemini Ernst & Young, Fortune Magazine, and the Straits Times bestow the Singapore Innovation Award. A*STAR confers the National Science Award and National Technology Award to recognize accomplishments in fundamental and applied research respectively. SPRING bestows the Singapore Quality Award, the People Excellence Award, and the National Productivity Award.

60 A soundcard is an add-on board for a PC that can record and play back digital audio, and is standard in most PCs.

We believe that there is now a considerable awareness of the opportunities in entrepreneurship and innovation and aspiration towards creating businesses and careers in science and technology.

4.6. SECTORAL INITIATIVES

The 1996 National Science and Technology Plan identified three technology clusters as being of strategic importance to Singapore's future economic development:

- Biotechnology and environmental technology;
- Electronics and manufacturing technology; and
- Information technology.

4.6.1. Biomedical Sciences

The 1996 National Science and Technology Plan pointed to "Biotechnology and Environmental Technology" as a strategic cluster and also identified the Ministry of Health (as overseer of the National Medical Research Council) as playing an important role. Subsequently, A*STAR and the EDB have changed the emphasis to "Biomedical Sciences," with the cluster comprising the pharmaceutical, medical technology, biotechnology, and healthcare services industries.

The former NSTB invested heavily in research into biomedical sciences, supporting three research institutes – the Institute of Molecular and Cell Biology, the Institute of Molecular Agrobiology, and the Bio-Processing Technology Centre – in addition to R&D in the universities and private sector.

Following the institutional re-organization, A*STAR further cemented the national commitment to biomedical sciences by forming the Biomedical Research Council on an equal basis with the Science and Engineering Research Council. Within two years, A*STAR established three new research institutes – the Genome Institute of Singapore, Bioinformatics Institute, and the Institute of Bioengineering and Nanotechnology. Consistent with the new strategic direction to emphasize "red" as contrasted with "green" biology, A*STAR dissolved the Institute of Molecular Agrobiology.

The EDB has targeted biomedical sciences as one of the strategic clusters for Singapore's future economic growth. In 2002, the cluster accounted for S$9.7 billion manufacturing output (7% of the total), and S$6.5 billion of value-added (18% of the total). Most attractive from the national viewpoint is the S$905,000 value-added per worker, compared with the average of S$109,700 for the manufacturing sector as a whole.[61]

61 EDB website, http://www.sedb.com; *Economic Survey of Singapore 2002*, Statistical Appendix.

Working closely with A*STAR and other agencies, the EDB aims to develop Singapore as a centre for upstream activities beyond manufacturing including R&D, testing, and trials. The government has made considerable investments in the infrastructure for the cluster, including in the intellectual property rights framework, research talent and a skilled workforce, research support, facilities for testing and trials, and venture funding. To date, Eli Lilly and Novartis have established research centres in Singapore.

Case Study: Institute of Molecular and Cell Biology (IMCB)

The IMCB was established in 1987 adjacent to the science and medical faculties of the National University of Singapore. Beginning with 38 scientists, it has grown to an international research staff of 400. IMCB focuses on cell biology, developmental biology, structural biology, genomics, and infectious diseases.

IMCB has been successful in attracting international talent and performing scientific research. Sir David Lane, Chairman of the Institute's Scientific Advisory Board, claims that, "the Institute has become recognised internationally as one of the world leading centres for biological research".[62]

Led by Sydney Brenner, the IMCB and the Joint Genome Institute of the U.S. Department of Energy formed a consortium to sequence the genome of the fugu fish. In a major scientific accomplishment and important milestone in rational genome analysis, the Fugu Consortium announced the draft sequence on October 26, 2001, and subsequently published it in *Science*.[63]

The Institute's commercial impact is less clear. Its *2002 Annual Report* declares that, "IMCB scientists have published over 900 research papers in top international journals and filed *several* patents" (emphasis added).[64] More promising is MerLion Pharmaceuticals, a spin-off from a S$60 million joint venture established in 1993 with GlaxoSmithKline and the EDB. The joint venture had established a milestone of 1.3 million assays per year from multiple drug screens of natural sources, including micro organisms, plants, and marine invertebrates. These yield 20-30 novel compounds as leads for the development of new medicines.

62 Institute of Molecular and Cell Biology, *Annual Report 2002*, page 3.

63 *Science*, 297: 1301-10, 2002.

64 Institute of Molecular and Cell Biology, *Annual Report 2002*, page 50.

4.6.2. Information Communications Technology (ICT)

Early on, the Singapore Government identified ICT as important to the country's future development and achieved substantial success applying ICT in an enabling role. In 1981, the government established the National Computer Board (NCB) to computerize the civil service and statutory boards. Subsequently, the NCB's role was expanded to promote information technology throughout the country. In August 1991, the NCB published IT2000, a plan to propel the nation towards the "vision of an Intelligent Island".

Then NCB Chairman Lim Swee Say declared, "We want to be not just one of the most computerised nations, but one of the best computerised nations in the world by the year 2000".[65] The NCB provided substantial incentives to promote the adoption of ICT. In 1995, it launched a S$200 million Cluster Development Fund to accelerate the deployment of IT2000 applications. Within two years, S$75 million had been committed to support 55 projects in such diverse sectors as education, law, healthcare, manufacturing, logistics, and construction.[66] A further $45 million was committed the following year.[67]

In 1996, the NCB, Telecommunication Authority of Singapore, and National Science and Technology Board jointly financed the establishment of Singapore ONE, a national broadband network. The agencies intended that the broadband infrastructure would enable the provision of data-rich applications and services to Singapore and the region.

65 Release of National Computer Board Annual Report 1995/1996, 27 November 1996.

66 Release of National Computer Board Annual Report 1996/1997, 28 October 1997.

67 Release of National Computer Board Annual Report 1997/1998, 15 October 1998.

Table 21: ICT statistics: Singapore, New Zealand, Korea

	Singapore			NZ		Korea	
	Jan-00	Jun-01	Jun-02	Jun-00	Jun-02	Jun-00	Jun-02
Computers per Capita	48.3/100			36.2/100		23.8/100	
Access to home computer	59%			40%	49%	57%	70%
ISP Accounts per 100				14.0		23.2	
Households	42%				16.7		18.9
Broadband Connections per 100				0.5	1.1	13.2	19.1
Of population 10+		34%	42%				
Use of e-commerce	$1.17 billion	$2.75 billion					
Share of total commerce						8.1%	
Websites/1000				10.5	15.3	6.6	11.0
Secure servers/100,000	12.5	12.9		12.65	25.5	0.52	1.2
Internet hosts/1000				92.6	109.1	10.8	8.7
Domain name registrations/1000				17.7	28.8	10.5	10.1

Source: Bronwyn Howell, ISCR.

Table 22: Comparative ICT Statistics, 2000

	Singapore		New Zealand		Korea		Taiwan	
	Rank	Value	Rank	Value	Rank	Value	Rank	Value
Computers per 100 pop	4	48.3	12	36.0	25	19.0	23	22.5
Internet users per 10,000 pop	13	2986.8	21	2166.7	6	4025.4	16	2812.6
Internet hosts per 10,000 pop	13	437.6	6	900.9	32	84.1	12	492.3
Cellular phones per 100 pop	9	68.4	27	40.3	19	56.7	1	80.3

Source: WEF, 2002, pp 384-6.

Table 21 and Table 22 show that New Zealand appears to: lag Singapore in internet use; is in the middle of the pack in terms of computers per head of population and seems to be out-performing Singapore in terms of the number of secure servers and internet hosts. However, this is only half the story. In the next section, a case study of Singapore ONE, evidence is provided which suggests that while a greater proportion of the population have Internet access in Singapore than in New Zealand, the Internet is not being used any more intensively in Singapore. In other words, greater infrastructure penetration may not be translating into greater use. This raises questions about the value of subsidising the rollout of infrastructure, at least in urban areas where there appear to be adequate incentives for private firms to invest.

In 1999, recognizing that digital technology had led to the convergence of information technology and telecommunications, the government merged the NCB with the Telecommunication Authority of Singapore to form the Info-Communications Development Authority (IDA). The IDA promotes the adoption and use of ICT and is the sector-specific regulator for telecommunications.

With regard to ICT as a business in itself, the Singapore Government has certainly tried hard. In January 1998, the NCB and the EDB jointly established a S$500 million Innovation Development Scheme to subsidize new products and processes in the ICT and related industries.[68] Adopting the EDB-SPRING model, the IDA established the Infocomm Local Industry Upgrading Programme (iLIUP) to develop the local ICT industry by leveraging business relationships with MNCs. At time of writing, the iLIUP involved 22 MNCs and more than 200 Singapore enterprises.[69]

Singapore has been relatively successful in creating hardware, including embedded systems. A major success story is Creative Technologies, which dominates the world market for soundcards. However, Creative operates under the constant threat that multimedia chips will render soundcards obsolete. In 2000, a Singapore team won an internal Hewlett-Packard competition to develop the company's Jornada line of handheld computers.[70]

The country has been less successful in software and services. In 1998, the NCB's R&D division was merged with another entity to form a national research institute, the Kent Ridge Digital Laboratories. At the opening of the new institute, Deputy Prime Minister Lee Hsien Loong highlighted two start-ups – New Alloy Media and AsiaWorks. At the time of writing, neither could be located through an Internet search.

Case Study: Singapore ONE[71]

Singapore has achieved high levels of access to broadband infrastructure, at least in part due to Singapore ONE. The NCB's 1995/96 annual report projected that, "Singapore ONE will be the launching pad for new multimedia contents, hardware and software platforms, and applications and services in the Asia Pacific. It will serve not only as a pilot project site but also as a platform to develop new innovations."

Initially, owing to the high cost of residential access, broadband service attracted few residential subscribers. Singapore ONE's main business was to provide corporate customers with high-bandwidth data communications, much to the chagrin of monopoly Singapore Telecommunications from which backbone circuits were leased.

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68 Release of National Computer Board Annual Report 1995/1996, 27 November 1996.

69 "Industry Development" at http://www.ida.gov/.

70 Irene Tham, "HP trims Jornada unit in Singapore," C-Net, July 16, 2002.

71 As noted on page 66, Singapore ONE is a national broadband network jointly financed by the NCB, Telecommunication Authority of Singapore, and National Science and Technology Board.

However, with the full liberalization of the domestic telecommunications market in April 2000, prices for residential broadband access fell and demand took off. While the user base took four years to reach 100,000, it doubled in just the following six months.

There is no conclusive evidence, however, that Singaporeans are using this connectivity more, or for different applications, than New Zealanders using predominantly dial-up infrastructures.[72] For example:

- 79% of Singaporeans spent a total of 10 hours or less per week using broadband applications[73] (survey figure), yet the average time per month spent by each of New Zealand's 900,000 dial-up Internet users connected to their ISPs via Telecom is 37 hours per month.[74] This suggests that in spite of availability, Singaporeans are not making especially great use of the internet; and

- The most frequently used applications in Singapore are (in descending order) email, online browsing, instant messaging, music, software downloads shopping, banking and online games.[75] This is very similar to surveys in virtually all other countries including Australia[76], New Zealand[77], the United Kingdom[78], Korea[79] and Sweden.[80]

Whilst high connection numbers exist overall, there appears to be a bias towards residential rather than business usage in Singapore. For example:

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72 This review was provided to CRA by Bronwyn Howell, ISCR.

73 IDA Singapore Survey on Broadband and Wireless Usage in Singapore 2002, p. 15.

74 Howell, Bronwyn and Mark Obren. *Telecommunications in New Zealand: 1993-2003*. Wellington: ISCR http://www.iscr.org.nz

75 IDA Singapore Survey on Broadband and Wireless Usage in Singapore 2002, p. 16.

76 AnalystFocus May 2003 Consumer Metrics.

77 Howell, Bronwyn and Mark Obren. 2002. *Broadband Diffusion: Testing for Vintage Capital, Learning by Doing, Information Barriers and Network Effects.* Wellington: ISCR. http://www.iscr.org.nz

78 Oftel Internet and Broadband Brief March 2003.

79 Jee, Kyoung-yong; Jane Ji-Eun Kang; Joong-gul Ko and Moon-Koo Kim. 2003. *The Balanced Role Model of Korea's Broadband Internet Diffusion: Focusing on Supply-Push and Demand-Pull.* Paper presented at the Asia-Australasia Regional Conference of the International Telecommunications Society, Perth Western Australia, June 22-24, 2003.

80 Shim, Yongwoon; Heejin Lee and Kyunglim Yun. 2003. *The Growth of Broadband Internet in Sweden: Contributing Factors*. Paper presented at the Asia-Australasia Regional Conference of the International Telecommunications Society, Perth Western Australia, June 22-24, 2003.

- Secure servers per head of population, which are required to transact secure transactions, are more widely diffused in New Zealand than Singapore (see Table 21);

- Internet hosts per head of population, which measure domain name-linked computers connected to the Internet (and hence a measure of business Internet use) are twice as high in New Zealand than in Singapore; and

- Anecdotally, despite extensive efforts to encourage business use of the technology through the deployment of content and applications[81] such as e-Government, use by businesses in Singapore has been slow. For example, cash remains the dominant method of exchange for businesses such as taxis (credit cards/electronic payment is unusual).

It is difficult to ascertain whether the high broadband penetration levels are attributable solely to Singapore ONE or whether other factors are the key determinants. The compact geography and high population density of Singapore, for example, are conducive to the deployment of alternate technologies. In contrast to most other countries where either cable modems or DSL dominate, Ethernet LAN is the dominant broadband technology (43%) in Singapore.[82] Compact geography and high population density make this a very economical technology (c.f. CityLink in Wellington) that offers much higher traffic speed and capacity. Furthermore, we would expect these factors to make entry by a private firm relatively easy, raising questions over the efficiency effects of the public financing of Singapore ONE.

The extent of subsidies (at least S$150 million) available to both business and residential consumers have undoubtedly induced connection. These include:

- Subsidies for content creation and application;

- Inducements to foreign content providers to host servers in Singapore;

- Government sharing of the business risks by underwriting test and development applications; and

81 See IDA (2000), *Singapore: Where the Digital Future Is.* Singapore: Infocomm Development Agency of Singapore, p. 9.

82 IDA (2002), *Singapore Survey on Broadband and Wireless Usage in Singapore,* p. 14.

- Co-sharing the cost of international leased circuits to ensure that Singapore prices remain internationally competitive whilst full competition is developed.[83,84] In addition, early adoption is being encouraged by subsidising not only broadband access but also the equipment needed to connect (e.g. computers, modems)[85].

Singapore faces some natural advantages in establishing itself as an information hub for Asia as it has always been the centre of communication networks where information for business transactions has been exchanged. However, the available evidence tends to suggest that despite applications being made available, there is still a delay relative to the US, New Zealand, Australia and even Japan in adopting extensive business use, especially in the small business sector (see taxis above). This is not unique to Singapore, however – similar delays are evident in Korea[86]. What is surprising is the slower uptake of a technology that substitutes for physical person-to-person exchange, given the historic role of Singapore as a location where information exchange for mercantile activity has always occurred. It is likely that the Internet has eroded some of Singapore's natural advantage as an information exchange hub (with concomitant higher business uptake in countries such as Australia and New Zealand that have previously relied upon trade through Singapore).

Nonetheless, the technological capability and generous subsidies appear to have been attractive to foreign-owned businesses wishing to conduct business from a base in Singapore.[87]

4.6.3. Creative Industries

Singapore's thinking about the creative industries – arts and culture, design, and media – is distinctly ambivalent as to whether these have a main role in the nation's economic development or are just supporting actors.

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83 IDA (2000). *Singapore: Where the Digital Future Is.* Singapore: Infocomm Development Agency of Singapore, p. 9.

84 Anecdotal evidence from a New Zealand fibre provider wishing to peer with a Singaporean one indicates that the Singaporean product was up to 5 times the price of the New Zealand one; special negotiations with SingTel were undertaken to ensure that Singapore consumers faced the same price as New Zealand ones.

85 *ibid.*

86 Howell, Bronwyn. 2002. *A New Zealand Response to the United States 'Broadband Problem'.* ISCR Research Paper presented at the International Telecommunications Society Asia-Australasia Conference, Perth, Australia, June 22-24, 2003.

87 IDA, (2003). *Singapore: a Snapshot of the Infocomm Sector.* Singapore: Infocomm Development Agency of Singapore, p. 5.

The government has long maintained tight control over the newspaper and broadcasting industries. In 1984, it forced the merger of two Chinese-language newspapers and the English-language newspapers into the Singapore Press Holdings. The articles of association of Singapore Press Holdings limit individual shareholdings.

Until 2000, both newspaper publishing and television broadcasting were monopolies of government-linked companies. Then, in one very limited step, the government allowed the newspaper company and the television broadcaster to enter the other's market. The result is a pair of intertwined duopolies.

In 2002, the government established the Media Development Authority (MDA) with the dual roles of promoting the growth of the media industry and managing content to protect core national values and safeguard consumers' interests. The MDA has issued a Code of Practice to ensure fair market conduct and effective competition in the newspaper and broadcasting industries.

In May 2003, Minister for Information, Communications and the Arts Lee Boon Yang announced a S$100 million five-year fund to support the development of the media industry. Half of the budget was allocated to co-fund development of TV programmes that would "appeal to international audiences," while a quarter was allocated to subsidize the development of "Made-by-Singapore" films.[88] The remainder supported a Digital Broadcasting Development Fund to subsidize up to 70% of the costs of developing new digital content and services for broadcasting, education in media, and overseas market development.

The government appears to consider that the role for the *upstream* element of the creative industries – arts and culture (or content) – is to support the development of Singapore into a "world-class city". Prime Minister Goh Chok Tong noted: "entrepreneurship is closely correlated with the level of cultural vibrancy…the arts can help individuals to become more creative, in areas beyond the arts... Furthermore, a culturally vibrant city attracts global creative talent."[89]

Accordingly, the government has invested heavily in arts and culture that cater to international tastes. It spent S$600 million on the construction of Esplanade, a collection of theatres and concert halls, and S$16 million on the grand opening.[90] By contrast, the National Arts Council grants just S$6.9 million to local groups and S$10 million for the annual arts festival.

88 Speech by Dr Lee Boon Yang, Minister for Information, Communications & the Arts, at The Media 21 Industry Forum, "Co-Creating The Future: Singapore As A Global Media City," Zouk, 8 July 2003.

89 Prime Minister Goh Chok Tong, National Day Rally Speech, 18 August 2002.

90 "Artistic ambitions don't play well in uptight Singapore," *Australian Financial Review*, December 14, 2002.

4.7. FUTURE POLICIES

In December 2001, Singapore Prime Minister Goh Chok Tong appointed an Economic Review Committee (ERC) with Deputy Prime Minister Lee Hsien Loong as chair. The ERC was commissioned in response to significant external and domestic challenges, including the Asian financial crisis, the rise of China, the maturity of the domestic economy, and limitations of the domestic workforce.

In parallel, Prime Minister Goh also appointed the Remaking Singapore Committee, chaired by Dr Vivian Balakrishnan, Minister of State for National Development, to address the social and political dimensions of future national development. The Committee aimed to "reach out to a wide cross-section of Singaporeans to understand their aspirations and goals; and to explore new ideas, directions and plans to re-make Singapore, along side our search for new economic strategies".

The ERC reported in February 2003. Its analysis and recommendations resonated with those of the Economic Committee (also chaired by Lee Hsien Loong) commissioned in response to Singapore's 1985-86 economic recession. However, the ERC made several key departures, including:

- New emphasis on building further growth on domestic enterprise as distinct from multi-national companies;
- New emphasis on biomedical sciences;
- Shift in regulatory philosophy away from government prescription towards one of individual responsibility; and
- Moderation of growth expectations to 3-5% per annum, comprising labour force growth of 1-2% and productivity growth of 2-3% (as contrasted with the historical experience of rates exceeding 7% per annum).

While the ERC report proposes a shift in emphasis towards individual responsibility, it continues to underscore the central role of government agencies and government-linked companies. Though this approach may not accord with received economic theory, the Singapore government apparently considers it might be reasonable in a larger context in which competition takes place at the level of nations as distinct from businesses.

As the ERC deliberations took place, the Singapore Government re-focused and re-organized three of the lead agencies for economic development:

- Agency for Science Technology and Research – to promote and support research and development of relevance to industry and to emphasize bio-medical sciences;

- International Enterprise Singapore – to spearhead the external wing of the Singapore economy, emphasizing the projection of Singaporean businesses to the region; and

- SPRING (Standards, Productivity, and Innovation Board) – to lead the upgrading of local industry.

Following the ERC report, the 2003 government budget laid out three major directions for the future:[91]

- Strengthen global economic ties, especially to Southeast Asia and particularly through bilateral and multilateral free trade agreements;

- Increasing competitiveness and flexibility; and

- Entrepreneurship.

To ensure that Singapore's tax rates would be competitive with other international hubs, the government had previously charted a course to rebalance fiscal policy, reducing corporate and individual tax rates while raising the goods and services tax (GST). While the government had planned to raise GST from 3% to 5% in 2003, the tax was raised to 4% only, with the full increase deferred for one year owing to the economic recession. Further, the 2003 budget:

- Left the corporate tax rate unchanged at 22%, while affirming the intention to reduce the rate to 20% by the following year;

- Left personal tax rates with a top marginal rate of 22% unchanged;

- Exempted interest earned from deposits *exceeding* S$100,000 from income tax; and

- Reduced the ceiling for CPF (Central Provident Fund) contributions and the contribution rate for employees aged 50 and above, while deferring for two years the restoration of CPF contribution rate of 36% to the full 40%.

The adjustments to CPF contributions were consistent with the government's new emphasis on individual responsibility. To the extent that the fiscal rebalancing leads to a net loss of revenue, it will be interesting to see whether the government also progressively lowers the safety net of housing, education, healthcare, and other social services.

91 "Budget" at http://www.mof.gov.sg/.

In the previous budget, the government made significant changes to the corporate tax system, including the abolition of taxes on dividends, and the introduction of group relief to allow deduction of losses incurred by subsidiaries. Regarding personal tax, it had revised the tax treatment of employee stock options and share awards.

The 2003 budget also included new tax incentives for:

- Income from foreign sources;
- Investments in foreign subsidiaries;
- Investments in start-ups;
- Businesses in the logistics and trading sector;
- Investment in intellectual property; and
- Offshore trust services.

5. AN EVALUATION OF SINGAPORE'S INNOVATION POLICIES

5.1. INTRODUCTION

Section 4 of this report described and to the extent possible evaluated Singapore's specific growth and innovation policies. The purpose of this section is to draw together that evaluation and to take a more holistic view.

5.2. ROLE OF GROWTH AND INNOVATION POLICIES IN SINGAPORE

The rapid economic growth of East Asia, and specifically the "Four Tigers" (Hong Kong, Singapore, South Korea, and Taiwan) over the 1980s and 1990s sparked considerable research into the reasons for their success. However, it is far from straightforward to identify the impact of specific government policies on national economic growth. In particular, Sarel (1996) observes that:

- In analysing the "successful" policies of the East Asian Tigers, there is a clear selection bias. A scientific study would also analyse the outcomes in less successful countries, such as some in Africa or South America;
- In most cases, it is impossible to offer a realistic counterfactual scenario, i.e., what would have been the growth rate absent the specific government policies?; and
- It is difficult to identify the direction of causality. Many public policy variables (such as education) are positively correlated with growth. But does education drive growth, or do faster-growing countries spend more on education?

Sarel (1996: 251) concludes that:

> *All these examples do not attempt to prove that policies are not important. Rather, they try to make the modest point that we still understand very little about the relationship between public policy and the miraculous growth rates of the East-Asian economies. Other countries should be careful in trying to imitate the East-Asian policies. Not understanding the causality between growth and industrialisation, in particular, proved to be a very costly mistake for many poor countries that pushed for a rapid industrialisation in a futile effort to boost economic growth.*

The high growth rates of the East Asian economies have been attributed in part to favourable initial conditions. In particular, countries that were poorer, had good primary education, and in which the distribution of income and of land was less unequal achieved significantly higher growth in the period 1960-85 (Rodrik 1994c).[92] Further work identified the importance of "institutional quality," encompassing quality of the bureaucracy, rule of law, risk of appropriation, and repudiation of contracts by the government (Rodrik 1997).[93]

Singapore certainly scores high on institutional quality. Other factors that surely contributed to growth include: relatively low barriers to trade and foreign investment ("relatively" because, until recently, services were heavily protected); prudent monetary and fiscal policies; a strong commitment to education; and geography.

Policies whose contribution might not be so clearly positive were liberal policies for employment and immigration of highly skilled workers, and the forced high savings rate.

Singapore's high savings rate has been criticized for driving excessive investment: "the Singapore government has, since the early 1960s, pursued the accumulation of physical capital via forced national saving" (Young 1992). On the other hand, Singapore does not restrict outward investment, hence excessive saving is simply channelled to offshore investments (Toh and Ng 2002).

More controversial would be the various incentives administered selectively to particular industries and sectors by the EDB and other agencies:

> *"the opaqueness of the Singapore approach raises the questions about its viability for governments under more public scrutiny. Although the money that Singapore spends on industry-specific training and research programs clearly has benefits, these costs are not published; and whether Singapore taxpayers are the net beneficiaries remains open to question"* (McKendrick et al. 2000: 273).

Even if interventionist industrial policies did assist growth, it is possible that this was because Singapore started with an undeveloped economy at independence in 1965: "Making the transition from a low-investment economy to a high-investment economy requires a hands-on government" (Rodrik 1997: 3).

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92 Sarel (1995) and Wong (1995) both raise issues with the robustness of these results.

93 A literature review by Aron (2000), "Growth and Institutions: A Review of the Evidence," sought to "link quantitative measures of institutions, such as civil liberties and property rights, with growth of gross domestic product across countries and over time." The review found quantitative support for a link between the quality of institutions and investment and growth, though the evidence was not robust.

Further, such successes do not prove that Singapore could not have performed even better. If the government did not commandeer such a high percentage of savings through the CPF, would more people have ploughed their savings into entrepreneurship rather than housing? If entry of unskilled and low-skilled foreign workers had not been so liberal, would businesses have tried harder to raise productivity? Absent the EDB's aggressive drive to seek investment by U.S. electronics manufacturers, would Singapore have been so vulnerable to shocks from the U.S. economy?

A question of still broader scope is whether, with Asian values and the communitarian ethic so deeply rooted, Singapore has foregone the opportunity to establish a culture of innovation and entrepreneurship among the population. The evidence on the innovativeness of Singaporeans is mixed. For example, in Table 23 Singapore ranks quite well in the World Economic Forum study of comparative indicators of innovation.

Table 23: Global Competitiveness Indicators of Innovation

Indicator		Singapore	New Zealand
Technology sophistication	Rank	13	23
Median = 4.2	Score	5.9	4.8
Firm level innovation	Rank	5	43
Median = 5.3	Score	6.5	5.3
Firm level technology absorption	Rank	9	24
Median = 5.0	Score	6.1	5.5
FDI & technology transfer	Rank	1	37
Median = 5.1	Score	6.3	5.2
Quality of scientific institutions	Rank	15	14
Median = 4.6	Score	5.6	5.6
Company spending on R&D	Rank	11	28
Median = 3.9	Score	5.2	4.0
	Rank	1	41

Indicator		Singapore	New Zealand
Subsidy for firm level R&D[94] Median = 3.3	Rank	1	41
Tax credit for firm level R&D Median = 3.2	Rank	24	61
	Score	5.7	2.3
University/industry collaboration Median = 3.9	Rank	3	25
	Score	5.6	4.4
Government procurement of advanced technology products Median = 3.9	Rank	1	30
	Score	5.7	4.1
Availability of research scientists, engineers Median = 5.1	Rank	14	49
	Score	5.9	4.8
Brain drain Median = 4.0	Rank	12	47
	Score	5.2	3.5
R&D spending % GDP 1997, %	Rank	24	26
	Score	1.13	1.04
Govt prioritisation of ICT Median 4.6	Rank	1	40
	Score	6.4	4.7
	Rank	1	38
	Score	6.0	4.0

Source: WEF, 2002.

94 As noted earlier and in 0, the measurement of R&D is subject to severe problems when recorded R&D attracts subsidies. This raises questions about the comparability of Singapore and New Zealand reported rates of R&D given the difference of incentives for reporting faced by firms in each country, and may at least partly explain New Zealand's relatively low ranking.

However, consider the results of the GEM global entrepreneurialism study, which compares national performance of countries in this respect. The results of this are shown in Table 24. New Zealand ranks considerably ahead of Singapore, indeed most countries including the US. New Zealand's Total Entrepreneurial Activity (TEA)[95] prevalence rate is 18.2 per cent of the adult population, making New Zealand second to Mexico but statistically equal to Mexico and Australia. Mexico, Australia, and New Zealand are therefore the three most entrepreneurial countries in the world, according to this study.[96]

Table 24: Entrepreneurial League Table by Country and Entrepreneurial Activity

	TEA[97] Opportunity Entrepre-neurship (%)	TEA Necessity Entrepre-neurship Rate (%)	TEA Overall Entrepre-neurship Rate (%)	Total Population
New Zealand	**15.05**	**2.84**	**18.23**	**3.9**
Australia	12.47	3.24	16.21	19.4
Mexico	11.36	6.88	18.74	101.9
U.S.A.	10.36	1.24	11.66	278.1
Ireland	8.97	2.07	12.12	3.8
Brazil	8.53	5.68	14.21	174.5
Korea	8.01	5.67	14.85	47.9
Hungary	7.86	3.35	11.42	10.1

95 GEM (2001) notes: "The Global Entrepreneurship Monitor (GEM) Total Entrepreneurial Activity Index (TEA) is computed by adding the proportion of adults involved in the creation of nascent firms and the proportion involved in new firms. People involved in both nascent and new firms are counted only once. A person was considered to be involved in a nascent firm if he or she had engaged in any activity to start the firm in the past 12 months, expected to own all or part of the firm once it became operational, and the initiative had not paid salaries and wages to anyone, including owner-managers, for more than three months. A person was considered to be a principal in a new firm if he or she reported managing an operating business, and was a sole or part owner, and the business had not paid salaries and wages to anyone, including owners and managers, since 1998 (42 months at survey time)."

96 To qualify as an entrepreneur, the respondent must answer affirmatively one of the first two questions: 'You are, alone or with others, currently trying to start a new business, including any type of self employment? OR You are, alone or with others, trying to start a new business or a new venture with your employer an effort that is part of your normal work?' Then the person must also answer affirmatively the following questions: 'Over the past twelve months have you done anything to help start this new business, such as looking for equipment or a location, organizing a start-up team, working on a business plan, beginning to save money, or any other activity that would help launch a business?' 'Will you personally own all, part, or none of this business?' 'Has the new business paid any full-time salaries, wages, or payments in kind, including your own, for more than three months?' Only a person who answers all of these questions affirmatively will be considered a true entrepreneur (Source: GEM 2001).

97 See footnote 95 for explanation of this acronym.

	TEA[97] Opportunity Entrepre-neurship (%)	TEA Necessity Entrepre-neurship Rate (%)	TEA Overall Entrepre-neurship Rate (%)	Total Population
Italy	7.77	2.14	10.17	57.7
Finland	7.63	0.71	9.33	5.2
Canada	7.56	3.01	10.98	31.6
Norway	7.38	0.23	8.7	4.5
Denmark	6.72	0.44	8.07	5.4
South Africa	5.98	2.93	9.37	43.6
Argentina	5.83	4.5	10.52	37.4
Portugal	5.53	1.4	7.09	10.1
Spain	5.49	1.98	7.78	40
Sweden	5.49	0.79	6.67	8.9
Netherlands	5.38	0.38	6.38	16
United Kingdom	5.03	1.39	7.69	59.6
Russia	4.97	1.13	6.91	145.5
Germany	4.81	1.88	7.04	83
Poland	4.74	4.96	9.99	38.6
Singapore	**3.96**	**1.23**	**5.19**	**4.3**
India	3.8	7.45	11.25	1,030.00
France	3.76	1.32	7.24	59.6
Belgium	3.61	0.8	4.59	10.3
Japan	2.31	1.94	5.08	126.8
Israel	2.07	0.55	5.98	5.9
Total Country Average	6.63	2.49	9.77	2,463.30

Source: GEM (2001), *Global Entrepreneurship Monitor New Zealand 2001*, Table 4.

Despite the mixed results of these different studies, certainly the perception in Singapore is that the level of innovation and entrepreneurship is a concern.

There are no objective analyses of the cost-effectiveness of Singapore's industry policies that address the questions that we have posed. The only possible answers lie in assessments at the level of the whole economy, which we review in the next section.

5.3. TOTAL FACTOR PRODUCTIVITY DEBATE

5.3.1. Growth Accounting

In the absence of objective analyses of the cost-effectiveness of Singapore's industry policies, we must rely on assessments at the level of the whole economy. Taking the view that Singapore began from similar initial conditions as the other East Asian Tigers (Rodrik 1994), it would be fair to assess the performance of its government by the overall economic performance, and in particular, the growth of productivity.

Following Solow (1956), the standard economic methodology for analysing the sources of growth is to model national output by some production function and then decompose the growth of output according to inputs to that function:

- First, the growth of output is attributed to the growth of all measured inputs, including tangible capital and labour. Researchers have invested considerable effort to refine the measures of capital (Gapinski 1999) and labour (Tan et al. 2002) to reflect differences in quality, and to develop measures of other inputs, including land (IMF 1995); and

- Second, the growth of output that cannot be attributed to measured inputs – the *residual* – is attributed to improvements in productive efficiency. This residual is widely known as growth in "total factor productivity" (TFP).

As the measured TFP growth is a residual, it is sensitive to any systematic errors in the measurement of the inputs. A particular issue is the measurement of capital stock, which is sensitive to assumptions about the start of accumulation and depreciation rate (Sarel 1995; Wu and Thia 2002). The measured TFP growth may also be sensitive to the specification of the production function, and assumptions regarding the output share of capital and the quantity of labour per capita (Sarel 1995).

Historically, economic growth has been associated with increases and falls in total factor productivity. Nineteenth century U.S. economic growth can be largely attributed to the growth of tangible inputs (Abramovitz and David 1973). Likewise, Japanese economic growth between the Meiji Restoration and the first World War depended mainly on the expansion of tangible inputs, principally capital (Hayami and Ogasawara 1996).

By contrast, in the post World War 2 period, technical progress was the most important source of growth for the G5 developed countries – France, West Germany, Japan, the United Kingdom and the United States (Boskin and Lau 1990; Kim and Lau 1994).

5.3.2. Four Tigers

In Table 27, we summarize the key findings on the growth of productivity among the four East Asian Tigers. An early study (Chen 1977) yielded relatively high rates of TFP growth, ranging from 3.6% in Singapore to 5.0% in South Korea.

However, subsequent studies found relatively low rates, casting doubt on the earlier study (Young 1992 and 1995; World Bank 1993; Kim and Lau 1994 and 1996).[98] These suggest that the economic growth of the Four Tigers was driven by increases in the input of capital and labour. Indeed, the Four Tigers actually experienced a significant decline in productive efficiency *relative* to the industrialized countries (Lau and Park 2003).

Particularly instructive was the contrast between Hong Kong, which has largely followed a "laissez faire" approach to economic policy, and Singapore, which pursued active industrial policies:

> *While the Hong Kong government has emphasised a policy of laissez faire, the Singaporean government has, since the early 1960s, pursued the accumulation of physical capital via forced national saving and the solicitation of a veritable deluge of foreign investment* (Young 1992)

> *[T]otal factor productivity has contributed substantially to economic growth in Hong Kong, its contribution to growth in Singapore is next to nil … Singapore is a victim of its own (industrial) targeting policies, which are increasingly driving the economy ahead of its learning maturity into the production of goods in which it has lower and lower productivity* (Young 1992)

Given the initial similarities of Hong Kong with Singapore – small densely populated areas, majority Chinese population, and British-style legal framework and civil administration, the comparison of the two is probably the closest to a natural experiment on the efficacy of Singapore's industrial policies. However, to provide a broader context, we provide an overview in 0 to this report of the roles taken by government in each of then Four Tigers, against their common background of spectacular economic growth. Our research on the economies of these countries has of necessity been very brief and non-critical. However, the description in 0 should still illustrate the variation in economic models across these countries.

The chief findings of 0 are that:

98 In fact, Tsao (1985) was the first to spot Singapore's low rate of TFP growth.

- Strong and consistent economic growth in south East Asia has occurred both with and without large scale government intervention;

- It is arguable that initial government intervention in South Korea, Taiwan and Singapore resolved a market failure in the form of coordination problems. In particular, there was a relatively high pre-existing level of human capital compared to physical capital, making latent returns to capital investment very high. Large private British institutions in Hong Kong may have fulfilled this coordination role, at least early on;[99] and

- Starting in the 1970s, government interventions in South Korea and Taiwan appear to have been less successful than at the start of development in each country in the 1960s. This is consistent with the coordination failure hypothesis, which implies rapidly declining returns to government intervention as the coordination problem is addressed and resolved.

99 For an alternative view on the primary cause of economic growth in the tiger economies, see footnote 232.

Table 25: Growth in Total Factor Productivity

	Hong Kong	Singapore	South Korea	Taiwan	Australia	New Zealand
GDP growth (19..-…)						
Chen (1977)	4.3	3.6	5.0	4.3		
World Bank (1993)	3.7	1.2	3.1	3.8		
Young (1995)	2.3	0.2	1.7	2.6		
Kim and Lau (1996)	2.4	1.9	1.2	1.2		
Sarel (1995)	3.8 (1975-90)	1.9 (1975-90)	3.1 (1975-90)	3.5 (1975-90)	n.a.	n.a.
Gapinski (1999)						
Hsieh (2002)	2.0-2.1 (1966-91) 2.9 (1973-91)	1.5 (1971-90) 2.2 (1968-90) 1.6 (1973-90)	1.6-2.1 (1966-90)	3.4-3.9 (1966-90)	n.a.	n.a.
Diewert and Lawrence (1999)[100]					1.25 (1972-98)	0.81 (1972-98)

Further analyses found higher rates of TFP growth (Sarel 1995; Hsieh 2002). Particularly significant is Hsieh's (2002) analysis, which calculated TFP growth using a dual rather than primal approach for inputs. While the conventional primal approach relies on national accounts to calculate the capital stock and quantity of labour, the dual approach side steps certain measurement problems by using market data to calculate the real rental rate on capital and real wage, and then infers TFP growth.

100 See Appendix A for further details on TFP growth estimates for New Zealand and Australia.

The results from the dual approach (Hsieh 2002) were broadly similar to those from the primal approach (Young 1995; Kim and Lau 1996) for Hong Kong and South Korea. However, the dual approach yielded significantly higher TFP growth rates for Singapore and Taiwan. The discrepancy was especially large for Singapore.

Nevertheless, even the revisionist analyses (Sarel 1995; Hsieh 2002) still found that TFP growth in Singapore was as low as half of Hong Kong's.

5.3.3. Singapore

Singapore's record on productivity growth presents two issues:

- Why does the conventional, primal approach under-estimate TFP growth relative to the dual approach using market prices?
- Why did Singapore's productivity growth fall short of Hong Kong's?

One set of reasons concerns the peculiar aspects of Singapore's national accounts, which have bearing on both of the above issues. As a national policy, the Singapore government has subsidized the sale of public housing, both directly and indirectly by stipulating home purchase as one of the few investments permitted to be made from CPF contributions. Consequently, the "shadow price" of the stock of public housing probably fell short of the accounting number, and hence the national accounts probably over-stated the value of the public housing stock (Goh and Low 1996; Wu and Thia 2002).

Further, the market for rental of public housing is severely proscribed: the law prohibits the rental of entire units except under very stringent conditions. As a result, the recorded rental rates and hence the imputed contribution of owner-occupied housing to GDP are biased downward (Hsieh 2002; Wu and Thia 2002).

In 2002, over 20% of Singapore's workforce comprised foreigners on work permits. In order to limit social implications arising from foreign workers establishing local ties, the Singapore government deliberately limits work permits to two years and thereby encourages employers to "churn" their foreign workers. By counting foreign workers on par with locals, the national accounts probably over-state the labour input to economic growth, and hence under-state TFP growth (Wu and Thia 2002).[101]

Several other features of the Singapore economy also help to account for the discrepancy in TFP growth relative to Hong Kong:

101 Since TFP is a residual, if labour is overstated, then TFP will be understated.

- Non-tradables. Generally, Lau and Park (2003) observe that the lack of competitive pressure in the non-tradable sector might offset efficiency gains in the tradable sector. Indeed, Singapore's services sector, which was highly protected until recently, has consistently exhibited low or even negative TFP growth (Tan and Virabhak 1998; Mahadevan 2002); and

- Capital accumulation. Singapore's record of TFP growth has been noted to be sensitive to the period of analysis (Sarel 1995). As an economy steps up investment in capital, the capital-labour ratio rises and TFP growth will lower (Toh and Ng 2002). From the 1970s until the 1980s, the Singapore economy ramped up capital investment. This period coincided with the low TFP growth observed by Young (1995). With Singapore's capital-labour ratio changing less, the economy has registered higher TFP growth.

It may be argued that the Singaporean specific growth and innovation policies have assisted in the efficient accumulation of capital and labour, which has in turn resulted in significant growth for an economy starting from a low base in the 1960s. However, the evidence on the efficacy of these policies in promoting productivity improvements is mixed. Deliberate policies to admit foreign workers in large numbers and to encourage home ownership appear to have retarded the growth of productivity.

5.3.4. Openness as Commitment

To conclude our evaluation of Singapore's growth and innovation policies, we present a novel hypothesis that has not yet been empirically tested. One of the key economic justifications for leveraged buyouts is that by increasing debt, the top management of a company is committing itself to a thinner equity cushion, and therefore committing to work more closely in the interests of the owners. With the thinner cushion, there would be less room for "managerial slack".

Likewise, the commitment of an entire country to openness and dependence on foreign investment and human resources might have the same effect at the national level. Foreign capital and international talent is truly mobile. By tying itself to a continuing inflow of foreign capital and talent, the Singapore government is committing to a set of institutions and policies that favour a particular path of growth and innovation.

Combined with the concept of competition at a national level for capital and labour, the Singapore government's policy of openness could well achieve a high degree of economic efficiency. The government's commitment to free movement of capital ensures capital mobility. The government's commitment to internationally recognized school-leaving qualifications facilitates outward labour mobility. If the government under-performed, the return on capital and human resources would fall below (nationally) competitive levels, and capital and labour would shift elsewhere.

In this light, what might seem like a paradox – that Singapore's savings rate is the world's highest (Table 3), yet most manufacturing investment is funded by foreign capital – seems very rational. Singapore has committed to depend on foreign capital, and thereby, committed to fair, transparent, and competitive economic policies. Provided that the same policies apply to all sectors and there is no discrimination between foreign and domestic investors, then the overall policy mix is assured to be economically efficient!

6. APPLICATION TO NEW ZEALAND

Having analysed Singapore's growth and innovation policies and implementation, we now turn to consider whether or not any of those policies might be worth considering further for application in New Zealand.

6.1. COMPARISON OF CONTEXTS

We first compare and contrast the contexts for growth and innovation policies between the two countries. Similarities and differences between New Zealand and Singapore will have important implications for the applicability of Singapore's policies to New Zealand.

Table 26: Comparison of Contexts

	New Zealand	Singapore
Geography and resources	Extremely remote, with small and sparse population; agriculture, forestry, fishing, some minerals.	Along strategic air and maritime routes; close proximity to enormous populations and markets; densely populated city-state, although small population; no natural resources – imports even water.
Ethnic, cultural and social base	Ethnically heterogeneous with Pakeha majority; economic inequality across ethnic groups; Treaty of Waitangi as founding document.	Ethically heterogeneous with Chinese majority; diversity of cultures, religions; economic inequality across ethnic groups; Confucian ethics and collectivist culture.
Political and legal institutions	Westminster-style democracy; British common-law framework; "clean" and transparent public service; local legislation; recognition of property rights; compared to Singapore, relatively frequent political changes and resulting economic policy changes.	Westminster-style democracy; British common-law framework; "clean" but not so transparent public service; local legislation; recognition of property rights; strong governing party (continuously in power since 1959).
Economy and economic philosophy	Small and moderately rich economy, although with declining relative living standards since the 1970s to 1990; maintaining position since then; limited market system, although the degree of government intervention varies over time; relatively low savings rate; open economy.	Relatively undeveloped economy in the 1960s, but has very quickly grown into rich (but small) economy; hybrid economic model – market system subject to selective government intervention; open economy; high savings rate; persistent public sector surplus.

From this analysis, the key differences that emerge are:

- New Zealand's significant geographical disadvantage;
- Possibly a more individualistic culture in New Zealand;
- Relative political and economic policy volatility in New Zealand; and
- Lower savings rate and more volatility in budget balance in New Zealand.

6.2. COMPARISON OF POLICIES

In this section, we place the Singapore growth and innovation policies described in section 4 into the GIF framework, and map those policies to equivalent policies in New Zealand, if they exist. The result is the identification of a set of Singaporean policies in respect of which either:

- New Zealand has no equivalent; or
- New Zealand's equivalent is materially narrower in scope or shallower in depth.

Table 27: Comparison of Policies

Growth and Innovation Framework	Singapore Policies	New Zealand Equivalent?
Enhancing the Innovation Framework	Subsidisation of processes to transfer FDI technology to local firms.	No.
	Publicly financed venture capital (co-investment) funds.	Yes – Venture Investment Fund.
	Investment encouragement in approved start-ups via tax incentives (e.g., capital loss deductibility).	No.
	R&D tax incentives and other forms of assistance.	Yes - funding of grants to support private sector R&D (recently enacted).
	Overseas investment (by local firms) tax incentive (loss deductibility).	No.
	Publicly financed research councils and institutes.	Yes, e.g., the CRIs, the Marsden Fund and the NERF.

Growth and Innovation Framework	Singapore Policies	New Zealand Equivalent?
	Publicly funded secondment of research scientists and engineers from research institutes to local firms.	No, although interaction occurs at a more informal level.
	Advice to SMEs (either direct or subsidisation of consultants)	Yes, e.g., BizInfo, BizTraining.
	Loans to SMEs	No.
	Facilitation of clusters	Yes, e.g., Hobsonville.
Developing Skills and Talent	Subsidisation of training schemes for employees (for a wide variety of purposes, e.g., primary or secondary maths and English; skills redevelopment; ICT)	Yes - Modern Apprenticeships scheme, and other industry training initiatives. Although query whether scope is as wide.
	University partnerships with selected international institutions	Yes, to some extent.
	Regulation of tertiary-level enrolments to line up with demand-side predictions; bias towards science and engineering	Query whether the Tertiary Education Commission is heading in this direction? Also signalled by existing cross-subsidisation.
	Immigration policy is focussed on workers with relevant skill sets, as opposed to family unification.	Yes – immigration policy is becoming more focussed on people with relevant skill sets.
	Scholarships for foreign university students. All foreign students qualify for loans to cover their tuition and living expenses.	No, unless permanent resident.
Increasing Global Connectedness	Foreign direct investment encouraged by tax incentives and "one-stop shop" investment facilitation.	Not generally – New Zealand's FDI regime has been passive to date. However, there are examples of more active incentives, e.g., in respect of Ericsson Synergy and the film industry.

Growth and Innovation Framework	Singapore Policies	New Zealand Equivalent?
	Singapore International Foundation: ▪ Supports relief and volunteer work ▪ Supports overseas networks of Singaporeans	Yes – foreign aid programmes; Kiwi Clubhouse network; WCNZ Networks; KEA; GNOK.
	Contact Singapore: ▪ General overseas marketing and promotion of opportunities in Singapore ▪ Recruitment and promotion services through overseas offices	MORST employs country coordinators in certain countries; Jobs New Zealand website; New Zealand Trade & Enterprise.
	International advisory panels for government and agencies	No.
Focussing Government Resources	Biomedical sciences: ▪ Research institutes ▪ Venture funding	Yes, e.g., the CRIs, the Marsden Fund and the NERF, and the VIF.
	ICT: ▪ Incentives to adopt	No.
	▪ Publicly financed broadband infrastructure	Not to same scope – more of a regional and educational strategy (Project PROBE).
	▪ Subsidisation of ICT innovation	No.
	▪ Subsidisation of processes to transfer FDI technology to local firms	No.
	▪ Research institute	Yes, e.g., the CRIs, the Marsden Fund and the NERF.

6.3. APPLICABILITY

In this section, we briefly address the potential applicability to New Zealand of the set of policies identified in section 6.2. In particular, we provide our brief views on the costs and benefits of each of these policies, and on whether or not it is worth considering each of these policies further. We stress that our views are tentative only, and that a more detailed analysis would be required prior to a recommendation on whether to implement one or more of the policies in New Zealand.

Table 28: Application to New Zealand

Policy	Benefits	Costs	Worth considering further?
Subsidisation of processes to transfer FDI technology to local firms	A key benefit of FDI is the associated technology spillovers. However, it is difficult to see why the beneficiaries of these spillovers (local firms) don't have the incentives to appropriate the benefits.	▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	No. However, it would be worth considering whether competition policy could be more permissive of coordination between firms.
Investment encouragement in approved start-ups via tax incentives	▪ May overcome under-investment consequent upon capital market imperfections ▪ May provide positive signalling effect	▪ Risks of lobbying and capture ▪ In general, government employees are likely to have less experience, poorer information and poorer incentives than private investors ▪ May crowd out private investment ▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	No. While there are conceptual justifications for subsidisation of start-ups, the evidence on the success of governments in "picking winners" is at best mixed, and arguably very negative.

Policy	Benefits	Costs	Worth considering further?
Overseas investment (by local firms) tax incentive	Difficult to see any misalignment between private and social investment incentives.	▪ Over-investment overseas, potentially at expense of domestic investment. ▪ Risks of lobbying and capture ▪ In general, government employees are likely to have less experience, poorer information and poorer incentives than private investors ▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	No.
Publicly funded secondment of research scientists and engineers from research institutes to local firms	Conceptually, firms may under invest in this human capital, because of the externalities. May improve transfer of scientific know-how as well as tacit knowledge, and so, improve absorption of new technology among businesses. Low cost and low risk.	▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	Yes. The literature is very supportive of government assistance for R&D. While this particular policy does involve a public agency making a decision about where to invest the resource (as opposed to, e.g., a generic tax incentive), presumably the risks can be managed contractually with the recipient firm. Lobbying and capture risks are probably mitigated by the fact that the ultimate decision must be a voluntary one by the scientist; presumably she wouldn't accept the role if she didn't believe in the science.

Policy	Benefits	Costs	Worth considering further?
Loans to SMEs	May overcome under-investment consequent upon capital market imperfections	▪ Risks of lobbying and capture (as presumably loans would be at subsidised rates, vis a vis the rate available from private banks) ▪ In general, government employees are likely to have less experience, poorer information and poorer incentives than private bankers ▪ As public sector cannot be better than banks at eliciting private information from borrowers, the government would take on risks that the private sector is not willing to do ▪ May crowd out private investment	No. While Singapore mitigates some of the risks by running its schemes through private banks, this is likely to introduce a moral hazard problem.
Advice to SMEs (whether directly provided by government agencies or via subsidisation of consultancies)	Rationale is probably a mixture of capital market imperfections making it costly to raise finance for the investment in advice, and/or the externalities associated with education.	▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	Yes. A relatively low cost, low risk intervention.
Facilitation of clusters	The literature suggests that clusters enhance innovation. However, there is no apparent divergence between private and social returns. In other words, private firms have the appropriate incentives to form clusters anyway. Government policy should be aimed at removing impediments	▪ Risks of lobbying and capture ▪ In general, government employees are likely to have less experience, poorer information and poorer incentives than private investors	Yes, but limited to removing impediments to the formation of clusters, e.g., regulation and competition law that makes coordination difficult. But to avoid "picking winners," the removal of impediments should be generic and not ad hoc.

Policy	Benefits	Costs	Worth considering further?
	to the formation of clusters.	▪ May crowd out private investment ▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	
Subsidisation of training schemes for employees	Because the firm does not own human capital, the firm is not able to fully appropriate the benefits of its investment. Accordingly, from society's perspective there will be under investment, potentially justifying government subsidisation.	▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	Yes. While New Zealand does have some training schemes, the Singaporean schemes appear to be broader in scope. However, consideration should be given to the inverted-U shaped relationship between education and economic growth found by Krueger and Lindahl; the payoffs in New Zealand may not be as large as in Singapore.
Foreign direct investment encouraged by tax incentives and "one-stop" shop investment facilitation	Conceptually, FDI has significant benefits, although the empirical literature is more ambiguous. Because one of the conceptual benefits is technology spillover, then we might expect there to be under-investment from a social perspective, potentially justifying government encouragement.	▪ Risks of lobbying and capture ▪ In general, government employees are likely to have less experience, poorer information and poorer incentives. ▪ May crowd out private investment. ▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	Yes. At a minimum, appropriate policies would include those aimed at reducing the information asymmetries faced by prospective foreign investors and any policy uncertainty. We emphasise the importance of policy certainty, particularly in respect of economic regulation.

Policy	Benefits	Costs	Worth considering further?
International advisory panels comprising business, academic, and institutional leaders.	Update on current strategic thinking and policy; network for promotion of NZ business and research.	▪ Efficiency costs of taxation, and/or opportunity costs of alternatives uses of that tax money. ▪ Administrative costs.	Yes. A very low-cost move with large potential returns.
Incentives to adopt ICT	Lower prices through subsidies bring forward the point at which consumers substitute from one technology to another.	There is no justification for a policy to encourage investment in assets such as ICT that do not exhibit spillover effects. Private and social incentives are aligned. Furthermore, any such policy would lead to resource allocation distortions and "picking winner" problems, i.e.: ▪ Risks of lobbying and capture. ▪ In general, government employees are likely to have less experience, poorer information and poorer incentives. ▪ May crowd out private investment.	No. Furthermore, we note that New Zealand appears to be performing comparatively well on ICT uptake (see Table 21).
Publicly financed broadband infrastructure	There may be externalities associated with broadband infrastructure.	▪ May crowd out private investment. At least in urban areas in New Zealand, the private sector is rolling out broadband. ▪ Risks unduly early inefficient over-investment in infrastructures if deployed too far in advance of the availability of	No, at least not in urban areas where private investment incentives appear to exist. Also relies on governments 'picking technology winners' in advance of applications being developed which will determine the type, extent and location of infrastructure needed.

Policy	Benefits	Costs	Worth considering further?
		availability of applications[102] ▪ May encourage inefficient over-investment in idle or under-utilised consumer equipment required to connect.	No evidence that infrastructure availability per se encourages application development, although it may encourage the commercial deployment of an application once it has been developed.
Subsidisation of ICT innovation	Because of externalities, there is likely to be under-investment in innovation from society's perspective.	▪ Subsidy may be used as a substitute source of finance rather than as a stimulating force for innovation. May also result in the "picking winners" problem, i.e.: ▪ Risks of lobbying and capture ▪ In general, government employees are likely to have less experience, poorer information and poorer incentives ▪ May crowd out private investment	Yes. The literature is very supportive of government assistance for R&D. To mitigate the "picking winners" problem and the finance substitution problem, a generic tax cut may be more appropriate (although defining what is meant by "ICT innovation" will be difficult and may engender game-playing). Treatment of ICT innovation should probably be generic with other R&D activity; there is nothing particularly special about ICT.

102 For example, countries like Sweden have vast quantities of under-utilised infrastructures for which there is no obvious use and no current horizon on when the sunk investment will be recouped. Shim, Yongwoon; Heejin Lee and Kyunglim Yun. 2003. *The Growth of Broadband Internet in Sweden: Contributing Factors*. Paper presented at the Asia-Australasia Regional Conference of the International Telecommunications Society, Perth Western Australia, June 22-24, 2003.

7. CONCLUSIONS

The rate of economic growth in Singapore since independence has been spectacular, and its economic model is unique. Accordingly, it is incumbent on policy analysts and makers in other countries to scrutinise Singapore's performance for lessons to be drawn and applied elsewhere. Throughout the OECD,

It is generally considered by economic researchers of Singapore that the following factors have been important in Singapore's growth:

- Institutional quality;
- Relatively low barriers to trade and foreign investment;
- Prudent monetary and fiscal policies;
- Low corporate tax rates;
- A strong commitment to education; and
- Geography.

From the point of view of innovation and dynamic efficiency, we would particularly highlight from this list institutional quality and openness of the economy to trade and investment:

- Institutional quality includes the clear specification and enforcement of property rights. Combined with Singapore's relative political and economic policy stability (compared to countries such as New Zealand), this institutional quality would provide investors with a relatively high level of certainty; and
- As discussed in section 5, we hypothesise that Singapore's openness and dependence on foreign capital and labour imposes an efficiency discipline on economic policy. The openness also enhances the flow of new ideas into Singapore.

However, it is unfortunately not possible at this stage to make any strong claims about the effectiveness of Singapore's more recent "active" growth and innovation policies. Methodologically, it is extremely difficult to rigorously analyse these policies, and any studies carried out by the Singaporean agencies are not public.

It may be argued that the Singaporean specific growth and innovation policies assisted in the efficient accumulation of capital and labour, which in turn resulted in significant growth for an economy starting from a low base in the 1960s. However, the evidence on the efficacy of these policies in promoting productivity improvements is mixed.

It is also relevant to note that:

- Other countries in East Asia that have experienced similar growth rates to Singapore have adopted quite different economic models, with the extreme example being the relatively non-interventionist Hong Kong;

- At the time of independence, Singapore's economy was undeveloped – in other words, it started from a low base; and

- There is a concern that Singapore's policy strategy (and other factors) may have stifled entrepreneurship and productivity improvements.

Finally, there is the question of culture. The self-described phrase "Singapore Inc" is very apt – the interests of Singaporeans have been relatively well aligned towards common goals. Query whether the people of countries such as New Zealand would feel as comfortable with this type of approach.

Nevertheless, our study has identified a set of interesting policies in respect of which there is merit in considering their application in New Zealand. It is very difficult to assess the effectiveness of these policies based purely on the Singaporean experience. A more thorough comparative institutional public policy analysis is required for each one, potentially including a wider sample of countries that have tried them.

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9. USEFUL WEBSITES

- A*STAR http://www.a-star.edu.sg/
- Contact Singapore http://www.contactsingapore.org.sg/
- Economic Development Board http://www.sedb.com/
- International Enterprise Singapore http://www.iesingapore.com/
- Jurong Town Corporation http://www.jtc.gov.sg/
- Media Development Authority http://www.mda.gov.sg/
- Ministry of Finance http://www.mof.gov.sg/
- Ministry of Trade and Industry http://www.mti.gov.sg/
- Ministry of Manpower http://www.mom.gov.sg/
- Singapore Government Press Release Archive: http://www.gov.sg/singov/news&pr.htm
- Skills Redevelopment Program http://www.srp.org.sg/
- SPRING http://www.spring.gov.sg/
- SPRING's portal for SMEs http://www.enterpriseone.org.sg/

APPENDIX A: THE ROLE OF GOVERNMENT IN FACILITATING INNOVATION

The purpose of this section is to provide a framework for thinking about the costs and benefits of government policies that are aimed at stimulating innovation. It is not a thorough literature review, but is somewhat higher level and largely conceptual.

A.1 EDUCATION

Education is widely recognised as a factor relevant to productivity and an activity that governments around the world are almost ubiquitously involved in. In this section, we describe the socially optimal allocation of resources to education as defined in the literature, and then discuss the impediments to the successful allocation of the resources via the market mechanism and the role that this implies for government intervention.

A.1.1 Estimating the Impact of Education

The economic literature addressing the economic effects of education and human capital is divided between micro- and macroeconomic level studies.[103] Our interest is in the latter, because microeconomic studies typically do not capture externalities and therefore identify the social (as opposed to private) returns on education investment.[104] There are two competing frameworks:

103 Microeconomic studies measure the effect of education on wages and productivity. Macroeconomic studies measure the effect of education on GDP and aggregate production. In principle, the two approaches can be reconciled. However, Sianesi and Van Reenen (2002:12) note that the problem with such a reconciliation is that there are many more methodological problems in interpreting results of estimates under the macro approach. Macroeconomic estimates of the effects of education are uniformly larger than equivalent microeconomic estimates, but this could simply be due to "aggregation biases" of various sorts, as well as to the undue imposition of restrictions (notably of linearity and homogenous impact of education).

104 However, Van Reenen and Sianesi (2002:12) note, "other micro evidence points to positive externalities in the form of lower crime, reduced welfare dependence, better public health and parenting, all factors that are likely to positively affect economic productivity." Though important, these externalities differ from the spillover and knowledge externalities which on which this study focuses.

- The **Neo-classical**[105] framework attempts to attribute growth rates to component inputs and residual productivity growth.[106] Under this framework, an increase in education levels is predicted to result in a one-off increase in the economy's growth rate; and

- The **New Growth Economics** framework emphasises the endogenous determination of economic growth, rather than exogenous technological change. Under this framework, an increase in education levels is predicted to result in a permanent increase in the economy's growth rate.

Empirical studies find education levels positively correlated with economic growth. However, there are a number of complications in measuring the effect of education on growth. For example, the positive correlation between education and national income does not necessarily imply that increased expenditure in education will cause an increase in national income, since:

- The innate ability of individuals, not education, may be the true source of productivity.[107] Able individuals tend to earn higher qualifications, and there may be a spurious relationship between education and growth; and

- The primary value of education may be as a signal to employers, rather than an enhancer of productivity in itself.[108] While such signalling is valuable, it suggests additional expenditure on education and training will have little incremental effect on the national income.

105 The Neo-classical model is also known as the Solow model.

106 The so-called Solow 'residual' (the six sevenths proportion of output growth that could not be attributed to growth in capital and labour in Solow's seminal 1957 study) made it clear that the growth of real income per capita cannot be fully accounted for by increases in the measured quantities of the capital and labour inputs alone.

107 For example, see Denison (1964).

108 See Spence (1974).

Formidable problems also afflict the measurement and specification of the relationship between education and national income. These problems include measuring human capital, small data sets,[109] systematic differences in parameters across countries, reverse causality (e.g. faster growing countries invest more in education), and education being a normal good that expands with income. However, these problems have not stopped the development of a body of empirical work attempting to capture the macroeconomic relationship between education and economic growth, though clearly much work remains to be done. The next section provides an overview of the results of this literature before setting out the case for government intervention in markets for education and on-the-job training.

A.1.2 Empirical Estimates of the Returns to Education

The empirical evidence suggests both human capital and technological know-how are important to economic growth. The evidence also indicates that the effect of education on growth is not homogeneous; strategies for investing in education and training need to be highly discerning if the desired impact on growth is to be realised.[110] Overall returns to education compare favourably with rates of return on physical capital.[111]

By Stage of Education

The effects of education vary by the stage at which it occurs, as outlined in Table 29.

109 Macro empirical studies usually have small annual data sets with which to make estimates, at most one observation for each of the last few decades, limiting the explanatory power of models.

110 OECD (1998:63).

111 See Table 37 at page 204.

Table 29: Macroeconomic Effects of Education by Stage

Stage of Education	Result
Pre-School	There appears to be no evidence on the relationship between economic growth and pre-school education.
Primary	A one-percentage point increase in primary school *enrolment* rates is estimated to lead to a two-percentage points increase in the per capita GDP growth rate. A one-percentage point increase in the *total stock* of primary human capital would lead to less than one percentage point increase in the growth rate. The effects of primary education are larger for the poorer developing countries. Estimates of returns to wealthy countries is difficult because of the limited variation within this homogenous sample.
Secondary	A one-percentage point increase in secondary school *enrolment rates* leads to a 2.5 to 3 percentage points increase in growth, the effect being smaller (around 1.5 or zero) for OECD countries. An additional year of *total stock* of secondary education seems to lead to 0.5-1.2 percentage points faster growth rates, again with no impact for OECD countries.
Tertiary	For OECD countries, a one-percentage point increase in the annual growth of human capital increases growth by 5.9 percentage points.
On-The-Job	The returns of training to economic growth have been ignored by the macroeconomic literature, as has the relationship between the level of education and subsequent investments in human capital accumulation on the job. However, the micro literature provides ample empirical support to the prediction that more highly educated individuals also enjoy enhanced work related training later on in working life.

Source: Sianesi and Van Reenen (2001).

The impact of changes in education at each level varies according to the state of a country's development.[112] Growth in the poorest and in intermediate developing countries is most affected by primary and secondary education respectively. Growth in OECD countries is most affected by changes in tertiary skills (see Gemmel, 1996).

Other empirical results include:

112 See Mingat and Tan (1996), cited in OECD (1998,65).

- **Levels of education and decreasing returns**: Krueger and Lindahl (1998) show that the data seem to infer an inverted-U shaped relationship between education and economic growth. Krueger and Lindahl quantify this relationship and find the peak at 7.5 years of education, which is *below* the average 1990 OECD education level of 8.4 years. The finding that the average OECD country is on the downward-sloping portion of the education-growth profile, "casts doubt on the likelihood that there are large growth externalities from the initial level of education, especially in OECD countries" (p.38). If their results were taken literally, the findings imply *negative* growth returns to further expansion of education funding in developed countries;

- **Education subject**: Murphy, Schleifer and Vishny (1991) investigate whether the allocation of students to different tertiary subjects matters for growth. They find that the relative importance of engineering in education (as captured by the ratio of college enrolments in engineering to total college enrolments) has a positive impact on growth, while the relative importance of legal studies has a negative effect. However, these results are based on a small sample and are not especially reliable;

- **Indirect Effects of Human Capital on Growth**: Human capital may have an effect on other factors which affect growth so that investments in education may have both direct and indirect effect on economic performance. For example, human capital may indirectly increase growth if it stimulates the accumulation of other productive inputs such as physical capital (e.g. Barro, 1991, Gemmel, 1996, Benhabib and Spiegel, 1994), technology (e.g. Griffith, Redding and Van Reenen, 2000, Cameron, Proudman and Redding, 1998, Benhabib and Spiegel, 1994) or health (Barro and Lee, 1994), or discourages factors like population growth and infant mortality which hamper per-capita growth; and

- **Training and Economic Growth**: Investment in training by enterprises is essential to increasing productivity and maintaining competitiveness, but the effects of training on economic growth has been ignored at a macroeconomic level by the empirical literature.[113] Training programmes may improve macroeconomic outcomes by improving employment gains under conditions of skill shortages or mismatches (Calmfors, 1994; OECD, 1993). Several studies show that spending on active labour market programmes can help lower unemployment, including its "structural" or long-term level (Scarpetta, 1996), and can help labour markets to adjust to sudden change.

113 OECD (1998:60).

A.1.3 The Case for Government Intervention

Education is rich in spillovers. This conclusion rests upon the insight that ideas – especially ideas tested and reduced to codified scientific and technological information – have some important attributes found in public goods, in particular non-exclusivity and non-rivalry. Accordingly, private operators in competitive markets cannot be expected to produce or distribute knowledge and information at a rate consistent with a social optimum.

For on-the-job training, spillovers include the fact that investments in staff training do not result in an asset that is "owned" by the firm.[114] The knowledge is embodied in employees who will take that knowledge with them on exiting the firm.[115]

This unavoidable separation between investment and possession limits the ability of the firm to appropriate returns from its investment.[116]

These spillovers imply a divergence between private and social rates of return and a potential role for government intervention that has the effect of aligning those private and social returns.

A.2 R&D INCENTIVES

Research and development is a key driver of economic growth. Many studies on the relationship between R&D and growth have been carried out. A recent study by the OECD, for example, concludes the following:

- An increase of one per cent in business R&D[117] generates 0.13 per cent in productivity growth. The effect is larger in countries that are intensive in business R&D;

114 See OECD (1998:60).

115 Two studies from France have looked at worker mobility following training and come to different conclusions. Hocquet (1997) reports that the positive impact of training is four times higher if it is followed by mobility within the same sector than if no mobility follows it, which is support for the existence of training externalities. Goux and Maurin (1998), on the other hand, show that continuous training has no significant effect on the wage paid by the firm providing training, the training decreases the wage loss associated with an interfirm mobility, and the mobility decision is not significantly affected by the wage differential (quoted in OECD 1998).

116 However, the view that employers will only pay for firm-specific skills is challenged by Loewentstein and Spletzer (1997), who show that most of the skills learned in training are useful elsewhere. In a subsequent paper, Loewentstein and Spletzer (1998) find that completed spells of general training paid for by *previous* employers have a larger wage effect than completed spells of general training paid for by the *current* employer, suggesting firms will invest in general training in spite of poaching problems. Few of the costs of training appear to be passed on to workers in the form of a lower wage while in training.

- A one per cent increase in foreign R&D generates 0.46 per cent in productivity growth, and the effect is larger in countries intensive in business R&D; and

- One per cent more in public R&D generates 0.17 per cent in productivity growth. The effect is larger in countries where the share of universities (as opposed to government labs) is higher, and in countries which are intensive in business R&D.[118]

The value of business R&D and the extent of spillovers are apparent from these estimates. R&D is an investment which is positively and significantly related to productivity and economic growth.

A.2.1 Rationale for Government Intervention

The rationale for government support of R&D is grounded in the belief that private returns to R&D are less than the social return, leading the private sector to under-invest in R&D (Arrow 1962). A large empirical literature has sought to estimate the rate of return to R&D, generally finding that the social rates of return to R&D substantially exceed private rates of return. These findings are summarised by Griliches (1992):[119]

> *In spite of (many) difficulties, there has been a significant number of reasonably well-done studies, all pointing in the same direction: R&D spillovers are present, their magnitude may be quite large, and social rates of return remain significantly above private rates.*

Private under-investment in R&D is consequently suggested for two reasons:

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117 There is an acute measurement problem with business R&D: more R&D expenditure is revealed the more it is subsidised. This is particularly relevant to New Zealand as it reports low R&D per capita and has not historically provided tax incentives for this activity. Accordingly, at least part of the low rate of R&D being reported in New Zealand may be attributable to weaker incentives to report it than elsewhere. See 0.

118 These results from D. Guellec and B. van Pottelsberghe de la Potterie, "R&D and Productivity Growth: A Panel Analysis of 16 OECD Countries," STI Working Paper 2001/3 (Paris: OECD, 2001).

119 In Griffith, Van Reenen and Redding (2001).

- The social benefits from new technologies are difficult to appropriate by the private firms bearing the costs of their discovery. The product of R&D – knowledge – has public good characteristics: use by one firm does not preclude its use by another. If knowledge cannot be kept secret, the returns to the investment cannot be fully appropriated by the firm undertaking the investment.[120] Firms will therefore be reluctant to invest at a relevant level, leading to the under-provision of R&D investment in the economy. Griliches (1992) reviews the extensive literature on social and private returns to R&D and estimates that social returns are between 150% and 200% of private returns;[121] and

- Imperfect capital markets may inhibit firms from investing in socially valuable R&D projects (Griliches 1998; Romer 1990). There are various imperfections that can adversely affect the market's allocative efficiency (meaning that funds are not flowing into projects having the highest returns). Significant information asymmetries may exist in relation to very small start-up ventures where there is no track record of financial performance and the key business assets are intangible. Other factors claimed to affect the market mechanism include a risk adverse investment culture (with potential investors imposing a very high discount rate), general lack of confidence in SMEs, and a poorly developed (not sufficiently liquid) secondary market for securities to provide an exit mechanism for investors.

The appropriability problem of knowledge and capital markets imperfections do not mean private investors will fail to deliver research; the existence of these problems is held to imply sub-optimal provision by private investors.[122] Less investment in R&D can be expected to occur than the returns to the whole of society justifies.[123] This, in turn, provides government policy with an opportunity to facilitate research and enhance the outcomes delivered by the market.

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120 Specifically, Hall (2002) notes that the surplus appropriability problem is that innovators are not able to appropriate the entire "consumer surplus" associated with the good they create. A mark-up of price over cost distorts sales downward from the optimum level that would occur is the good were sold at its marginal cost of production.

121 Studies by Jewkes, Sawers, and Stillerman (1958) and Mansfield et al. (1977) suggest spillover problems are particularly severe among small firms, which are often unable to defend effectively their intellectual property or to extract most of the rents in the product market. This is relevant to the New Zealand market, which is marked by an unusually high proportion of small firms (see *R&D Review – Interim Paper*, February 2000).

122 There is much research on the gap between privately and socially optimal investment. For example, Jones & Williams (1999) model investment in R&D and find that, robust to reasonable changes in parameter values, in the absence of taxes and subsidies, the decentralized economy under invests in R&D, with the primary impetus coming from the surplus appropriability problem.

123 For an accessible discourse on the rationale for government funding of education, which is also rich in public good characteristics, see David (1999).

Given this rationale, it is perhaps not surprising that government R&D support is widespread around the world; the governments of Australia, Finland, Norway, Spain, Israel, the U.S. and Singapore, to name a few, all actively support R&D using a variety of mechanisms.[124]

A.2.2 Relationship between Government Assistance and R&D Investment

Government assistance for R&D may help stimulate investment in R&D in the following ways:

- By lowering the incremental cost of a given investment in R&D, but not (directly) impacting on incremental expected returns, it is hoped the firm will substitute other investments for R&D and increase total investment expenditure; and

- Depending on the form of aid, government assistance for R&D may ease short-term liquidity constraints, particularly for small firms, facilitating R&D that would not otherwise occur.

The question of whether government assistance results in higher investment in R&D is an empirical rather than theoretic question. If, from the firm's point of view, R&D assistance eases the cost of liquidity (because it is cheaper to apply for a government subsidy than to raise funds in the capital market), firms may view the R&D subsidy as a substitute source of financing rather than a stimulating force to do more R&D.

Another question raised by direct government assistance is whether such assistance ends up stimulating investment in R&D that is worth doing. A risk of government assistance is that, rather than allow firms to engage in profitable research, subsidies simply turn an unprofitable investment in R&D into a profitable one and there is a net loss to the investment. Lach (2002:371-2) writes:

> *Another channel through which publicly funded R&D projects may crowd out privately financed R&D is through their effect on the price of inelastically supplied R&D inputs (David and Hall, 2000). Suppose the subsidy does indeed turn an unprofitable project into a profitable one. Then, if the costs of hiring additional R&D personnel are high, the firm may decide to discontinue a previously profitable project. The commitment to undertake the subsidized project may crowd out other non-subsidized projects.*

A.2.3 Evaluating the Costs and Benefits of Government Assistance

The value of public assistance for private investment in R&D and capital formation requires an assessment of the costs and benefits of such a program. This assessment can be solved in three steps:

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124 Lach (2002:370). See Table 38 in the Appendix for a summary of tax assistance for R&D in 25 countries.

1. Calculate how much additional R&D occurred as a result of assistance;

2. Estimate the social value of that additional research; and

3. Estimate the economic social cost of the assistance. Hall (1995:13) writes:

> *The total social cost consists of the net tax revenue loss due to the credit plus the costs of administering it, both to the firm and to the Internal Revenue Service. In practice, the cost computed has been simply the gross tax credit claimed. At best this has been done by simply adding up the credits claimed by the firms that use the credit (Mansfield 1986, Hall 1993), sometimes adding in the unused credits that have been used to offset prior-year liabilities.*

Conceptually, measuring the amount of R&D induced by a tax credit is a *ceteris paribus* exercise, in which researchers ask how much more R&D firms did given government assistance than they would have done if there had been no credit. The counterfactual is rarely, if ever, observed, and researchers are forced to fall back on a variety of methods to try to estimate the level of R&D without the subsidy.[125]

A.2.4 Empirical Evidence on the Private Response to Government Assistance

Absolute Effects

Overall, a substantial body of empirical evidence shows that public assistance for private R&D does induce additional investment in research.

- Hall (2001) estimates a price elasticity of R&D spending equal to unity, a "value obtained in a broad range of studies," for example Hall and Van Reenen (2000), conclude that studies on US firms by Berger (1993), Hall(1993), Hines(1993) and Baily and Lawrence (1987; 1992) all conclude that an elasticity of total R&D spending during the 1980s is on the order of unity, maybe higher.[126] Furthermore, they also study research on tax credits for R&D in other countries, including Australia, Canada, France, Japan and Sweden and find that the central conclusion from these studies is not different to those using US data.

- Griliches and Regev (2001) estimate the separate effects of subsidized and company financed R&D expenditures on output and productivity of Israeli manufacturing firms. Their findings point to significant and, in some cases, very large effects of subsidized R&D on output.

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125 Hall (1995:11).

126 See Table 38 for a summary of empirical studies on the R&D tax credit in the United States.

- The Australian Bureau of Industry Economics (BIE)[127] surveyed the response to the 150 per cent R&D tax concession in 1992. 23 per cent of the 839 respondents reported that the tax concession had been critical to their proceeding with at least one R&D project in the last three years. 40 to 50 per cent of respondents indicated that the Concession had had a significant or very significant effect in allowing projects to be continued; widened in scope; or improved in quality. These responses, taken together, suggested that the amount of additional R&D expenditure induced by the Tax Concession might lie in the range of 10 to 17 per cent of eligible R&D expenditure. BIE conclude that the Australian 150 per cent R&D tax concession generates only modest inducement of new R&D. Nevertheless, given Australia's circumstances at the time the Concession was introduced, the concession has probably had significant effects in increasing firms' innovativeness, and contributed to their international competitiveness. More innovative firms had better capacity to penetrate markets and achieve growth and higher profitability.

- Bloom, Griffith and Van Reenen[128], examined the sensitivity of R&D to changes in its user cost in nine countries over the period 1979-1997. Variation in fiscal incentives across countries and over time serve as quasi-experiments helping to identify the elasticity of R&D with respect to changes in the user cost. Their primary conclusion is that fiscal provisions matter. There is considerable variation in the user cost of R&D within and across countries induced by the very different tax systems that have operated over our sample period. The econometric analysis suggests that tax changes significantly effect the level of R&D even after controlling for demand, country-specific fixed effects and world macro-economic shocks. The impact elasticity is not large (just over –0.1), but over the long run may be more substantial (about unity in absolute magnitude.

- Irwin and Klenow (1996)[129] evaluated the SEMATECH program in the US, which was a research consortium established in 1987. About half of the consortium's annual budget (about $200 M) was financed through government subsidies. In their study, Irwin and Klenow found that SEMATECH was successful in eliminating excessive duplication of R&D which was a major objective of the consortium. They also had more rapid growth in sales than non-member firms. However, performance in terms of physical investment, return on assets, sales and productivity growth showed no difference compared to non-member firms.

127 Hawkins, Lattimore (1994) http://edie.cprost.sfu.ca/~grii/papers/hawkins/hawkin6.html.

128 Bloom, Griffith & Van Reenen (2002:25).

129 In Klette, Moen, Griliches (1999).

- Branstetter and Sakakibara (1998)[130] examined the performance of Japanese research consortia which were heavily subsidised by the Japanese government. Their econometric results show that a membership in the consortia typically stimulated private R&D spending and also made the research effort more productive.

- Klette and Moen (1999) studied the impact of a series of governmental programs aimed at supporting commercial R&D projects in Norwegian manufacturing related to IT. The econometric analysis revealed few significant differences between the supported firms and the non-supported firms despite the large amounts of R&D support provided.

- Lach (2002) uses data on Israeli manufacturing firms in the 1990s and finds evidence that R&D tax credits greatly stimulated company financed R&D expenditures for small firms, but had a negative effect on the R&D of large firms (although not statistically significant).[131] One interpretation of these results is that large firms get subsidies for projects that would have been undertaken even in the absence of the subsidy, whereas small firms do not. This differential effect of the subsidy may reflect a higher cost of raising capital by small firms than by large firms. The time pattern of the estimated effects also suggests that in the presence of some type of constraint (either capital or skilled labour), the commitment to undertake the subsidized R&D project may result in other R&D projects' being temporarily crowded out (Lach 2002:372).

Substitution versus Complementarity

In the U.S., Wallsten (2000) showed that a subset of publicly traded, young, technological intensive firms, reduced their R&D spending in the years following the award of a Small Business Innovation Research grant. Klette and Moen (1998) conclude that the R&D subsidies were successfully targeted at firms that have significantly expanded their R&D expenditures, and that there is little tendency for crowding out in their sample of high-technology Norwegian firms.[132] Busom (2000) finds that in about 30% of the Spanish firms in her sample, public funding fully crowds out privately financed R&D.

130 In Klette, Moen, Griliches (1999).

131 The Israeli experience is of interest because its high-tech sector boomed in the course of the last decade, both by national and international standards. Government R&D and innovation policies are perceived as crucial elements of this success story (Trajtenberg, 2002).

132 This para quoted from Lach (2002:371).

One third of studies reported on by David et. al. (1999) show that public R&D funding is a substitute for private investment. David et. al. show substitution is more likely in studies conducted at the line-of-business and firm level. Studies at the industry and higher aggregation levels are more likely to find public funding as a complement to private R&D investment.

David et. al. also show that the rate of net substitutability varies by country. Whereas 10 of 12 of studies based on data from countries other than the US report complementarity, only 12 of 21 U.S. studies find net complementarity.

A third feature of interest in Table 30 is the regional contrast in the findings that emerges within the group of studies conducted at and below the level of the firm. Here one sees a marked difference between the distribution of the US-based findings and the much higher relative frequency with which complementarity is reported by analysts working exclusively from U.S. evidence.

Table 30: Summary Distribution of Econometric Studies of the Relationship between Public and Private R&D Investment

	Studies reporting "net" substitution	Total number of studies
Level of aggregation: Firm and Lower[133]		
Number of studies surveyed	9	19
Based on U.S. data only	7	12
Based on other countries' data	2	7
Level of aggregation: Industry and Higher		
Number of studies surveyed	2	14
Based on U.S. data only	2	9
Based on other countries' data	0	5
All levels of aggregation	**11**	**33**

Source: David, Hall, and Toole (1999:47-48).

133 The findings in Toivanen & Nininen (1998) for large firms and small firms each are counted here as a separate study.

Temporal Effects

Government assistance takes time to have an effect on research efforts of firms. First, it takes time to learn about credits and, second, because R&D is costly to adjust in response to temporary tax cuts.[134] Hall (1995) finds that the response to an R&D tax credit tends to be fairly small at first, but increases over time. She notes that this result is consistent with studies based on non-US data. Hall finds that the responsiveness of R&D to tax credits in countries has risen over time, as these schemes assume an air of permanence in many countries.

Griffith, Van Reenen and Redding (2001) also find that the benefits of R&D tax credits are more substantial in the long run. Over periods as short as one year, the costs of R&D tax breaks may exceed the benefits of additional R&D stimulated. However, over long periods the benefits of R&D tax breaks are "far more attractive and is cost-effective under a wide range of assumptions."[135]

In an earlier study of US R&D tax policy during the eighties, Hall (1993) confirms that the R&D spending of a firm does respond to financial incentives on the margin, although the response is greatly dampened by the long run nature of such an investment. One highly successful example of a government policy that did increase the rate of technological change, but only after a substantial lag, was the creation of the new academic discipline of computer science in the 1960s. Even after the passage of 40 years, the magnitude of the payoff from this investment is still growing.[136]

A.2.5 Is R&D Worth Subsidising?

Griffith, Redding and Van Reenen (2001) measure the benefit of an R&D tax credit in the UK by the effect on value added in the short and long run, and compare the increase in value added to the likely exchequer costs of the program under a number of scenarios. They show that, in the long run, the increase in GDP outweighs the costs of the tax credit. The short run effect is far smaller with value-added only exceeding cost if R&D grows at or below the rate of inflation.

134 Hall (1995:25).

135 At page 22.

136 See Mowery (1996).

Hall (1995) argues it is likely that the social return to industrial R&D in the United States exceeds the social cost, even after the effect of existing tax subsidies.[137] Typically, R&D tax credits have a tax revenue loss that is slightly larger than the amount of induced R&D. The true social benefit-cost ratio adds administrative costs and other tax effects to the loss and the excess social returns to the induced R&D (above its private cost) to the gains. The former is likely to be substantially smaller than the latter, implying a full benefit-cost ratio above one.[138] However, measures of these corrections are scarce.

Jones and Williams (1998) calculate that the optimal quantity of resources to devoted to research and development in the U.S. is at least two to four times actual investment.

All studies on the relationship of R&D, however, must be treated with caution for two reasons. First, measurement problems are especially relevant to R&D because when R&D is subject to subsidy and other activities are not, more R&D expenditure will be claimed for a given amount of R&D effort. This may imply a spurious relationship between R&D effort and tax incentives. Secondly, Goolsbee (1998a) shows that additional expenditure on R&D may in fact only have weak effects on innovation rates because the supply to highly-skilled labour is very inelastic.[139]

However, taken as a whole there is evidence that tax does have an effect on R&D performed, the most compelling evidence coming from the quasi-experimental approach of calculating a user cost of R&D and estimating an explicit econometric model. A tax price elasticity of around unity (i.e., a dollar in tax credit for R&D stimulates a dollar of additional R&D) is still a good ballpark figure, although there is a good deal of variation around this from different studies as one would expect.[140] Once the social value of R&D is taken into effect, which comes on top of the private benefits estimated in studies, the empirical literature offers support for public assistance of private R&D.

A.3 VENTURE CAPITAL ASSISTANCE

A.3.1 What is Venture Capital?

Kortum and Lerner (1998) define venture capital as

137 Hall (1995:10).

138 Hall (1995:25).

139 See page 160.

140 Hall and Van Reenen (2002:467).

> *[E]quity or equity-linked investments in young, privately held companies, where the investor is a financial intermediary who is typically actively as a director, an advisor, or even a manager of the firm.*[141]

Jeng and Wells (2000) define venture capital as private equity invested by institutions or wealthy individuals in both publicly quoted and privately held companies where these private equity investors are more actively involved in managing their portfolio companies than regular, passive retail investors. Under these definitions, venture capital comprises three kinds of investing: seed, start-up, and expansion investment. These definitions exclude buyouts.

Empirical studies show the effect of venture capital on recipient firms is to stimulate, or permit, higher growth in firms than other forms of financing. One study, for example, found that revenue growth for venture capital-backed high growth companies in 1995 was 36.8% compared to 23.8% for non-venture capital-backed high growth companies.[142] Much of the recent growth in high-technology firms in such nations as Israel, Singapore, and Taiwan has been attributed to government venture capital initiatives.[143]

141 Kortum & Lerner (1998:3n1).

142 Quoted in Jeng and Wells (2000:245).

143 See Organization for Economic Cooperation and Development 1996. [quoted in Lerner 1999].

The role of venture capital in start-ups, however, should not be over-emphasised. Venture capitalists tend to fund only the cream of the ideas crop. In the US, Lerner (1999:291) reports that in 1997, a record year for venture disbursements, 707 companies received venture financing for the first time. The Small Business Administration estimates that 885,000 businesses were started in that year.[144] Of the firms that submit business plans to private venture organisations, historically only 1% have been funded. Instead, the vast majority of capital for new enterprises comes from entrepreneurs themselves, using personal savings and ongoing earnings to bootstrap their businesses, or from wealthy relatives, friends, and other "angel" investors.[145] In New Zealand, there were 14 venture capital firms in New Zealand that were members of the Australian Venture Capital Association (AVCA) at the end of 2000. Total capital was US$332 million. Invested capital was US$151 million and available capital was US$148 million. The total number of investments at the time was 108, comprised of 81 current portfolio companies and 27 completed divestments. During 2000, there were 37 investments totalling US$49 million.[146]

Table 31: Value of New Venture Capital Deals as Proportion of Total Private Capital Investment Spending

	US	Australia	New Zealand
1988	0.8%		
1999	2.4%	0.8%	0.8%

Source: Infometrics (2000:13).

144 Also see Fenn, Liang, and Prowse (1995).

145 In addition, Florida and Smith (1993) report that venture capitalists fund a small fraction of the US commitment of resources to innovation. Venture capitalists invest $1.5 billion to $4 billion each year, while the US as a whole spends more than $150 billion per year on R&D, nearly $80 billion of which comes from the private sector. During peak years, venture capital investment, which covers a much wider range of activity than just R&D, represents less than 5 percent of private-sector R&D spending and just 2.5 percent of total R&D spending.

146 GEM (2001), *Global Entrepreneurship Monitor New Zealand 2001*.

Venture capital is an especially attractive equity finance structure because it gives companies leeway in their repayment schedule.[147] By focusing on start-ups, venture capitalists develop specialist expertise and economies of scale in locating and financing potentially successful start-up ventures.[148] Gompers and Lerner (1999) outline the venture capital process. The investment decision of venture capitalists is usually made after very careful consideration, and is subject to heavy ongoing monitoring. Funds are often disbursed in stages, and managers of these venture-backed firms are forced to repeatedly return to their financiers for additional capital, in order to ensure that the money is not squandered on unprofitable projects. The decision to invest in a project is frequently made conditional on the identification of a syndication partner who agrees that the investment is attractive. Venture capitalists intensively monitor managers, and investors often demand preferred stock with numerous restrictive covenants and representation on the board of directors.[149]

Jensen (1993) describes the type of investor needed in this environment as "active investor," which is precisely what venture capital delivers to new firms.[150] Sahlman (1990) and Jensen (1993) find that venture capitalists solve the corporate governance and monitoring problem through extensive initial due diligence about start-up companies' businesses. Furthermore, they maintain a close relationship by frequently visiting and talking to company management. The venture capitalists also sit on the boards of directors.[151]

A.3.2 Economic Rationale for Government Intervention in Venture Capital

The literature offers three explanations for efficient intervention of government officials in venture capital markets.[152]

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147 The literature on entrepreneurship finds that liquidity constraints are binding and, therefore, critical to entrepreneurs (see Evans and Jovanovich, 1989). This underscores the importance of venture capital as a way to circumvent liquidity constraints.

148 Jeng and Wells (2000:246).

149 Various aspects of the oversight role played by private equity investors are documented in Gompers (1995), Lerner (1995), and Sahlman (1990); the theoretical literature is reviewed in Barry (1994). Quoted in Lerner (1996:3-4).

150 The higher involvement of venture capitalists in their investments is regarded by some as a cost of using venture capital, prompting the term "vulture capitalist" (Florida and Smith, 1993:64).

151 Quoted from Jeng and Wells (2000:247). This higher intervention in the running of the business in which they have a share is seen by some entrepreneurs as a downside to venture capital (see footnote 150).

152 Other forms of government involvement in venture capital includes regulation and law-making. The US has the world's largest and most pervasive venture capital markets alongside heavy government regulatory involvement. In the US, venture capitalists are tightly regulated, with the government specifying in some detail the rules, and setting up legal and regulatory mechanisms, for enforcing those rules (e.g. rules about the vesting of shares).

Economies of scale in monitoring investments: The structure of private venture investments is inappropriate for many small-scale, early stage ventures. Venture funds tend to make substantial investments, even in young firms: in the US, the mean venture investment in a start-up or early-stage business between 1961 and 1992 was $1.8 million (in 1992 dollars).[153] The substantial size of these investments is largely a consequence of the time-consuming nature of to negotiations and monitoring. Furthermore, governance and regulatory considerations lead investors to limit the share of the fund that any one limited partner holds.[154] Because of fixed monitoring costs, venture capitalists are typically responsible for no more than a dozen investments, and venture organisations are usually unwilling to invest in very young firms requiring only small capital infusions. The leading alternative source of private equity for small firms is through individual investors and such financing is usually much less than what a venture fund will consider investing.[155] This gives rise to a gap in funding between individual investors and venture capitalists. Government awards may partially fill this gap.[156]

Social returns to R&D exceed private returns: Government intervention in venture capital markets may be justified if spillovers from R&D result in private under-investment in R&D compared to a social optimum.[157] Even if there is no market failure in venture capital (i.e. no divergence between social and private returns), government assistance for venture capital could still be efficient if it stimulates investment in markets in which under-investment in R&D is occurring.[158]

153 Gompers (1995).

154 The structure of venture partnerships is discussed at length in Gompers and Lerner (1996a).

155 Freear and Wetzel (1990) report that median financing round raised by private high-technology firms from individual investors was about $200,000. 82% of the rounds from individuals were under $500,000.

156 Lerner (1996:10-11). However, if private investors avoid small investments because of the fixed cost of monitoring, it is not clear how government can avoid those costs and justify the investment.

157 It is worth noting, however, that private responses to spillovers, such as joint ventures and mergers, can also internalise spillover problems. Jacquemin and Slade (1989) claim cooperation in R&D is the most important benefit of joint ventures. Ordover and Willig (1985) and Grossman and Shapiro (1984) argue that R&D in high-technology industries requires special treatment under competition law, stemming from the public aspect of research, and the limited threat of permanent market power accruing to joint venturers in industries in which technology is changing rapidly. Cooperation in research may also eliminate wasteful duplication of efforts.

158 Lerner (1999) highlights the importance of R&D spillovers as a key rationale for direct government intervention in the venture capital industry.

Signalling Effects of Public Funding: Informational asymmetries may make it costly – or entirely preclude – access to external capital for small firms. Myers and Majluf (1984), and Greenwald, Stiglitz, and Weiss (1984) demonstrate that equity offerings of firms may be associated with a "lemons" problem.[159] However, the award of public venture capital may provide a valuable signal to potential investors and customers about the prospects of the recipient firm. If public awards were purely an honorary designation, they might more readily be designated for explicitly political considerations. However, the presence of a substantial financial component and the associated regulatory provisions that govern such awards may limit these pressures and insure that the awards are an effective signal of the quality of a firm's technology.[160]

A.3.3 Costs of Government Support for Venture Capital

The economic literature has closely examined the distortions that government interventions in markets can cause. Olson (1965) and Stigler (1971) discuss, and Peltzman (1976) and Becker (1983) formally model, the theory of regulatory capture, which suggests that direct and indirect subsidies will be captured by groups that stand to gain substantial benefits and whose collective political activity is not too difficult to arrange (i.e., when "free-riding" by coalition members is not too large a problem). Stigler (1971) points out that even very small firms can organize to benefit from public largess. More recent models (summarized in Laffont and Tirole (1993) and in Rodrik (1994a)) have incorporated voters, politicians, and/or bureaucrats as distinct actors, often in a principal-agent relationship.

Distortions may manifest themselves in several ways. One possibility (discussed, e.g., in Eisinger (1988)) is that firms may seek transfer payments that directly increase their profits. Politicians may consent to these transfers to politically connected companies or politically important groups. A subtler problem, discussed by Cohen and Noll (1991) and Wallsten (1996), is that officials may seek to select firms based on their likely success, regardless of whether the government funds are needed. In this case, they can claim credit for the ultimate success of subsidised firms, even if the marginal contribution of the public funds was low (Lerner 1999:292).

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159 The term "lemons" describes market failure in the used car market due to information asymmetries, and is from Akerlof (1970). In the context of venture capital, if the manager is better informed about the investment opportunities of the firm and acts in the interest of current shareholders, then he will only issue new shares when the company's stock is overvalued. Many studies have recorded declines in stock prices on the announcement of equity issues, largely because of the negative signal that it sends to the market. Stiglitz and Weiss (1981) show information problems exist in debt markets (quoted in Lerner, 1999).

160 Lerner (1996:26). Lerner (1999) finds that SBIR awardees receiving large subsidies did not perform better than those receiving smaller subsidies. This suggests the benefits of these awards are limited to a certification function. However, this may not justify welfare-enhancing government intervention if such signals are sent at the same cost as information privately developed would send. Instead, government involvement may have the effect of subsidising the fixed costs of due diligence for the private sector. We are not aware of anything in the literature that suggests government will be in a position to extract this information at lower cost.

In markets for venture capital, Leleux and Surlemont (2003) argue government intervention tends to occur in ways that are counterproductive:[161]

- Public fund managers are often government employees, and may not have the experience, skills or drive necessary to select and support entrepreneurial companies;

- Managers face incentive structures which often differ markedly from the traditional private fund arrangement, where partners share in the profit through performance-linked bonuses. Public sector managers often face fee-based incentive packages, with very different incentive effects;

- More problematic, if public funds finance projects at below-market rates, they may end up attracting the best projects, leaving only "lemons" for private VC firms to fund, making the entry of new, independent private equity funds more difficult. The government may crowd-out private investment;

- Florida and Smith (1993) argue that government assistance may cause the over-stimulation of the start-up of new firms, and (inefficiently) drag the limited supply of entrepreneurs away from more established and competent firms. This has the effect of pulling ideas out of strong, established, well-financed companies and passing them into the hands of entrepreneurs who are then in an inferior position to fully exploit the idea; and

- Government assistance may damage the ability of venture capitalists to quickly direct resources to where expected returns are sufficient to justify investment risk, and withdraw funds where anticipated returns are not sufficient. Historical records show that aggregate availability of venture capital in the US has been extraordinarily volatile through time.

In addition, fixed monitoring costs appear to be a real barrier to private sector investment in small firms. However, it is not clear that governments are in a better position to deal with these costs, other than being willing to accept sub-competitive returns on investment (i.e. a subsidy).

These arguments can be used to posit two negative effects for direct public intervention in the venture capital process: (1) capital can be misallocated, and (2) the government may create additional barriers to private entry.

161 These examples from Leleux and Surlemont (2003:84).

Experience with government venture capital programs suggests caution is warranted. Studies of the performance of the longest running government-sponsored venture capital program, the SBIC, show that, in spite of some notable successes, the program has performed poorly overall. An early study, in 1961, stated that the benefits were so great and the controls so few that the program had essentially created a "license to steal." Other evaluations found that SBICs generated significantly lower rates of return than private venture capital funds, and that their lending practices were far more parochial than their private counterparts. By the early 1980s, the role and function of SBICs had been eclipsed by innovations in the private sector, particularly the emergence of the venture capital limited partnership as a mechanism for attracting private funds to the venture capital industry. By 1993, SBICs made up just 5 percent of the total venture capital pool.

According to Florida and Smith (1993), venture programs (measure at state level in the US) fail to measure up to privately provided capital on every relevant measure of performance.[162] Evaluations indicate that most state programs have lost money or generated rates of return considerably below that of private funds. Lerner (1999:296) reports that recipients of multiple subsidies under the SBIR[163] program commercialise projects at a significantly lower rate than other firms. Florida and Smith (1993) report the programs have also failed in terms of more conventional economic development criteria such as business generation and job creation. Even the most favourable evaluations conclude that the programs have created only a very small number of new businesses and generated only a limited number of jobs.

In addition, government venture capital programs are subject to political pressure. Lerner (1999:296) reports that interest from congressmen representing US districts with few awards went beyond questions about the overall distribution of awards to include in some cases inquiries about the status of particular SBIR applications. Lerner records significant pressure on government agencies to select firms that are likely to succeed, resulting in pressure to select firms that would have succeeded even without the award. There is evidence of political influences in the allocation of SBIR funds. In almost every recent fiscal year, all 50 states have received at least one SBIR award.[164]

162 Florida and Smith (1993:66).

163 The largest U.S. public venture capital initiative is the Small Business Innovation Research (SBIR) program. It provided over $6 billion to small high-technology firms between 1983 and 1995.

164 U.S. Small Business Administration (1996).

At a broader level, some commentators argue the government is simply ill-suited to the high-risk, high-return world of venture capital, where tremendous profits from one or two successes are needed to offset nine or ten failures.[165] Nurturing even one success requires venture capitalists to become intimately involved in the management of start-up enterprises. Venture capitalists are required to make hard-headed decisions on increasing investments in promising companies; they required to close down laggards. However, democratic governments tend to avoid termination of any sort, and may tend to direct venture capital into pet projects or politically important electorates.[166]

A.3.4 Empirical Evidence

In a recent study of 15 European countries, Leleux and Surlemont (2003) test an eight-year data set for three hypotheses on whether direct public interventions:

- Tend to "seed" underdeveloped VC industries;
- Prevent the emergence of active VC markets by "crowding-out" private funds; or
- Facilitate their development by signalling and certifying their social value.

They find that the evidence does not support the seeding or the crowding-out hypothesis; government funding tends to be directed at industries with large human resource needs that are later in their development (beyond the seeding stage). Secondly, there is no evidence to support the hypothesis that public venture capitalists crowd-out private venture capitalists from the industry (i.e. public intervention in the venture capital industry tends to be a *consequence* of the development of the industry, not a *cause*). Thirdly, public sector funding causes the development of larger venture capital funds overall, also evidence against the crowding-out hypothesis. Leleux and Surlemont (2003) conjecture these results may be consistent with the effect of signalling of venture capital awards by national authorities.

165 Florida and Smith (1993).

166 Leleux and Surlemont (2003) test whether public VC funds tend to be directed at labour-intensive European industries, the hypothesis being that such funding would be more in line with political employment objectives. They find no evidence of such bias in the allocation of public venture capital funds.

Other studies, however, show that public funds can be a substitute for private investment. Irwin and Klenow (1996) show that semiconductor manufacturers substantially reduced their own R&D spending while participating in the Sematech consortium.[167] Wallsten (1996) shows that the subset of SBIR awardees that were publicly traded reduced their own spending on R&D in the years immediately following the award.

Studies have examined the performance of public venture capital initiatives. For example, one study found the SBIC program, unlike private venture capital firms, very rarely had post-investment controls in place. This enabled entrepreneurs to create a 'license to steal' from the government.[168]

Lerner (1996) studied firms receiving assistance under the US SBIR program and found that:

- An SBIR award alone had little impact on employment and sales;
- SBIR awards had a strongly positive impact on firms that were in areas simultaneously receiving venture financing, but no significant impact on other firms; and
- The beneficial effect of SBIR awards was greatest if the firm was in an area attracting considerable venture investment, but not in a frequently financed industry.[169]

However, Lerner (1999)[170] shows that SBIR awardees grew significantly faster than a matched set of firms over a ten-year period. The positive effects of SBIR awards were localised, confined to firms based in zip codes which already attract substantial venture capital activity.

These findings are consistent with the literature on capital constraints and the literature on the importance of geographic effects. However, Wallsten (1996) argues, capital constraints are unimportant and firms simply substitute SBIR funding for their own expenditures.

167 Established in 1991, Sematech is a public-private joint partnership that represents about half of semi-conductor manufacturers in the world.

168 Florida and Smith (1993).

169 Lerner (1996:20).

170 Lerner (1999).

Conclusion

Empirical research conducted to date has not been conclusive regarding the efficacy of publicly funded venture capital. Where research has been undertaken, it has occurred in large economies, especially the United States. Clearly, further study is needed, particularly in smaller economies. For many overseas programs, further time is needed to be able to empirically assess their microeconomic effects with many programs being established over the past 5-10 years.[171]

A.4 CLUSTERING

Gans and Stern (2003:12) define clusters as:

> *…geographically proximate groups of interconnected companies, industries, and associated institutions in a particular field, linked by commonalities and complementarities.*

Technological clusters have developed around the world and are recognised as centres of innovation. Well-known and successful clusters in Europe and the US include Silicon Valley (California), Route 128 (Massachusetts), the Emilia-Romagna region in Italy, and Baden-Wurttemberg in Germany. Clusters continue to thrive around the world in spite of the communications revolution that has reduced the effects of distance in many activities. Pavitt (1987) explains:

> *[M]ost technology is specific, complex, often tacit, and cumulative in its development. Such tacit knowledge is much harder, or even impossible, to transfer by wire: it requires geographical proximity and face-to-face contact to maximize knowledge transfer of this sort.*

A.4.1 Causes of Clustering

The literature suggests three broad reasons for clustering:

- The desire to minimise transport costs;
- The existence of positive externalities from agglomeration. When firms cluster, benefits to firms arise from the effects of knowledge spillovers. These externalities lead to a self-reinforcing process that induces more firms to join the cluster. This process continues until either congestion effects or radical technological discontinuities intervene; and
- The opportunity to serve the market created by firms and employees located in the city.

171 In addition to being a source of funds, venture capitalists are a potentially valuable source of expertise on commercialisation. See page 139.

Positive externalities or spillovers are central to clustering in knowledge-based industries, and can be categorised into:[172]

- Economies of intra-industry specialisation, where greater industry size permits firms to pursue greater specialisation;
- Labour market economies, where industry size reduces search costs for firms looking for workers with specific training relevant to that industry;
- Enhanced communications among firms, which can accelerate the up-take of innovations; and
- Public intermediate inputs tailored to the particular need of local industries.

A.4.2 Why Clusters Cause Innovation

At least three reasons have been advanced for why clusters induce higher innovation.

1. **Knowledge accumulation** is relevant to the performance of clusters as innovation machines. The Marshall-Arrow-Romer innovation theory[173] argues that externalities, which arise from the proximity of firms in the same industry, have an important influence on firm growth. This happens because knowledge accumulated by one firm tends to help the technological development of other firms. Industries that are regionally specialised benefit most from within-industry transmission of knowledge and should, therefore, grow faster than those that are regionally dispersed.

2. Clusters raise innovation by **reducing uncertainty**. Uncertainty is reduced because clustering facilitates a collective learning process, in turn increasing the speed of diffusion. The close presence of other innovators sharing similar experiences makes regional networking important, and offers a mechanism that enables risk sharing and reduces uncertainty (Camagni 1991a).[174]

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172 Henderson (1986: 48) provides these sources of location externalities from the urban economics literature.

173 This theory developed from a combination of works. See Romer (1986, 1990) and Krugman (1991a). These papers develop arguments about specialisation set out in Marshall (1920). This development, when coupled with the analysis of Arrow (1962) on the nature of invention and technological advance, yields this new theory of innovation and growth. [see Baptista for references]

174 Allen (1983) describes more fully how spillovers resulting from close contact and observation can reduce uncertainty.

3. Clustering also improves innovation by **facilitating interaction between suppliers and clients**. This allows for spillovers and feedbacks that induce innovation and organizational improvement (Fagerberg 1995). Repeated interactions between users and producers of a technology decrease the costs of technology transfer and accelerate diffusion (Lundvall 1988). Slaughter (1993) found that, in some cases, users appear to be a greater source of ideas to enhance technology development than the producers of that same technology.

A.4.3 Empirical Evidence

There is substantial empirical evidence in support of knowledge spillovers as a cause of clustering:

- Jaffe (1986) found that productivity growth increases with both own R&D and R&D of neighbouring firms in technological space, as do the returns to R&D activity;

- Bernstein (1989) and Bernstein and Nadiri (1989, 1991) estimated the effect of intra- and inter-industry spillovers on firms' cost structures, finding evidence that inter-industry effects have a strong downward effect on average costs of production. These cost benefits would be greater in firms with larger R&D spending;

- Acs et al. (1992) find evidence that geographical proximity seems to play an important part corporate patenting rates, since there is strong co-location of university and corporate R&D at the state level, and this co-location of activity has a positive impact on the generation of knowledge;

- One of the first studies on the location of patented inventions was Thompson (1962). He found that more than 90 per cent of the patents in the sample had their origin in central metropolitan areas, suggesting that invention was essentially an urban phenomenon;

- Jaffe (1989) found that corporate patenting activity within a particular state increases with the level of research expenditures undertaken by universities in that state. Acs et al. (1992), replicating Jaffe's study, found a strong correlation between university and corporate R&D at the state level, with both having a positive impact on the generation of knowledge;

- Jaffe et al. (1993) used data on patent citations to determine the extent to which knowledge spillovers are geographically localized. Their results find a strong localization of spillovers. Most spillovers occur within a metropolitan area, but some occur within the same state;

- Feldman (1994) found an important correlation between the location of innovative output and of manufacturing value-added. Her results indicate that regional innovative output increases in the presence of high private and academic research expenditure within the state and, in particular, the location of related industries nearby. This seems to demonstrate the importance of regional networks of innovators in highly innovative industries; and

- Baptista and Swann (1998) found that firms located in strong clusters, where employment in their own (two-digit) industry is high, are significantly more likely to innovate than firms located in more sparsely populated clusters.

Clusters also raise productivity, as the following studies show:

- Henderson (1986) found strong evidence that industry concentration in a particular location raises factor productivity;

- Ciccone and Hall (1993) found a positive elasticity between geographical density of employment and productivity; and

- Glaeser et al. (1992) do not detect a positive relation between industry concentration and city employment growth, but find evidence that industry diversity and competition have a positive effect on growth.

In summary, the literature suggests that networks of related innovating firms, such as those found in successful clusters, make an important contribution to innovative effort, output and productivity. Proximity to rivals seems to cause improvements in the internal organisation of firms, boosting the growth and performance of both incumbents and entrants.

A.4.4 Maximising the Value of Clusters

All clusters are unique. Those that are successful for their success for different reasons. The benefits of locating in a cluster (or industrial district) are related to the availability of skilled labour and intermediate goods suppliers, and also to the easy transmission and discussion of new ideas. Three properties are common to all successful innovative clusters:

- Formal and informal networking, allowing for effective transfer of technology and other organizational capabilities;

- Close user-producer collaboration allowing for production flexibility and joint development; and

- Mobility and flexibility in the local labour market, allowing for low redundancy costs and easy adaptation to changes in products and processes.

A.4.5 Technology Incubators[175]

In some countries, spillover effects and the benefits of clustering have been used as a rationale for government encouragement of technology incubators.[176] In Europe, parks have often been established through a partnership between national and local governmental institutions, private firms and local universities, and were intended to replicate earlier US success stories.

Some authors are critical of the effectiveness of parks.[177] In spite of the diffusion of parks in Europe, the evidence provided by the literature is not clear on whether innovation rates of park firms exceed comparable firms located off-park.

- In an early study of UK firms, Monek et al. (1988) found that:
  - The percentage of qualified scientists and engineers out of the total workforce and the R&D intensity, measured by the ratio of R&D expenses to sales, of on-park firms were higher than those of firms in a control sample;[178] and
  - No statistically significant difference emerges between on- and off park firms as to the number of patents and copyrights (see also Westhead and Storey, 1994).
- Westhead (1997) found that tenant firms do not outperform firms located off park in terms of the number of new products and services launched to both existing customers and new markets.
- A recent study by Colombo and Delmastro (2002) found Italian technology firms located in technology parks do not innovate at higher rates or produce more patents than an outside-park control group, though in-park firms do grow faster and attract more highly educated staff.[179]

175 This section on incubators is based on Colombo and Delmastro (2002).

176 Incubators are defined to include science parks and business innovation centres.

177 See, for example, Macdonald (1987).

178 These results were not replicated in a later study (Westhead, 1997), which found such differences to be statistically insignificant.

179 The study also showed that incubated firms also showed a greater likelihood of establishing formal cooperative relations, both of commercial and technical nature; the difference between the on- and off incubator samples was especially remarkable as concerns technical collaborations with universities.

- Similar to the results of Colombo and Delmastro (2002), Westhead and Storey (1994) show, using data over the period 1986-1992, that UK independent park firms had consistently higher growth rates than their off-park counterparts. Their results also indicate that parks were able to attract more qualified entrepreneurs.

This literature, though not unanimous, suggests that if the objective of government is to raise innovation rates then government-sponsored technology incubators may not be especially helpful.

A.4.6 Policy Implications

The reviewed literature identifies no significant barriers to the formation of clusters. Furthermore, there does not appear to be any suggestion of a divergence between public and private returns to the development of a cluster. While spillovers are the source of market failure in other innovation activities discussed, cluster spillovers are different in that firms within the cluster both supply and receive spillover benefits. To the extent these spillovers encourage agglomeration, government intervention cannot be expected to raise welfare.

Accordingly, there appears to be little justification, either theoretical or empirical, in support of government assistance in the formation of clusters. Policy implications seem to be limited to removing impediments to the private development and success of clusters. This includes:

- Reducing restrictions on the mobility of labour; and

- Creating safe harbours that permit cooperation and collaboration between rivals without fear of anticompetitive consequences.

A.5 THE INNOVATION SYSTEM[180]

Innovation is not produced by merely having adequate levels of each input into the innovation process. Linkages and interaction between different factors and different parts of the economy are essential. This section describes the importance of developing these linkages and outlines suggested government policy responses.

A.5.1 Description

There is no one factor determining the innovative capacity of a nation. Innovation depends on strength in a number of areas:

180 This section closely follows Gans and Stern (2003).

- An innovation-conducive environment depends on the quality of human resources, effective public policy, and innovation-oriented corporate investment;

- Innovation primarily occurs in private companies. Clusters in which oligopolistic firms compete on the basis of innovation (but cooperate in other areas like dissemination of new products and ideas) is crucial to innovation;[181] and

- Universities and other "institutions for collaboration" have a central role in facilitating knowledge transfer, and are central determinants of the innovative capacity[182] of a region or particular location.

According to Porter (1990; 1998), the foundation of international competitiveness begins with:

- Effective public policy; and

- Clusters competing on the basis of innovation and value enhancement.

A higher rate of innovation in one nation does not come at the expense of others. The ability of firms in one country to create new ideas may actually complement innovations created in others. Thus, raising innovation rates can improve the prosperity and productivity of all nations, and collectively increase world economic growth. However, a clear pre-requisite for such growth is the existence of information linkages between countries.

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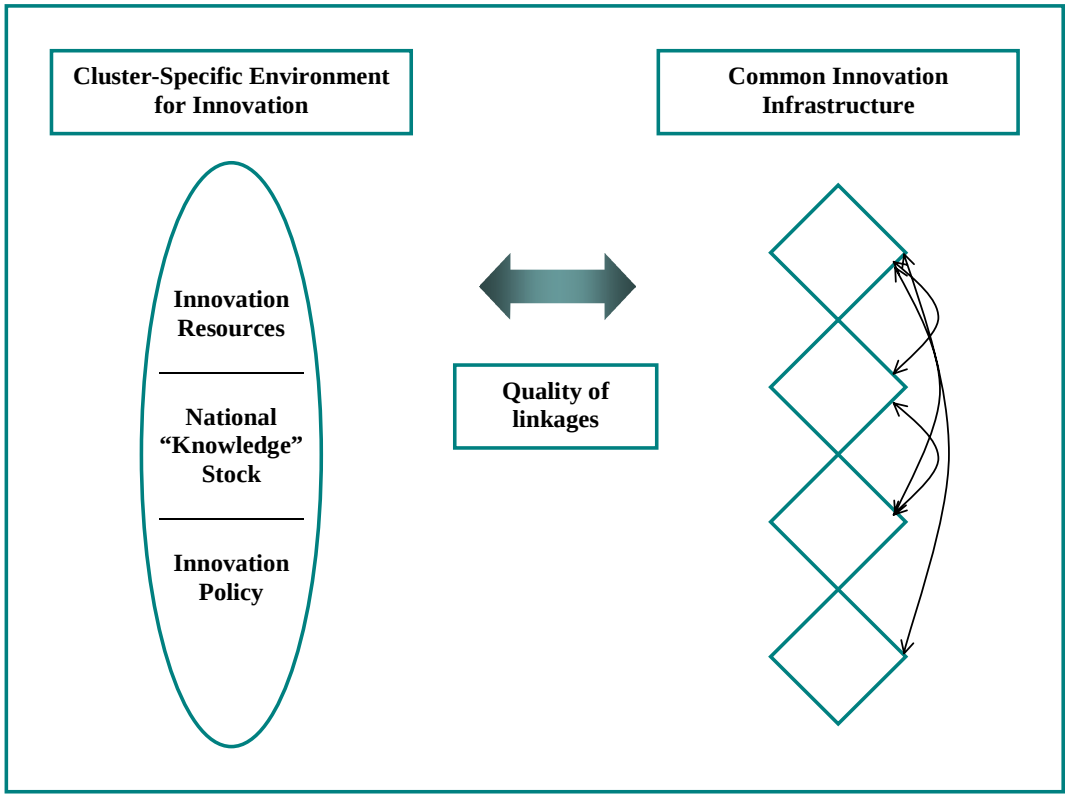
181 For example, Baumol (2002:ix) writes: "[M]anagements are forced by market pressures to support innovative activity systematically and substantially, and success of the efforts of any one business firm forces its rivals to step up their own efforts. The result is a ferocious arms race…with innovation as the prime weapon. At the same time, there is profit to be earned by an innovating firm by licensing others, at a suitable price, to use its proprietary technology. The result is widespread cooperation among firms in the dissemination of up-to-date technology, and that, in turn, hastens widespread replacement of obsolete products and processes."

182 The term "innovative capacity" has been used extensively by prior researchers in the economics, geography and innovation policy literatures. For example, in the economics and innovation policy literature, Pavitt (1980), along with co-authors at the Sussex Policy Research Unit, employed the term in a similar way as used here in the economics and innovation policy literature. Suarez-Villa (1990, 1993) provides a fuller articulation of the concept within the geography literature, focusing on the specific linkage between invention and innovation. See Gans and Stern (2003) for references to literature discussing the origins and definition of innovative capacity in the academic literature.

Figure 4: Drivers Of National Innovative Capacity



Source: Gans and Stern (2003).

Figure 4 shows the drivers of innovative capacity. The left side represents the cross-cutting factors that support innovation throughout many or all industries. This includes:

- Investments in basic research;
- Investment in education;
- A network of universities conducting research and training scientists, engineers, and others in advanced problem-solving; and
- Policies that affect the incentives for innovation in any industry.

On the right side, the diamonds signify the innovative environment of clusters.[183] The lines connecting clusters indicate spillovers can occur across clusters, as well as within them. The finite geographic extent of spillovers means that in large countries the focus on cluster-based innovation is appropriately done at the regional rather than national level.

A.5.2 Common Innovation Infrastructure

The common innovation infrastructure is the set of factors supporting innovation throughout an entire economy. It includes the pool of human and financial resources devoted to scientific and technological advances, the economy wide public policies bearing on innovative activity, and the economy's inherited level of technological sophistication. Specifically, the common innovation infrastructure includes:

- Investment in basic research;
- Tax policies affecting corporate R&D and investment spending;
- Supply of risk capital;
- Aggregate level of education in the population;
- Pool of talent in science and technology;
- Information and communication infrastructure;
- Protection of intellectual property;
- Openness to international trade and investment; and
- Overall sophistication of demand.

183 According to Gans and Stern, it is appropriate to focus on clusters (e.g., information technology) rather than individual industries (e.g., printers) because there are powerful spillovers and externalities that connect the competitiveness and rate of innovation of clusters as a whole.

The foundation of a nation's common innovation infrastructure lies in its scientists and engineers who are involved in innovation. Sustained government support for research, particularly university-based research, augments the pool of scientists and engineers since research funding often end up attracting new talent into the country. The overall education level is an important element of a country's innovative capacity; the ability of firms to develop specialised expertise in designing innovative products and processes depends on the availability of sufficiently talented labour.[184]

However, raising education levels is not enough to guarantee innovation. Empirically, the quality of science in a country (as measured by the number of important publications) is only a weak predictor of national success in commercial innovation.[185] Other institutions that enhance the common innovation infrastructure include:

- A strong information infrastructure;
- Access to capital, particularly for the translation of innovations into commercial products and services;
- An appropriate set of federal and state policies, such as:
  - Policies that protect intellectual property;[186]
  - Other policies, including the extent of R&D tax credits, a regulatory environment that encourages competition, and efficient taxation of capital gains – affect incentives for innovation across the economy; and
  - Policies toward the openness of the economy to international competition are also an essential component of the national innovative environment; open borders encourage upgrading through increased competition and the inflow of ideas.

A further aspect of the common innovation infrastructure is the degree of sophistication in the tastes of consumers. The drive for innovative products is derived in great measure from the domestic demand for such products.

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184 Although technological work is performed by only a small subgroup of the labour force, innovative personnel are not necessarily technical staff. Innovation arises in numerous domains, such as marketing, service, and management.

185 See Stern, Porter and Furman (1999).

186 In the absence of protection of intellectual property, firms will keep discoveries secret. One rationale for IP protection is therefore providing the promise of rewards for encouraging firms to disseminate their knowledge by making such dissemination profitable (Gans and Stern 2003:44-5).

Finally, there is an important reciprocal interaction between the common innovation infrastructure and cluster-specific circumstances. Each cluster in the nation draws on the common innovation infrastructure, but its investments and choices also contribute to the development of the common innovation infrastructure, which we now describe in more detail.

A.5.3 Quality of Linkages

The quality of the connections between a nation's common innovation infrastructure and individual industrial clusters is crucial, since such linkages increase innovation, and strong clusters both feed from and provide for development of the common infrastructure. Without strong linkages, upstream scientific and technical advances can diffuse to other countries more quickly than they can be exploited at home.[187]

A particularly important linking institution is a nation's university system. The university sector is a key channel by which basic, fundamental research leads to the emergence of innovation-oriented domestic clusters. In addition, public policy that pressures universities to conduct relevant research and produce high-quality students fosters links from innovation clusters to the common innovation infrastructure.

A strong university sector provides an important conduit through which basic, fundamental research results serve to catalyse the emergence of innovation-oriented domestic clusters. By placing pressure on universities to conduct relevant research and produce high-quality students with specific technical skills, private funding and involvement in the university sector may serve to foster a key reverse linkage from the clusters to the common innovation infrastructure.

A.5.4 Distilling the Measures of Innovative Capacity

According to the theoretical framework of Porter and Stern (2000), measuring the innovative capacity of a country requires measures that reflect the common innovation infrastructure, the innovation environment in clusters, and the quality of linkages between these two areas. There is no "magic bullet" to any of these measures. However, Gans and Stern (2003) note that when several of these influences improve concurrently, national innovative capacity will tend to rise.

Quality of the Common Innovation Infrastructure

- Aggregate personnel employed in research and development;
- Aggregate expenditures on research and development;

187 For example, although early elements of VCR technology were developed in the United States, it was three companies in the Japanese consumer electronics cluster that successfully commercialised this innovation on a global scale in the late 1970s.

- Strength of protection for intellectual property;
- Share of GDP Spent on secondary and tertiary education; and
- GDP per Capita.

Cluster-specific Innovation Environment

- Percentage of R&D expenditures funded by private industry; and
- Concentration of patents across broad technological areas.

The Quality of Linkages

- Percentage of R&D performed by universities (discussed above).

A.5.5 Empirical Evidence

Using the above measures, empirical estimates show a strong relationship between the strength of national innovative capacity and per capita international patenting. Gans and Stern (2003) note that this result is interesting: while countries differ in the institutions and mechanisms used to influence and conduct innovative activity, there is a clear relationship between a small set of measures of the innovation environment and a key measure of innovative output which holds across all the countries.

Empirical estimates are very successful in explaining innovation capacity. Overall, the measures of the strength of national innovative capacity explain more than 97 percent of the variation in international patenting. These results are robust to a variety of alternative specifications and appear to have been consistent over time.[188]

One of the strongest influences on innovative capacity is the relative size of the R&D workforce. Estimates suggest a 20 percent increase in the size of the R&D workforce in a country would lead to a change in the predicted value of the Index of just over 14 percent. Both the level of R&D expenditures and the proportion of funding from industry also play decisive roles in determining the level of innovative outcome. The results suggest that increasing the percentage of total R&D expenditure funded by private industry by 10 percentage points (e.g., by shifting industry's share from 50 to 60 percent of total expenditures) increases the level of innovative capacity by over 13 percent.

188 See Stern, Porter, and Furman (2002).

The magnitude of other effects, such as the strength of intellectual property and the extent of public funds devoted to education, is somewhat smaller, but are important as well. The imperfect measure of the strength of linkages (the share of R&D performed by universities) also turns out to be a significant but modest contributor to international patenting performance.

GDP per capita is a strong statistical determinant of international patenting as well, reflecting the importance for innovative capacity of a strong accumulated knowledge pool and a sophisticated and demanding domestic customer base.

A.5.6 Role for Government

The role of the government is to ensure that the innovative capacity basis exists by investing in the linkages between the three dimensions of common innovation infrastructure, cluster-specific environment, and the quality of linkages.

Universities have been identified as having key roles in the facilitation of linkages between research and industry commercialisation. In leading innovation economies, the university system has three roles. First, it provides required training for a technically skilled labour force. Second, it undertakes "basic" research investments that serve as the foundation for a country's industrial clusters. Third, by serving as a neutral broker within and among companies themselves, universities serve to serve as a knowledge hub through which spillovers are achieved.

Governments can raise innovation by appropriate funding and policy mechanisms. Universities as linkage mechanisms can be enhanced by research grants between industry and universities. A second way is to promote R&D that has been carried out by universities. A less centralised solution is through the use of R&D tax breaks for company funding of university research. Gans and Stern (2003:48) argue this would directly induce a process of interaction between industry and universities.

Other opportunities for linkages may exist in venture capital. Although venture capitalists are usually viewed as simply a source of funds, they are also a source of specialist expertise in managing the commercialisation of new technologies, as well as providing a network that encourages the dissemination of these technologies. A linkage role for venture capitalists and industry and universities may prove especially productive, again implying a role for government in facilitating these links.

A.6 FOREIGN DIRECT INVESTMENT[189]

As a mechanism for international technology transfers, foreign direct investment (FDI) may be one of the most important. The empirical evidence, though limited, shows:

- In 1995 over 80 percent of global royalty payments for international transfers of technology were made from subsidiaries to their parent firms (UNCTAD 1997);
- The importance of FDI for international trade in technology: during 1985-97, between two-thirds and nine-tenths of technology flows were intrafirm in nature;[190]
- Multinational firms are concentrated in industries that exhibit a high ratio of R&D relative to sales and a large share of technical and professional workers (Markusen 1995);[191] and
- FDI lowers concentration and increases competition in the host country.[192,193]

189 This section is based on Saggi (2002).

190 UNCTAD (1999).

191 It is commonly argued that multinationals rely heavily on intangible assets, such as superior technology, for successfully competing with local firms that are better acquainted with the host country environment.

192 For example, see Driffield (2001).

193 Teece (1985) argues that FDI flows are determined by the desire to internalise across national boundaries (vertical FDI), or to exploit assets through foreign production (horizontal FDI). Teece (1985) then points out that vertical integration is a response to market failure. Accordingly, vertical FDI may reduce a monopoly problem in the host country. Cho (1990) cites this effect in the Indonesian banking sector, arguing that foreign presence reduces concentration, particularly where entry barriers deter domestic entry.

Not surprisingly, governments around the world have aggressively pursued FDI. Many regions of the UK, in common with most of Europe, have development agencies, who have come to see themselves as the marketing function for the region to attract internationally mobile investments.[194] For more than 20 years the UK has encouraged investment from abroad by spending substantial sums on marketing its regions around the world. Partly as a result of this spending, the UK has received more inward investment than any other European Union Member State since 1980.[195] Particular regional development corporations, such as the Welsh Development Agency, Scottish Enterprise, and One NorthEast, have been concerned with attracting inward investment, and the 1980s witnessed an upsurge in foreign investment with an increasing tendency to locate in peripheral regions.[196] These policies appear to have been successful in attracting inward investment: Wales, Scotland and the North of England all attracted shares of FDI out of proportion to their size.[197]

A.6.1 Sources of FDI Technology Spillovers[198]

At a general level, the literature suggests the following potential channels of spillovers.

- **Demonstration effects**. Local firms may adopt technologies introduced by multinational firms through imitation or reverse engineering.[199]

194 Driffield and Taylor (2000:93).

195 Driffield and Hughes (2003). The UK attracted 41% of all Japanese investment between 1984 and 1991, some 9% of total Japanese foreign direct investment (FDI) and 21% of all US FDI since 1987 (Driffield, 1999).

196 Nijkamp and Blaas (1995) examine how the European Regional Development Fund (ERDF) has influenced private investment rates across European regions. Hill and Munday (1994) provide similar results for domestic regional inward investment incentives for the UK. Wren and Taylor (1999) demonstrate that investment incentives have had the effect of changing the regional distribution of economic activity across the UK in general. Accordingly, it appears that investment incentives have encouraged firms to locate away from regions that demonstrate a more obvious location advantage. This may explain the limited positive spillovers from FDI observed in regional areas (see page 153).

197 See Figs 1 and 2, Driffield and Hughes (2003).

198 The other major benefit of FDI is the potential for agglomeration economies. Models of regional development that are based on agglomeration and capital mobility essentially model economic development as a path dependent process (see, for example, Markusen and Venables, 1999). Agglomeration economies are relevant to clustering (see section A.4).

199 The literature notes that FDI may occur for reasons of *technology exploiting* or *technology sourcing*. FDI motivated by technology exploitation is likely to have greater productivity spillover effects on the domestic economy than FDI which is motivated by the desire to acquire technology from the domestic sector. Driffield and Love (2002) empirically test for and find a relationship between FDI motivation and productivity spillover effects on the relevant host country sector: spillovers, in the form of domestic productivity gains, from technology *exploiting* firms are greater.

- **Labour turnover**. Workers trained or previously employed by the multinational may transfer important information to local firms by switching employers or may contribute to technology diffusion by starting their own firms.[200]

- **Vertical linkages**. Multinationals may transfer technology to firms that are potential suppliers of intermediate goods or buyers of their own products.

Empirically, the effect of these spillovers on productivity appear substantial. Barrell and Pain (1997) estimated that around 30% of the productivity growth in UK manufacturing between 1985 and 1995 could be associated to the impact of inward investment. The "ripple" effect of changes in production and working practices triggered by the presence of new inward investors appears to have been especially important.

200 The available evidence on labour turnover itself is mixed. For example, although Gershenberg's (1987) study of Kenyan industries finds limited evidence of labour turnover from multinationals to local Kenyan firms, several other studies document substantial labour turnover from multinationals to local firms. Rhee (1990) discusses the case of the garment industry in Bangladesh. Korea's Daewoo supplied Desh (the first Bangladeshi firm to manufacture and export garments) with technology and credit. Thus, Desh was not a multinational firm in the strict sense; rather, it was a domestic firm that benefited substantially from its connection with Daewoo. Eventually, 115 of the 130 initial workers left Desh to set up their own firms or to join other newly established garment companies. The remarkable speed with which the former Desh workers transmitted their know-how to other factories clearly demonstrates the role labour turnover can play in technology diffusion.

Pack (1997) discusses evidence documenting the role of labour turnover in disseminating the technologies of multinationals to local firms. For example, in the mid-1980s, almost 50 percent of all engineers and approximately 63 percent of all skilled workers that left multinationals left to join local Taiwanese firms. By contrast, Gershenberg's (1987) study of Kenyan industry reports smaller figures: of the 91 job shifts studied, only 16 percent involved turnover from multinationals to local firms.

A.6.2 Features of FDI

FDI has four features relevant to policy setting.

Option value: Firms will usually export to countries prior to committing to FDI. This is because FDI by a firm is at least partly sunk and made under uncertainty, implying the extinction of a valuable investment option.[201] This option is preserved if the company elects to first export, and in doing so learn about local conditions prior to deciding to invest domestically.[202] Policy implication: attempts to attract FDI should be targeted at firms already exporting into the country.

Domino Effect: A host country may be able to unleash a sequence of investments by successfully inducing FDI from one or two major firms, for two reasons. First, gaining information about a foreign country is costly and, once discovered, may spill over to rival firms. Firms seeking to invest in foreign markets will learn valuable lessons from the successes and failures of others.[203] Knowledge spillovers from the entry of the first firm reduce the fixed costs of further FDI, potentially inducing a domino effect. Second, strategic considerations may influence the choice between exports and FDI. For example, when two firms are exporting to a foreign market, a switch from exports to FDI by one may well create an incentive for FDI on the part of the other firm if it finds itself at a competitive disadvantage (see Lin and Saggi 1999). Policy implication: reduce informational asymmetries; target only the first one or two large firms in an industry in expectation of others following.

Complementarity with Human Capital: The recipient country can only appropriate technology spillovers from FDI if it has human capital of a sufficient standard. Access to foreign technologies alone may not be enough to increase the growth rate.[204]

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201 See Saggi (1998).

202 In his studies of British multinationals, Nicholas (1982, 1983) finds that 88 percent of the firms sold their products through a contract with a local agent before converting to directly owned sales or production branches. Kinoshita and Mody (1997) found that both private and public information play important roles in determining investment decisions. They argue that information regarding many operational conditions (such as the functioning of labour markets, literacy, the productivity of the labour force, and timely availability and quality of inputs) may not be available publicly. Such information is either gathered through direct experience or through the experience of others.

203 Lin and Saggi (1999) use a duopoly model in which the first firm to switch from exporting to FDI confers a positive externality on the subsequent investor by lowering its fixed cost of FDI.

204 See Borensztein and others (1998), Keller (1996) and Xu (2000).

Complementarity with Technological Capability: Making use of technological spillovers also requires a minimum level of existing technology. Glass and Saggi (1998) emphasise that indigenous technological capability in an industry constrains a country's ability to host foreign technology.[205] Policy implication: FDI that is "within reach" of existing human capital and technology of the recipient country will generate spillovers of greater value.

A.6.3 Empirical Evidence on Economic Effects

Productivity and Wages

It is generally assumed that technology spillovers will increase the marginal product of labour, and this increased productivity will show up in the wages for workers.[206] Driffield (1999) finds that inward investment acts to increase industry wages, and that domestic firms respond by reducing employment. Wang et. al. (2002) find labour productivity to be higher in foreign subsidiaries than in UK-owned firms, holding industry influences constant. Japanese-owned firms are estimated to have a 31% productivity advantage over UK-owned firms; US-owned firms have a 25% advantage and European-owned firms a 23% advantage.[207] Oulton (1998) finds similar results for US-owned firms. Griffith (1999) finds that in 1992 value added per worker in the UK was 39% higher in French-owned establishments, 32% higher in German-owned establishments; and 41% higher in US-owned establishments (after controlling for industry differences). Globerman et al. (1994) find that, after correcting for sectoral differences, foreign-owned firms operating in Canada have significantly higher productivity than Canadian-owned establishments. The cause of these productivity advantages also appear to differ by country: for US subsidiaries, intangible assets are important, while for Japanese and European subsidiaries capital intensity is important.[208]

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205 Haddad and Harrison (1993) find that when sectors were divided into high and low tech, the effect of FDI at the sector level was found to be more positive in low-tech sectors. The authors interpret this result as indicative of the lack of absorptive capacity on the part of local firms in the high-tech sector, where they may be further behind multinationals and unable to absorb foreign technology. Also see Xu (2000).

206 Early efforts in search of spillovers from FDI related inter-industry variation in productivity to the extent of FDI (Blomstrom 1986; Blomstroom and Persson 1983; Caves 1974; Globerman 1979) and found that sectors with a higher level of foreign involvement (as measured by the share of the labour force in the industry employed by foreign firms or the extent of foreign ownership) tend to have higher productivity, higher productivity growth, or both. However, causation was not established, and Aitken and Harrison (1999) note this literature may overstate the positive impact of FDI on local productivity because, instead of being the cause of the high productivity, investment may have been attracted by the more productive sectors of the economy.

207 Earlier estimates of productivity advantages of foreign firms are even higher. Davies and Lyons (1991) foreign-owned enterprises held a 48.6% productivity advantage over domestically owned enterprises in the late 1980s. The authors point out, however, that the superior performance of foreign-owned subsidiaries may simply reflect the fact that they are clustered in industries with above average productivity. This is labelled the 'structural' effect. Decomposing productivity into industry-level analysis, Davies and Lyons (1991) find that the productivity gap falls to 23.5%.

208 Wang et. al (2002).

Other studies show weaker effects of FDI on productivity and wages. Aitken and others (1996) find no positive impact of FDI on the wages of workers employed by domestic firms; instead the authors report a small negative effect for domestic firms. However, they find the effect for the entire industry is positive (since multinationals pay more), and that wage spillovers from foreign to domestic firms are associated with higher productivity in domestic plants. Griffith (1999) finds of no productivity advantages for Japanese-owned firms operating in the UK. Djankov and Hoekman (2000) find a *negative* spillover effect of FDI on TFP growth of purely domestic firms in the Czech Republic. However, when joint ventures are excluded from the sample and attention is restricted to the impact of majority-owned foreign affiliates (that is, FDI) on all other firms in an industry (including joint ventures), the negative effect loses statistical significance. Aitken and Harrison (1999) also find productivity in domestic plants declines when foreign investment increases i.e. negative spillovers from FDI, suggesting that this is caused by a loss of market share of domestic firms in combination with economies of scale. Overall, however, Aitken and Harrison (1999) find FDI weakly raises productivity over the entire industry.

Domestic Investment

Markusen and Venables (1999) show theoretically that inward investment into a region should stimulate domestic activity, and that this domestic development may eventually replace the original FDI. This result is dependent on the phenomenon generally described as the linkage effect, and is well documented in the regional science and technology spillovers literature (see, for example, Young et al., 1994, or Driffield, 2001b).

The empirical evidence tends to support the theory, showing that FDI tends to stimulate, rather than crowd out, investment by domestic firms. However, this result depends on the industry. In a study of UK manufacturing, Driffield and Hughes (2003) find that FDI significantly enhances domestic investment in motor vehicles and transport, *inter alia*, but discourages investment in the manufacturing of paper production and office equipment.

At a macroeconomic level, the fact that FDI usually involves capital inflows alongside technology transfers implies a positive impact of FDI on economic growth in the host country. However, there are two caveats to this:

- A positive correlation between FDI and economic growth may simply reflect the fact that countries that are expected to grow faster attract FDI because it yields higher returns i.e. causation could run from growth to FDI; and

- Multinationals often raise the required capital in the host country, and in such a scenario capital inflows associated with FDI may not be substantial. An optimistic view of FDI would then look to technology transfer and/or spillovers as the mechanism through which FDI may affect growth.

Using data from 46 developing economies, Balasubramanyam and others (1996) investigate the effect of FDI on growth. They report two main findings:

- The growth-enhancing effects of FDI are stronger in countries that pursue a policy of export promotion rather than import substitution, suggesting that trade policy is an important determinant of the value of FDI to the host country; and

- In countries with export-promoting trade regimes, FDI has a stronger effect on growth than domestic investment.[209]

The second finding may also be viewed as a confirmation of the hypothesis that FDI results in technology transfer.

An important finding by Driffield and Hughes (2003) is that the effect of FDI on domestic investment in the UK varies by geography. In particular, their study shows that peripheral regions of the UK which have targeted FDI using public money, including Wales and Scotland, suffer reductions in domestic investment i.e. crowding out. Driffield and Hughes (2003:284) write:

> *[T]he regions that appear to have suffered the greatest crowding out effects are those that have spent large amounts of public money on attracting inward investment as part of their regional development strategies.*

A possible explanation for the different effects across areas receiving and not receiving assistance is that domestic firms in assisted areas are unable to compete with MNEs, and exit industries that experience large scale assisted FDI. A further possibility is that the purchasing policies of MNEs contribute to this. Phelps, (1993), Turok (1993) and Turok (1996) show that local sourcing by MNEs in such regions is low, and that many 'locally produced' inputs are produced by secondary investors with vertical relations to the MNE.[210] A third explanation is that in cases where host regions or industries exhibit low levels of physical and human capital intensity, then domestic firms may not be able to assimilate any technology externalities that occur as a result of inward investment. A fourth, related explanation is that where firms are attracted to a region because of low wages, or simply because of a capital or employment subsidy, then the activities undertaken by the foreign firm may be low skill, low value added activities; technology spillovers will again be limited and the displacement effect will dominate.

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209 Borensztein and others (1998) also find similar results.

210 Driffield and Hughes (2003) find an exception to the negative relationship between domestic investment and assistance in Northern Ireland. Driffield and Hughes speculate that foreign investment in Northern Ireland may be more 'embedded' than in other parts of the UK. An alternative reason they propose is that domestic investment during the sample period was only stimulated by the exogenous shock to investment that was caused by FDI.

There is little benefit in subsidising FDI if firms are locked into existing arrangements that preclude direct investment. Glass and Saggi (2002) find that the ability of firms to switch modes from licensing technologies to FDI in response to policy changes is vital for ensuring that a subsidy to FDI leads to faster economic growth.

Finally, FDI can be expected to increase competition. Accordingly, domestic firms can be expected to suffer from this increase in competition from the entry of foreign firms. However, part of the benefit of inward FDI is that it can help eliminate relatively inefficient domestic firms.[211] Resources released in this process will be put to better use by foreign firms with superior technologies, efficient new entrants (domestic and foreign), or some other sectors of the economy. Furthermore, the additional competitive pressure on domestic firms combined with any technological spillovers may induce further innovation, bringing the considerable long run benefits of dynamic efficiency.

A.6.4 Rationale for Government Intervention

Policies designed to lure in FDI have proliferated around the world in recent years, but the empirical evidence reviewed here makes it difficult to base the case for these policies on the positive spillovers from FDI to domestic firms. However, studies that show no evidence of spillovers should be treated with caution if:

- They treat FDI as exogenous; or
- FDI spillovers, which may be vertical in nature, are examined horizontally.

Furthermore, all such studies find that the subsidiaries of multinationals are more productive than domestic firms. Thus, regardless of the evidence on the spillover issue, FDI does result in a more effective use of resources in host countries.

To the extent that spillovers to domestic firms are important, FDI by private agents may occur at suboptimal rates (compared to a social optimum) and government intervention may be justified on efficiency grounds. However, the jury is out on both the existence and magnitude of these spillovers. Accordingly, a solid case for government intervention cannot be made on the basis of FDI externalities.

211 A 2001 study by the OECD recommended that governments should establish policies that encourage unsuccessful firms to exit with minimum wastage of resources. The study found that most labour productivity growth originates within existing firms. However, there is also a significant contribution from the exit of firms with low productivity. By contrast, the entry of new firms usually has only a minor impact on aggregate productivity, the exception being firms in the ICT sector. See OECD, *Economic Outlook*, No. 69 (2001).

An alternative case for FDI incentives can be made on the basis of the increased competitive pressure that FDI brings to bear on domestic firms. Mexico's recent experience with FDI in its automobile industry is instructive. Initial investments by U.S. car manufacturers in Mexico were followed by investments not only by Japanese and European car manufacturers but also by firms that made automobile parts and components. As a result, competition in the automobile industry increased at multiple stages of production. Such a pattern of FDI behaviour (that is, investment by one firm followed by investment by others) reflects the strategic considerations involved in FDI decisions and a domino effect, discussed earlier.

Another policy issue is the problem of picking winners. Many Southeast Asian countries, for example, still do not allow free entry of multinational firms and often express preferences with regard to the type of FDI; that is, entry by Pepsi or Coke is viewed differently to entry by General Motors. Such policies are closely related to the idea of industrial targeting in general, and the pitfalls of the government's ability to correctly identify high-spillover industries are well known.

A.6.5 Policy Implications

The literature presented here suggests that targeting FDI assistance may be quite helpful for the host country in maximising spillover benefits. We noted above that Driffield and Hughes (2003) find FDI significantly enhances domestic investment in certain industries, and discourages investment in others. Accordingly, policy which encourages FDI should not be generic; instead it should target industries where FDI is likely to deliver the greatest benefits. The factors that determine an industry's suitability for obtaining benefits from FDI include:

- The extent to which the domestic sector can be expected to compete with larger, technologically superior firms that may also enjoy an entry subsidy;
- The industry-specific reasons for entry by the MNE; and
- The relative levels of domestic human capital and technology in the industry compared with the entrant.

The literature does support the use of FDI as a tool for the development of low-technology and low-skills areas, or as a tool for the development of all industries. Accordingly, FDI assistance should be targeted by:

- Industry;
- Source Country, since US, European and Japanese firms offer different sources of higher productivity;
- Geography, since the value of FDI varies by the capability of regions to absorb spillovers; and

- **Firm** – make use of the domino effect by identifying and targeting one or leading companies in an industry.

A.7 MIGRATION[212]

Other things being held constant, neo-classical theory associates population growth with negative effects on per steady state capita output and growth, a result of the (uncontroversial) assumption of decreasing returns to labour in the production function. Both natural population increase and immigration shares this presumption of negative per capita effects.

However, immigrants are not like new-born babies in one crucial respect. When immigrants enter the host country they bring with them the human capital accumulated in the origin country. In addition, after arrival they may accumulate human capital differently than the local population or they can influence the local people's accumulation of knowledge.

In the literature, the yardstick of the value of migration is not global economic welfare, including welfare of the country from which migrants have departed, but rather the economic welfare of the domestic population in the recipient country. This reflects the political factors that determine immigration policy in the context of national boundaries.

The value of migration to the recipient domestic population depends on the following four factors:

- Human capital of the immigrant;
- Net migration rate;
- Propensity of migrants to invest in human and physical capital after arriving; and
- Assimilation.

Assimilation refers to the ability of migrants to obtain education and obtain appropriate employment. Inasmuch as immigrants accumulate human capital differently than the local population, the assimilation process at least has the potential for being an important factor for the host economy growth.[213] However, since the mid-1990s the underlying assumption of the literature that a favourable assimilation process always accompanies a migration inflow has been disputed. To the extent that assimilation is less than perfect, the estimated benefits of immigration will be reduced.

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212 This section is based on Dolado et al (1994).

213 See Cartiglia (1992).

A.7.1 Empirical Estimates

Dolado et al (1994) produced widely-cited estimates of the effect of net migration on output per capita based on a modified Solow (neo-classical) growth model using data for nine countries, all net receivers of immigrants. Based on theoretical predictions from a Solow model augmented for human capital and migration, they produce a table showing the expected impact of various measures of immigration characteristics, which is summarised in Table 32.

Table 32: Estimates of Effect of Migration Factors on Growth

	Growth Rate	Steady State Output Level
Average human capital per immigrant	+	+
Net migration rate[214]	–	–
Migrant Investment Propensity	+	+

Source: Dolado et al (1994), Table 2.

Empirically, their results are consistent with Table 32. Dolado et al find a one per thousand increase of net migration reduces output per capita in the steady state by 1.6%.[215] The same increase of net migration reduces the growth rate of output per capita by 0.04 percentage points. The effects of a change in the immigrants versus domestic population human capital ratio, a 0.1 increase of this parameter increases output per capita in steady state by 0.41% and the current growth rate by 0.02%.

Endogenous growth models, rather than assuming exogenous growth at a defined rate as in neo-classical models, assumes growth is an endogenous function of the model. Scarth (1987) explains that endogenous growth models are used to explain why the world supply of capital does not flow inexorably from capital-rich countries to capital-poor countries. The neo-classical growth model would predict a lower marginal return from capital in high-income countries. However, it must be the case that the marginal product of capital is not falling in rich countries, despite the much higher level of the capital/labour ratio there. New growth theory involves removing the assumption of diminishing returns with respect to the reproducible factors of production.

214 Net migration rates are negatively related to per capita growth and steady state output because of the neo-classical assumption of declining returns. That is, marginal returns to labour decline as the supply of labour increases relative to all other inputs.

215 Assumes default parameters values. See the article for details.

Recent work by Ben-Gad (2003) using an endogenous growth model finds that, for the US over the last 35 years, the increase in the rate of immigration from 1.9 to 3.6 has lowered the rate of per-capita growth between 0.024% and 0.029%. Similarly, the drop in the relative level of educational attainment that is expressed of newly arrived immigrants as the drop in relative wages lowered the rate of growth per head by 0.029%. Taking the two effects together, Ben-Gad concludes per-capita income in the United States would be no more than 1.7 to 2.0% higher had the size and properties of the flow of immigration remained unchanged over this period.

In summary, migration has two conflicting effects on economic output:

- Larger net migration rates tends to reduce economic output per capita, a consequence of the assumption of declining returns; and

- Migration raises the human capital stock of the country; immigrants with more human capital tend to raise economic growth, other things being equal.

Overall, Dolado et al claim the dominant effect is probably the first; immigration will tend to depress per capita income unless the human capital of migrants is exceptionally high. However, the overall effect is in any case unlikely to be especially large. The reviewed literature makes two broad policy recommendations:

- There is benefit to local peoples of the recipient country of selecting migrants with a minimum level of human capital.[216] Whether that capital is defined by education or experience is not relevant; and

- Chang (1998) argues migrant tariffs rather than quota will more efficiently control migration levels. Tariff is set according to migrant education. Highly educated migrants would pay a negative tariff.

216 Empirical evidence suggests that the human capital of migrant populations is quite high anyway, almost as skilled as local people.

A.8 SUBSIDIES ON PHYSICAL CAPITAL[217]

Unlike human capital, physical capital is not generally considered to produce to spillovers. Furthermore, when technology is dynamic and future dominant technologies are uncertain, then subsidies risk unduly early investment in infrastructures deployed too far in advance of the availability of demand.[218]

On the face of it, this would leave little role for government since:

- In the absence of spillovers, social and private returns to investment in capital should generally be well aligned and investment can be expected to be efficient; and
- The costs of early investment are substantial, particularly when investment is sunk and made in unproven technologies that may turn out to be of no use to future applications.

In spite of these concerns, industrial investment strategy programs are supported by the governments of many countries. Factor subsidies have been used extensively in European countries as important policy instruments, usually in an attempt to reduce regional unemployment differentials (Armstrong & Taylor (1985) and Holden & Swales (1993)). Most developing countries provide fiscal incentives to encourage domestic and foreign investment. These schemes provide substantial capital subsidies and produce greater capital intensity in manufacturing (Lim (1992)).

Capital subsidisation has been at the centre of industrial policy in Israel over the last thirty years, and is the subject of efficiency analysis by Bregman (1998). The declared objectives of the scheme were to:

- Encourage economic growth and employment;
- Improve the balance of payments; and
- Disperse the population throughout the country.

Subsidies were allocated with the aim of favouring industrial plants located in designated development zones, and/or the encouragement of exports. Other general factors taken into consideration in the selection of projects, as declared by the Investment Authority, were the potential for creating employment, for contributing to the development of the area, and for profitability.

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217 This section is based on Goolsbee (1998) and Bregman (1998).

218 For example, Sweden has vast quantities of under-utilised broadband internet infrastructures for which there is no obvious use and no current horizon on when the sunk investment will be recouped. See Shim, Yongwoon; Heejin Lee and Kyunglim Yun. 2003. The Growth of Broadband Internet in Sweden: Contributing Factors. Paper presented at the Asia-Australasia Regional Conference of the International Telecommunications Society, Perth Western Australia, June 22-24, 2003.

Bregman (1998) argues the subsidisation system in Israel and elsewhere is full of discriminations:

- By destination - between production for local markets and exports;
- By ownership - between local and foreign investors;
- By industry - manufacturing versus services;
- By area;
- By type of asset (equipment versus structures); and
- In practice, also by size.

Bregman (1998) reports the Israeli scheme caused investors to prefer physical capital, which attracted the subsidy, to labour, which did not. Cheap capital, sometimes at a cost of less than half its value, apparently resulted in over-investment, poor utilisation of machinery and equipment in industry, and unbalanced growth in the economy.

Areas receiving the subsidies did not necessarily benefit over the long term. The high rate of subsidisation brought more investments but mainly for short periods. Many of the subsidised plants in these areas closed down a short time after the subsidisation period ended (Lavy, 1994). In general, participation in government subsidy schemes in order to set up new firms in developing towns appeared to be associated with shorter life span of firms. Bregman also reports the Israeli scheme was subject to costly lobbying of politicians. The government tended to prefer subsidising large firms that could deal with the bureaucracy and exert higher pressure on the politicians.

Bregman estimates the efficiency losses of the capital subsidisation scheme for the years 1990-94, and finds capital subsidies resulted in allocative production inefficiencies ranging from 5% for firms that received the average level of subsidies to 15% for heavily subsidised firms. Bregman also finds that much of the subsidisation appears not to have been necessary, in the sense that subsidised firms generally have earned higher rates of return on their total physical capital (including that portion which was subsidized) than firms that were not subsidised.

This last finding of Bregman's is consistent with those of Goolsbee (1998a), who investigates the impact of capital subsidies on the US market for labour. Goolsbee finds that a substantial proportion of capital subsidies end up on the bottom line of firms or passed through to employees, and may do little to stimulate capital investment: a 10% investment tax credit, for example, raises the relative wage of capital goods workers by 2.5%-3.0% on average and up to around 10%, depending on the workers' characteristics. Goolsbee concludes that:

> *The simple idea that wages rise when demand for goods increases in the short run can fundamentally change our view of investment tax subsidies. Policies intended to stimulate investment demand may, in fact, lead to large transfers to suppliers or producing workers with little increase in total investment. The propensity of policy makers in the U.S. to change investment tax policy every few years may do little to change the level of investment and much to give periodic windfalls to the manufacturers of investment goods and their workers.*

A.9 SUPPLY OF GRADUATES

Romer (2000) argues that innovation policy in the United States has erred by subsidising the private sector demand for scientists and engineers without considering whether the educational system provides the supply response from scientists and engineers necessary for these subsidies to work.

When governments subsidise R&D, it is hoped that firms will redirect their efforts towards the targeted activity. R&D is labour intensive and increased effort in R&D is usually taken to imply a re-allocation of labour so that a higher proportion of the work force ends up in R&D. Accordingly, policies that attempt to stimulate the demand for research and development require a positive response in the supply of engineers. According to Romer, the US education system seems incapable of providing this response. Instead, the evidence is that R&D subsidies end up raising wages for existing R&D labour with a relatively limited increase in the supply of labour or R&D effort (see Goolsbee 1998a).

Romer argues that steps are needs to raise the responsiveness of the supply of graduates to demand conditions in labour markets. Potentially, the returns to an increase in supply-side response is very high. In a survey of returns to investment in R&D, Griliches (1992) reports a wide range of estimates for the social return, with values that cluster in the range of 20% to 60%. If the true value of the social return on additional investment in R&D is 25%, then an increase in spending on R&D by 2% of GDP would *permanently* raise the growth rate by 0.5% per year.[219] If the true social return is higher, say 50%, the extra investment in R&D needed to achieve this result would be one additional percent of GDP

Part of the low responsiveness of students to conditions in the labour market is due to the lack of information that is available to students who are making decisions about careers in science and technology. Romer (2000) found that while business schools seems quite willing to supply post-graduate wage and labour outcome statistics, science departments are much less willing or able to do so. Romer argues that this suggests U.S. existing educational institutions may not lead to the kind of equilibration that we take for granted in many other contexts.

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219 For context, the average U.S. growth rate over the last century has been about 1.8% per annum (Romer 2000:9).

Romer notes the increasing importance of migration as a source of highly educated labour which is responsive to demand conditions. Furthermore, migrant graduates are relatively concentrated in high-returns fields (see Table 33).

Table 33: Proportion of Foreign Born Students Earning Ph.D. By Field of Study - U.S. (1993)

Field	% Foreign Born
Engineering	40%
Computer Science	39%
Social Sciences	13%

Source: Romer (2000:30).

A.9.1 Government Policy

Romer proposes the following goals for U.S. government policy.

1. Increase the fraction of 24-year-old citizens of the United States who receive an undergraduate degree in the natural sciences and engineering from the current level of 5.4% up to 8% by the year 2010 and to 10% by 2020.

2. Encourage innovation in the graduate training programs in natural science and engineering.

3. Preserve the strengths of the existing institutions of science.

4. Redress the imbalance between federal government subsidies for the demand and supply of scientists and engineers available to work in the private sector.

To achieve this, Romer offers the following schemes.

1. Provide training grants to undergraduate institutions that are designed to increase the fraction of students receiving NSE degrees.

2. Finance the creation of a system of objective, achievement-based (rather than normed) tests that measure undergraduate level mastery of various areas of natural science and engineering.

3. Create and fund a new class of portable fellowships, offered to promising school students, that pay $20,000 per year for three years of *graduate* training in natural science and engineering.[220]

A.9.2 Summary

The literature reviewed here is very limited and confined to the U.S. There is no information available to suggest that the policy ideas proposed here have relevance to New Zealand. However, similar concerns about declining numbers of science and engineering graduates have appeared here, and this literature has demonstrated a complementary connection between the efficacy of R&D subsidies and the supply response of technical labour to demand. If real (as opposed to reported) rates of R&D are to increase in New Zealand, then this section provides evidence that returns to R&D subsidies will be considerably increased by increasing the output of skills which is required for such research.

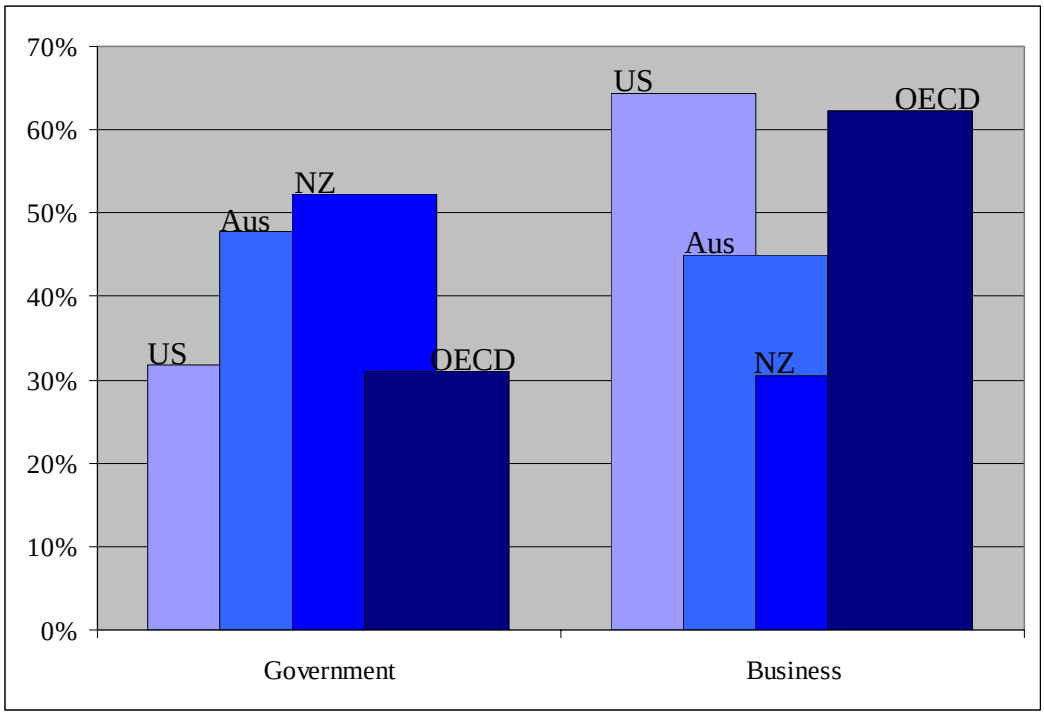
A.10 Overseas Trends in Public R&D Expenditure

According to the OECD (2002), countries within this organisation are devoting more resources to R&D. After some stagnation in the first part of the 1990s, OECD-wide R&D investments grew (in real terms) from US$416 billion to US$552 billion between 1994 and 2000. R&D expenditure increased from 2.04% to 2.24% of GDP. The European Union as a whole lagged behind the United States and Japan, with an R&D intensity of 1.9% in 2000 compared to 2.7% in the United States and almost 3.0% in Japan. This growth resulted almost exclusively from increases in industry-financed R&D, up by more than 50% in real terms between 1990 and 2000. Government funded R&D grew only 8.3% during this period. As a result, the share of total R&D financed by industry reached 63.9% in 2000, considerably above its level of 57.5% in 1990; government share in R&D expenditure declined from 39.6% to 28.9% over this period.

220 It could offer to a randomly selected treatment subgroup a fellowship that will pay $20,000 per year for 3 years of graduate education in natural science or engineering if the student receives an undergraduate NSE degree. There would be little reason to pay them a subsidy for undergraduate education. Virtually all of these students already go on to get an undergraduate degree. Granting the award before they begin their undergraduate study would allow them to take the science courses that prepare them for graduate study. Because the treatment group would be randomly selected, it will be easy to verify whether these grants increase the likelihood that a student receives an undergraduate NSE degree. One could also look among the students who continue their studies in graduate school and see whether the recipients of the portable fellowships select career paths that differ from the students who are supported under the existing RA and TA positions.

In New Zealand, government expenditure on R&D as a proportion of total spending is relatively high and business expenditure is correspondingly low. New Zealand public expenditure on R&D is nearly double the OECD average; business expenditure is less than half the average. These statistics, to the extent they are robust, raise some very interesting questions, e.g., is government spending on R&D crowding out private spending? Such questions are beyond the scope of this study, but are likely to be of importance to innovation policy.

Figure 5: Public and Private Expenditure As Share of Total R&D Expenditure (1997)[221]



Source: OECD Science, Technology and Industry Scoreboard 2001 (http://www1.oecd.org/publications/e-book/92-2001-04-1-2987/A.3.htm)

OECD governments are paying more attention to the contribution of science and innovation to economic growth. Governments have introduced a variety of new initiatives and reforms in several countries, including Australia, Canada, Hungary, Ireland, Korea and Spain. The countries have introduced comprehensive R&D policy frameworks, and in a number of countries, government institutions and agencies have been restructured in an attempt to improve the governance of innovation systems. Policy evaluation has become more widespread.

221 Other funding sources are "Other National Sources" and "Abroad," which are not represented here.

Many OECD countries are reporting actual or expected increases in their investment in R&D and innovation. EU leaders have pledged to increase spending on R&D and innovation to 3% of GDP by 2010. The governments of Austria, Canada, Korea, Norway and Spain have established explicit targets to increase national investment in R&D and innovation. Non-member countries, including China and Russia, also report significant increases in government R&D spending. All such attempts to raise levels of R&D spending will call for complementary efforts to increase the supply of the S&T graduates and research personnel, especially in the business sector.

In short, there has been an increasing focus on innovation as a source of future growth across OECD nations as governments around the world come to realise the importance of innovation to continued future economic growth. In this context, the review of the innovation policies of Singapore and other countries is a logical first step towards emulating and improving on the policy developments in other countries.

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APPENDIX B: INDUSTRIAL POLICY IN THE ASIAN TIGERS

B.1 INTRODUCTION

The Asian tiger economies (Singapore, Hong Kong, Taiwan and South Korea) have a number of striking similarities. Each has high investment ratios, relatively small public sectors, fairly competitive labour markets, and expanding exports.[222] They have undertaken large investments in their human capital and have well developed capacities to absorb new technology. They are relatively densely populated and limited in natural resources. The countries are also similar in several non-economic characteristics: compact geography, low population growth rates, and the Confucian tradition. Another similarity between the countries, and probably one of major significance, has been the relatively low degree of inequality of income and wealth.

However, the Asian tiger economies have dissimilarities as well, among them the quite stark differences in their approaches to economic development. This section briefly describes the roles taken by government in each of these economies against the common background of spectacular economic growth. The purpose of this description is to help place Singapore's economic success, and growth and innovation policies, in perspective. Our research on the economies of Hong Kong, South Korea and Taiwan has of necessity been very brief and non-critical. However, the following description should still illustrate the variation in economic models across these countries.

The chief findings of this section are that:

- Strong and consistent economic growth in south East Asia has occurred both with and without large scale government intervention;
- It is arguable that initial government intervention in South Korea, Taiwan and Singapore resolved a market failure in the form of coordination problems. In particular, there was a relatively high pre-existing level of human capital compared to physical capital, making latent returns to capital investment very high. Large private British institutions in Hong Kong may have fulfilled this coordination role, at least early on[223]; and

222 Nirvikar and Trieu (1996).

223 For an alternative view on the primary cause of economic growth in the tiger economies, see footnote 232.

- Starting in the 1970s, government interventions in South Korea and Taiwan appear to have been less successful than at the start of development in each country in the 1960s. This is consistent with the coordination failure hypothesis, which implies rapidly declining returns to government intervention as the coordination problem is addressed and resolved.

The co-ordination explanation for the spectacular growth of the Asian tigers simultaneously underscores the importance of initial conditions – the existence of a serious market failure to be resolved, in combination with high levels of human capital – and may explain why similar policies implemented in other countries have usually produced such disappointing results.

B.2 HONG KONG

Until the mid-twentieth century, Hong Kong was incorporated into the global economy as an East Asian entrepot. Hong Kong had the only developed deep water port on the southern coast of China, and prospered throughout much of its history as the gateway to China. It enjoyed a place as a trans-shipment point for goods and financial services between China and western countries. Hong Kong's industrial manufacturing dates back to the early 1950s. Since then, Hong Kong has developed to become a major commercial and financial services centre of south East Asia.

Unlike the governments of other tiger economies, the government of Hong Kong has broadly limited its support to the maintenance of macroeconomic and social stability. The Hong Kong government has adopted a 'bottom-up' approach to removing obstacles to industrial and commercial investment, rather than imposing a selective industrial strategy based on a 'top-down' model that was adopted elsewhere.[224]

224 Liang and Denny (1995).

From the 1970s, the government's approach was described as 'positive non-interventionism'. The government adopted a model of fiscal conservatism, characterised by stability and self-sufficiency. The government carefully contained the growth of public expenditure, even during recessions, in sharp contrast to the in-vogue Keynesian model of prioritising economic over financial stability. The government refused to provide tax subsidies to industries or to introduce progressivity in the tax system to redistribute income.[225] Instead, the government followed the neo-classical economic prescription by delivering physical infrastructure, national security, and a functioning legal system. The government intervened in the private sector only in the case of demonstrable market failure (e.g. a banking crisis in 1965). It developed institutions to improve the markets for labour, finance, and technology, and actively maintained a low cost structure to enable the poor to meet basic needs, through the regulation of the labour market and the costs of transportation, housing, health care and education.[226] The Hong Kong government was also unwilling to provide funds to support strategic industries. Hong Kong spent relatively little on R&D, compared to other Asian tiger economies (see Table 34).

Table 34: Public Expenditure on R&D in South East Asian Economies

Country	Public Expenditure on R&D (% of GDP)
Hong Kong (1993)	0.10%
Korea (1992)	2.17%
Taiwan (1991)	1.73%
Singapore (1993)	1.12%

Source: Tsui-Auch (1998).

The government did, however, intervene in the economy in a rather *ad hoc* way. For example, the government attempted to provide land for industrial uses, developing new towns and reclaimed lands for industries. In the late 1980s the government started to subsidise industrial-use land for companies using technology-intensive techniques, in an attempt to overcome land investments primarily for real estate returns rather than technology-intensive purposes. In another initiative, the Industrial Development Board (IDB) was set up to plan and monitor local industries.

225 Tang (1994).

226 See Ho (1992) and Schiffer (1992). The low costs were also partially subsidized by China, which supplied food and consumer goods to Hong Kong at stable and below world market prices until the early 1970s. The government considered the maintenance of a low cost structure important to provide a larger profit margin for the industrialists relying on labour-intensive industries.

In the 1990s, a change in the direction of government policy occurred, and interventionist industrial policies were more actively pursued. The government set up the Hong Kong Industrial Technology Centre in 1995 to enhance co-operation between industry and academia on technological development. The centre was modelled on similar institutions in Japan, Europe, and the USA, and serves as an 'incubator' for high-tech start-up firms and as a technology transfer agent between academia and industry.[227] Funding has been provided to encourage applied R&D in firms and universities through the establishment of the Applied R&D Scheme in 1993 and the Co-operative Applied R&D Scheme in 1995 to support product development projects undertaken in collaboration with institutes in mainland China.[228] There were also signs of an official attempt to respond to the City's demand for managerial and technical personnel: the existing universities and polytechnics were expanded, the new University of Science and Technology was established in 1991, and technical and vocational training was strengthened (though not very successfully, according to Tsui-Auch 1998).

In summary, the Hong Kong government has shifted from the 'positive non-interventionism' orthodoxy of the 1970s and 1980s to more recently adopt active industry-specific measures, although apparently not to anywhere the scale of Singapore. This shift in policy reflects both the change in industrial climate and the perceived success of selective industrial policies in neighbouring countries. As of 1998, Hong Kong's new Chief Executive had promised to further help promote industrial and technological development.

B.3 KOREA

Under the Rhee government of the 1950s, Korean policy was preoccupied by largely political considerations, and the government attached no particular importance to either economic growth or exports.[229] There were multiple exchange rates and a haphazard, ineffective programme of export subsidies.[230] However, after a military coup in 1961 the newly installed President Park made economic growth a priority.

227 Hong Kong Government (1996).

228 Hong Kong Government (1996).

229 Jones and Sakong (1980:272-273).

230 Frank et al. (1975: 38-39).

Park inherited a country with a set of advantageous initial social infrastructure conditions. In particular, Korea had a skilled labour force, relative to its physical capital stock and income levels. As well, the post Korean war involvement of the U.S. helped provide a politically and militarily stable and peaceful environment, conducive to development. However, according to Rodrik (1994b), the transformation to a modern economy required massive and coordinated shifts in resources. A market failure in the form of a coordination breakdown was blocking economic development;[231] while the rate of return to coordinated investments was extremely high, the rate of return to individual investments remained low.[232]

In response, the Korean government began a process of identifying areas of the economy that provided Korea with the greatest potential for growth. Investment subsidies were introduced, mainly in the form of the extension of credit to large business groups at negative real interest rates. Korean banks were nationalised after the military coup of 1961, and the government obtained exclusive control over the allocation of investible funds in the economy. Credit was allocated on the basis of "economic" criteria.[233] Interest rates were increased for depositors, and savings rose. Alongside this, a rapidly increasing contribution from government savings and a steady inflow of foreign savings enabled Korea to achieve a very high rate of investment during the 1962-73 period.

The Korean government socialised investment risk in selected sectors. The government provided an implicit guarantee that the state would bail out those entrepreneurs investing in "desirable" activities if circumstances later threatened the profitability of these investments. This guarantee induced aggressive expansion through the fail-safe government-sponsored investment activities. However, Park (1990) argues this risk taking was excessive.

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231 The profitability of the modern sector depends on the simultaneous presence of the specialized inputs; but the profitability of producing these inputs in turn depends on the presence of demand from a pre-existing modern sector. It is this interdependence of production and investment decisions that creates the coordination problem. Rodrik (1994b) argues that this coordination problem is most severe in economies characterised by high levels of human capital but limited physical capital – precisely the conditions in the tiger economies prior to economic take-off.

232 Rodrik (1994b) maintains that economic growth in Korea and Taiwan occurred after the government solved a market failure in the form of a large coordination problem. However, while this argument seems to fit well with the observed phenomena, Rodrik's view is at odds with the more traditional version of the source of economic growth in East Asia, which is that initial import substitution was followed by re-orientation towards export industries as a means of earning foreign exchange to fund imports. However, Rodrik's response to this line of reasoning is that it is incomplete and that, "[t]he measured increase in the relative profitability of exports during the 1960s is too insignificant to account for the phenomenal export boom that ensued." (p. 1).

233 Deserving users were judged on the basis of their investment plans, technology, domestic linkages, and scale economies. Since credit was more likely to be awarded to those with some track record, the loan allocations necessarily favoured established firms, and the chaebol in particular. This explains why, unlike in Taiwan, expansion of the manufacturing sector has come primarily through the growth of existing firms, rather than the entry of new firms.

In addition to providing subsidies, the Korean government played a much more direct, hands-on role by organizing private entrepreneurs into investments that they may not have otherwise made. According to Amsden (1989:80-81):[234]

> *[t]he initiative to enter new manufacturing branches has come primarily from the public sphere. Ignoring the 1950s, ..., every major shift in industrial diversification in the decades of the 1960s and 1970s was instigated by the state....*

The government established many new public enterprises in the 1960s and 1970s, particularly in basic industries characterized by a high degree of linkages and scale economies.[235] The Korean government helped establish a successful ship-building industry by guaranteeing the external borrowing of the firms involved in its development.[236] Hyundai, the car maker, was also provided with financial guarantees, opening a path to entry into the scale economies-rich car industry.

The government was also instrumental in establishing Korea's steel industry. The government provided POSCO with capital assistance as well as infrastructure subsidies (for the construction of water supply facilities, port facilities, an electricity generating station, roads, and a railroad line). In addition, the government supported downstream industries to ensure demand for POSCO's production. According to the World Bank, POSCO eventually became "arguably the world's most efficient producer of steel",[237] supplying Korean mini-mills with steel at below world prices.[238] Moreover, the presence of POSCO stimulated in turn a wide range of upstream industries, ranging from capital goods to spare parts.

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234 Quoted in Rodrik (1994b).

235 Jones and Sakong (1980).

236 An account in *The Economist* about how Daewoo got into the shipbuilding business provides an example of the willingness of government to promote investment: "Mr. Kim [the founder of Daewoo] found himself in shipbuilding in 1978, when the government twisted his arm to take over a near bankrupt project to build a giant shipyard at Okpo, on Koje island near the southern port of Pusan. 'I did not have a chance to say no,' says Mr. Kim. Indeed, the government simply announced the move when he was out of the country" (November 26th, 1994:81).

237 Cited in Wade (1990:319).

238 In the early 1970s, the Korean government was turned down by the World Bank when it applied for a loan to construct a steel plant. The World Bank's argument was that Korea did not have a comparative advantage in steel.

Not all government policies produced successes, however. Once sectors were well established, rather than deregulate the Korean government elected to tighten its grip over manufacturing industries and financial intermediaries, in part a result of the confidence gained by government programs in the 1960s.[239] In the 1970s, the government encouraged a big and ultimately unsuccessful import substitution of technology- and capital-intensive products. Government investment bail-out policy (discussed above) produced serious moral hazard problems which came to a head in the 1970s in the heavy and chemical industries, industries which the government decided were required due to demand side complementarities with other parts of the economy. On the back of investment guarantees, multiple industrial groups engaged in what was essentially a bidding war for access to these limited but potentially lucrative markets. The result was massive over-investment and duplication.[240]

These setbacks in the 1970s motivated trade and financial liberalisation in the 1980s. However, this was not successful and by the late 1990s, the Korean economy was faltering badly. This was at least in part caused by the sheer size of the chaebol who, according to Lee (2000), were exploiting the national economy for their own benefit.[241] Foreign debt exceeded 150 billion dollars, or four thousand dollars per capita, and had almost quadrupled during the period 1993-1997, making the country nearly insolvent. The fragile chaebol-structured economy was hit hard by the financial and currency crisis of 1997 and 1998. The crisis unemployment of 2 million workers or 8.6% of the total work force, and the growth rate fell from +7% to -5.8%. The IMF bailed out the Korean government with an aid package worth US$60 billion. The money was given under the condition that South Korea reformed its economy and the debt-laden chaebol. Since then, chaebol reform has continued with, for example, the recent formal break-up of Hyundai into component divisions.[242]

239 Park (1990:119).

240 Park (1990:119).

241 Lee (2000:2) lists the following harmful effects of the chaebol: excessive and illegal debt financing; boundless expansion of capacity; charging excessively high prices; driving rival firms and small industries out of business through predatory tactics; suppressing technological improvements; persuading government to restrict new entry or open market policies; speculation in real estate and the stock market; and illegal inheritance or transfer of property. Lee argues this, "led to the ruin of the national economy and eventually heralded the IMF crisis."

242 Reported in *Business Week*, 25 August 2003.

B.4 TAIWAN

During much of the 1950s, economic goals did not particularly rank high with the Taiwanese leadership. The government was preoccupied instead with the re-conquest of the mainland. By the end of the decade, it became clear that the communist regime on the mainland was firmly entrenched. Taiwan's party elders came to see that economic development could be a better guarantee of the party's survival.[243] At this point, the government turned its energies to eliminating many investment-deterring distortions (such as multiple exchange rates and macroeconomic instability).

Like Korea, Taiwan was well endowed with a highly skilled labour force but was capital poor, and it had a coordination problem inhibiting growth. However, government policy was quite different to that implemented in Korea. The Korean government has been collaborative and even coercive in relations with the private sector, while in Taiwan, the government has been more supportive than interventionist.[244]

A major milestone early in Taiwan's development was the Nineteen Point Reform Programme instituted in 1960. This contained a range of subsidies for investment, and signalled a major shift in government attitudes towards investment. The improvement of investment climate became a catchphrase, and the simplification of administrative procedures and the liberalization of regulative measures with regard to economic matters became an official goal.[245] In 1965, many of the remaining administrative controls on new plants or capacity expansion were removed altogether.

In Taiwan, investment subsidies took different forms to those in Korea. Real lending rates were generally positive and credit subsidies were much less important. However, public enterprises did get credit on favourable terms, and they also served to socialize investment risk. An increase in public savings made an important contribution to total savings in both countries. The increase in the savings rate in the early 1960s coincided with a sharp increase in government saving after 1961.[246]

243 Wade (1990:246).

244 Park (1990:118).

245 Lin (1973:96).

246 See Kuo (1983:8-9).

The most important direct subsidies in Taiwan came in the form of tax incentives. The Statute for Encouragement of Investment (enacted in 1960 in conjunction with the nineteen-point programme mentioned above) represented a "sweeping extension"[247] of the prevailing tax credit system for investment. Amongst other things, the maximum business income tax paid by enterprises was reduced and tax holidays on new investments were increased. These investment incentives were further expanded in 1965, at which time the business income tax was reduced in all priority sectors listed in the investment law, and specified manufacturing sectors (in basic metals, electrical machinery and electronics, machinery, transportation equipment, chemical fertilizers, petrochemicals, and natural gas pipelines) were given complete exemption from import duties on plant equipment.

The Taiwanese government also undertook a more direct role in the direction of the economy, taking steps to ensure that private entrepreneurs would invest in certain areas. The government helped establish industries including plastics, textiles, fibres, steel, and electronics. For example, Wade (1990) provides an account of how Taiwan's plastics plant for PVC was built under government supervision, and handed over to a private entrepreneur upon completion in 1957. More generally, it was common for the state to establish new upstream industries and then either hand the factories over to selected private entrepreneurs (as happened in the case of glass, plastics, steel, and cement) or run them as public enterprises.[248]

A major distinction in policy between Korea and Taiwan is in scale; while policy makers in Korea focussed on industries with scale economies (steel, car production, ship building) and, consequently, the development of massive firms, Taiwanese production is marked by a large number of small and medium size firms.[249]

The Taiwanese state was instrumental in the early stages of the development of the electronics industry. In 1974, the publicly-owned Electronic Research and Service Organization (ERSO) was formed to bring in foreign technology and disseminate it to local firms. ERSO built the country's first model shop for wafer fabrication and entered a technology transfer agreement with RCA. It trained engineers, who later moved to private firms. The strategy led to many private-sector offshoots that commercialised the technology developed by ERSO.[250]

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247 Lin (1973:85).

248 Wade (1990:78).

249 According to Park (1990), Taiwan's planners did not focus on production technologies with increasing returns, as occurred in Korea; instead they consciously drew on the large pool of experienced entrepreneurs in Taiwan to stimulate production.

250 Wade (1990:103-105).

However, other strategies were not successful. For example, a 1970s push by the Taiwanese government into the automotive industry via its public enterprises failed.

The approach taken by Taiwanese authorities in selecting industries to nurture in this fashion was not built on economic theory, but based on what Wade calls "engineering concepts" such as, "take-off, linkages, gaps, substitutions, and incremental extensions" (Wade, 188). As an example, Wade notes that the rationale for the construction of a stainless steel plant in the early 1980s was to "fill a gap in Taiwan's infrastructure." Similarly, "[d]evelopments in electronics are being promoted with the aid of an input-output map which highlights gaps in the production structure within Taiwan."[251] These observations tend to support the coordination role of government advanced by Rodrik (1994b).

Taiwan suffered little compared with many of its neighbours from the Asian financial crisis. The global economic downturn, however, combined with poor policy coordination by the new administration and increasing bad debts in the banking system pushed Taiwan into recession in 2001, the first whole year of negative growth since 1947. Unemployment also reached a level not seen since the 1970s oil crisis.

While the Taiwan government has been more active in the market than in Hong Kong, it less it has been less interventionist than Korea. The Taiwan government has in general confined its role to providing social and physical infrastructure and other public goods, and balanced public needs with a desire to encourage private enterprise in its intervention.[252]

B.5 SUMMARY

In both Korea and Taiwan the way policy-makers viewed the economy and their role in it accords with the logic of the coordination failure hypothesis. The Korean government has always perceived itself as a mediating agent and a facilitator for bringing about industrial change, through arm-twisting, subsidies or public enterprises as the circumstances may demand:

251 Wade (1990:188).

252 Park (1990:118).

> *The Korean government can be seen as having achieved integrated decision-making by acting as a central agent mediating among market agents, forcing and facilitating information interchange and insuring the implementation of the decisions reached. The power of coercion appears to have been important to carrying out this role effectively. But coercion has typically not been absolute; it has balanced costs and benefits. Thus the Korean government can be seen as having adjudicated between suppliers and users, weighing costs and benefits from a collective standpoint and often intervening to reward cooperative players and punish uncooperative ones.*[253]

In Taiwan:

> *[T]he basic philosophy underlying [the government strategy] is that an economy will undergo certain stages of development, and at each stage there are certain key industries (such as integrated steel mill, large shipyard, and petrochemical plants) which through various linkages will bring about development of the entire economy. This strategy also assumes that government officials know what those key industries are and what policy measures should be adopted to develop these industries.*[254]

According to Rodrik (1994b), the available evidence strongly suggests that pro-active government policy was directly responsible for the "miracles" of the Asian tiger economies of Korea and Taiwan, as well as Singapore. The governments of these countries essentially solved a coordination problem that permitted the take-off of these economies. Context is important to understanding why government intervention was so successful. It was the initial conditions of these countries that provided government policy with such a high payoff; government intervention helped remove coordination failures in economies where, because of the highly skilled workforce, the latent return to investment was already very high. The key initial conditions that were common to each of the tiger economies included:

- A relatively skilled population;
- Relatively equal distribution of wealth that eliminated powerful interest groups and permitted governments to focus on economic growth; and
- A stable and principally honest bureaucracy capable of operating without rampant rent seeking.

However, having set development in motion in the 1960s, Park (1990:121) argues that the merits of continued government intervention in the economy were at best questionable, particularly in the 1970s when some serious failures directly attributable to government policy occurred in Korea and Taiwan.

253 Pack and Westphal (1986:99), cited in Rodrik (1994:29).

254 Hou, 1988, cited in Rodrik (1994:29).

The conclusions of Park (1990) on the East Asian experience seem appropriate. First, the similar results achieved under such different government policies suggest that there is no ideal unique model for governments to follow. It may be that the initial conditions and structural characteristics of the economy prior to take-off are more important than the details of government strategy. Secondly, the coordination explanation of the tiger economies provides an answer to the problem of why similar government policies employed elsewhere have generally been so disappointing: in the absence of either a serious coordination problem or a skilled workforce (or both), the industrial policies of the Asian tigers might be much less effective. To the extent that this explanation correctly explains the observed growth patterns in these countries, the policy lessons of the south East Asian economic experience may be limited.

APPENDIX C: R&D AND MEASUREMENT PROBLEMS

Primary Source: Romer (2000)[255].

The evidence does seem to suggest that more generous tax treatment for R&D leads to higher reported levels of spending on R&D at firms. (See for example Bronwyn Hall and John van Reenen, 1999.) An additional dollar in tax benefits seems to lead to about one additional dollar in reported R&D expenditure by firms. However, there is much less evidence about the extent to which this increase in reported R&D spending represents a true increase in spending relative to that which would have taken place in the absence of the credit. It is quite possible that some of this spending comes from re-labelling of spending that would have taken place anyway. Deciding what qualifies for this credit is apparently a nontrivial problem for the tax authorities. Between 20% and 30% of claimed expenditures by firms are disallowed each year (Science and Engineering Indicators - 1998, p. 4-48).

For the SBIR program, Josh Lerner (1999) finds that firms that receive grants from the government experience more rapid sales and employment growth than a comparison group of firms selected to be similar to the recipient firms. This could be an indication that firms that receive grants do devote more inputs to R&D. But it could also reflect unobserved, intrinsic differences between the control group, which was constructed *ex post* by the researcher, and the recipient group, which was selected on the basis of a detailed application process that was designed to select particularly promising firms. In related work, Scott Wallsten (1999) finds that firms that receive a research grant from the government under the SBIR program seem to substitute these grant funds for other sources of funds, with little or no net increase in spending on R&D.

For both the tax credit and direct grant programs, we can identify a coefficient *m* which measures the true increase in private spending on R&D associated with each additional subsidy dollar from the government. In each case, there is some uncertainty and debate about how large this coefficient is. But for any positive value of *m*, the argument outlined above shows that the entire increase in spending may show up as higher wages for the existing stock of workers, with no increase in the actual quantity of research and development that is performed. As a result, even a well-designed and carefully implemented subsidy could end up having no positive effect on the trend rate of growth for the nation as a whole.

255 This Appendix does not represent a thorough review of the literature on measuring R&D. However, the centrality of R&D measurement in this review and the importance of the relationship between R&D funding and actual research effort meant that some comment on the problems associated with measuring R&D effort was necessary.

Recent work by Austan Goolsbee (1998a) suggests that, at least in the short run, the wage changes implied by a weak supply response are apparent in the data. He compares census data on wages for research workers with time series data that capture the variation in government spending on R&D. Direct government spending is well suited for this kind of analysis because it does not suffer from the concerns about additionality that are present for government subsidies for R&D. Surprisingly, using only these crude data, he finds strong effects on wages. For example, during the defence build-up between 1980 and 1984, federal spending on R&D increased, as a fraction of GDP, by 11 %. His estimates suggest that this increased wages for physicists by 6.2% and aeronautical engineers by 5%.

In the face of this argument, defenders of demand-side R&D subsidies can respond in three ways. First, they can argue that people are not the only inputs used in R&D. If other inputs such as computers and specialized types of laboratory equipment are supplied elastically, then government subsidies for R&D could increase the utilization of these other inputs even if the number of scientists and engineers remains constant. If this were truly the intent of the various subsidy programs, it would be much more cost-effective for the government to provide the subsidies directly for these other inputs. Salaries account for the majority of total R&D spending. For example, in university based research, annual research expenditures on equipment during the last decade have varied between 5% and 7% of total research expenditures (Science and Engineering Indicators - 1998, p. 5-2). If the goal of the subsidy program were to increase the equipment intensity of research and development and if the ratio of spending on equipment in the private sector is comparable to the figure for universities, a special tax subsidy for the purchase of equipment used in research would be substantially less costly than one that is based on total expenditures including salaries. Similarly, the government could achieve substantial savings, and still increase the use of equipment in R&D, if it restricted the grants provided by the SBIR and ATP programs so that these funds could be used only for additional purchases of equipment.

In the case of the targeted grant programs administered by the ATP or the SBIR, a defender could argue that even if the existing research subsidies do not increase employment of scientists and engineers in the economy as a whole, they can increase employment at the recipient firms, at the cost of a reduction in employment at other firms. If government agencies were able to identify an allocation across firms and projects that is better than the one the market would implement, the targeted grant programs could still be socially valuable. Even the strongest supporters of the subsidy programs are hesitant to make this kind of claim about the superiority of government allocation processes. Note also that because the research and experimentation tax credit is available to all firms, it cannot be justified on this kind of basis of any hypothesized ability of the government to improve the allocation of research inputs between firms and projects.

If the goal is not to encourage equipment investment in the R&D sector or to give the government a bigger role in deciding how to allocate scarce R&D personnel, some other motivation must lie behind these spending programs. The final response for a defender of these programs could be to dispute the basic assumption behind the supply-and-demand model outlined here and argue that, at least in the long run, the supply of scientists and engineers working in R&D in the private sector does respond to demand-induced changes in wage. But to make this case, one must confront some of the peculiar features of the educational system that actually produce these highly skilled workers and ask if there are more cost-effective ways to increase the supply of these types of workers.

APPENDIX D: THE CURSE OF DISTANCE

New Zealand domestic markets are small and isolated. Distance from other markets is relevant for cross-border trade, and to the extent of domestic competition from overseas. The empirical literature distinguishes between the influence of borders and distance-from-market on trade. McCallum (1995) shows that, in addition to the impact of distance, borders seem to sharply reduce trade: for equal sizes and distances, regions trade much more between themselves if they are not separated by a national border. McCallum estimates that intra-country cross state (US) and cross province (Canada) trade was some 2200% higher than across the US-Canadian border.[256]

Why does distance matter in international trade? The main explanation is transaction costs, consisting of transport costs (increasing in distance, so it is more costly to deliver products to consumers far away), the time elapsed before delivering the good, which represents costs when the product is perishable in nature or looses value after a short period of time.[257] Distance between countries is also correlated with the strength of cultural[258] and informational linkages between them and those links have been shown to be important in bilateral trade volumes.[259] Deardorff (1995) finds that what matters for bilateral export volume is not just the absolute distance between the two countries, but their geographic positions relative to all other countries.[260]

Deardorff (2002) argues that distance will be especially problematic for remote countries specialising in time-intensive products. Venables (2001) discusses the trade-off between proximity and production costs, and argues that technological change that makes timely production easier will lead to production shifting closer to the centre i.e. *increase* the trade-inhibiting effects of distance. Evans and Harrigan (2003) show that for apparel imports into the US where timeliness is important, products grew much faster from nearby countries than they did from the traditional sources of US apparel imports in East and South Asia.

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256 Andersen and Van Wincoop (2003) argue that the gravity equations of McCallum are not informed by economic theory and that when the relevant modifications are made the intra-country trade relative to cross border trade falls to 44%.

257 Hummels (2001) argues that the premium that must be paid for air shipment far exceeds the interest cost savings on inventory in transit. The great premium attached to timely air delivery implies a powerful force for agglomeration and/or spatial inequality that is distinct from the transport-cost economizing motive emphasized in the economic geography literature.

258 Wei (1996) estimates that two countries speaking the same language tend to trade 80% more with each other than otherwise.

259 See Rauch (2001).

260 For example, even though the distance between Australia and New Zealand is about the same as that between Spain and Sweden, we may expect the first pair to trade more with each other, partly because it is further away from other markets (e.g., Europe and North America).

Empirically, distance is generally, though not always, found to have a strong negative effect on trade. Wei (1996) estimates a one percent increase in distance is associated with a 0.8 percent decrease in trade. Countries sharing an international border tend to trade 30% more than otherwise, controlling for distance. However, Wei also finds that the trade-inhibiting effects of distance are declining. Testing EC countries, he finds that over the period 1986-1994 "home bias" – the tendency to trade internally rather than across international borders other things being equal – declined at the rate of about 5% per annum.[261] Against this, Krishna (2003) finds no correlation for the USA between trade and welfare arising from either distance or income relating to any of the USA's trading partners. Accordingly, the extent of the importance of an open trade relationship between New Zealand and any other particular country continues to be an open question.

However, much variation in trade is also accounted for by international borders. Some border effects can be attributed to different currencies (Rose (2000)) and the presence of tariffs and quota trade barriers (Wolf (2000)). Other elements are more subtle. Border effects arise within as well as between countries. Wolf (2000) for the USA and Combes, Lafourcade and Mayer (2003) for France show that state and regional boundaries affect trade. However, Combes et al explain a significant fraction of the French regional border effects by social networks (measured by employees' birth places) and by business networks (measured by inter-plant connections). They found that these networks interacted with distance effects on trade by reducing transport costs, and that the effects were present in all industries. The finding of such network effects might have been suggested by the literature on the history of institutions that facilitate trade.

The effects of distance on trade and the interaction of the distance and border factors are very difficult to assess. However, their assessment is important in establishing what might be expected of internal and external trade of an isolated economy. Despite the width of the Tasman sea, for New Zealand the analysis suggests that open access to trade with its relatively large near neighbour, Australia, is almost certainly extremely important for New Zealand trade, and for the competition it potentially brings to the New Zealand domestic market. This is especially important in light of the small size of New Zealand domestic market which, because of transaction costs and arguably network dislocations implied by distance, suggest a separation of New Zealand's domestic market from other markets to an extent not experienced by many other countries.

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APPENDIX E: GDP DATA

Table 35: Real Income Per Capita, New Zealand and the Four Tigers (1999 US$ PPP) 1950-2001

	New Zealand	Singapore	Hong Kong	South Korea	Taiwan
1950	10,401	2,289	2,287	794	965
1951	9,414	2,323	2,368	732	1,022
1952	9,588	2,351	2,452	776	1,098
1953	9,659	2,386	2,537	996	1,180
1954	10,747	2,393	2,625	1,045	1,234
1955	10,722	2,430	2,719	1,087	1,289
1956	11,051	2,405	2,814	1,068	1,310
1957	11,112	2,391	2,913	1,121	1,360
1958	11,281	2,366	3,015	1,147	1,431
1959	11,830	2,255	3,122	1,155	1,515
1960	11,621	2,383	3,232	1,140	1,546
1961	12,018	2,498	3,345	1,159	1,607
1962	11,991	2,599	3,767	1,157	1,692
1963	12,489	2,785	4,211	1,223	1,871
1964	12,834	2,620	4,462	1,292	2,049
1965	13,414	2,751	4,976	1,335	2,129
1966	14,005	2,982	5,017	1,459	2,281
1967	13,145	3,261	4,975	1,529	2,476
1968	13,000	3,651	5,032	1,684	2,621
1969	14,208	4,088	5,512	1,896	2,794
1970	13,808	4,577	5,873	2,015	3,081
1971	14,301	5,057	6,155	2,601	3,440
1972	14,662	5,632	6,674	2,641	3,906
1973	15,398	6,164	7,326	2,930	4,246
1974	15,986	6,471	7,312	3,109	4,095
1975	15,520	6,630	7,209	3,261	4,113
1976	15,751	7,011	8,153	3,585	4,743
1977	14,926	7,450	8,978	3,893	5,216
1978	14,982	7,993	9,566	4,191	5,762
1979	15,244	8,622	10,101	4,428	6,063

	New Zealand	Singapore	Hong Kong	South Korea	Taiwan
1980	15,319	9,341	10,831	4,243	6,123
1981	15,996	10,004	11,553	4,436	6,498
1982	16,163	10,444	11,686	4,700	6,721
1983	16,384	11,044	12,166	5,163	7,336
1984	17,023	11,703	13,247	5,543	8,123
1985	17,081	11,236	13,163	5,848	8,454
1986	17,412	11,188	14,395	6,459	9,468
1987	17,342	11,984	16,083	7,132	10,041
1988	17,221	13,008	17,239	7,859	10,018
1989	17,276	13,858	17,575	8,278	10,068
1990	17,012	14,704	18,038	8,976	10,220
1991	16,268	15,458	18,799	9,719	10,868
1992	16,279	16,176	19,804	10,151	11,569
1993	17,120	17,906	20,662	10,601	12,267
1994	17,777	19,591	21,273	11,358	13,021
1995	18,229	20,792	21,671	12,245	13,739
1996	18,505	22,005	22,105	12,938	14,462
1997	18,638	23,483	22,526	13,436	15,292
1998	18,518	23,132	20,726	12,418	15,844
1999	19,139	24,441	20,911	13,634	16,548
2000	19,417	26,659	22,732	14,897	17,099
2001	19,807	25,843	22,413	15,341	16,374

Source: Groningen Growth and Development Centre webpage (http://www.eco.rug.nl/ggdc/index-dseries.html#top)

Table 36: Real Income Per Worker, New Zealand and the Four Tigers (1999 US$ PPP) 1960-2001

	New Zealand	Singapore	Hong Kong	South Korea	Taiwan
1960	31,389	7,892	16,368	4,158	5,132
1961		8,228	17,384	4,216	5,306
1962		8,510	16,848	4,199	5,562
1963		9,067	17,969	4,421	6,115
1964		8,479	16,677	4,719	6,813
1965		8,852	18,881	4,755	7,249
1966		9,544	18,226	5,190	8,407
1967		10,376	16,165	5,380	8,525
1968		11,552	15,722	5,776	8,812
1969		12,860	15,326	6,469	9,019
1970		14,320	15,940	6,876	9,817
1971		15,329	16,621	8,649	10,794
1972		16,550	18,346	8,532	11,954
1973	39,676	16,906	18,535	9,123	12,297
1974	40,257	17,505	19,558	9,445	11,727
1975	39,466	18,001	18,603	9,839	11,920
1976	39,741	18,469	21,154	10,358	13,663
1977	37,233	19,164	22,417	11,070	14,532
1978	37,623	19,622	23,017	11,568	15,703
1979	37,904	20,132	23,942	12,219	16,315
1980	38,103	20,936	24,482	11,820	16,500
1981	40,144	21,412	24,950	12,250	17,500
1982	40,129	21,623	25,530	12,854	18,059
1983	41,750	22,830	26,760	14,206	19,300
1984	43,295	24,365	28,489	15,521	20,976
1985	42,053	24,592	28,274	15,940	21,777
1986	36,956	25,442	30,356	17,168	23,700
1987	36,799	26,711	33,515	18,152	24,489
1988	37,890	28,231	35,540	19,581	24,453
1989	39,270	29,485	36,579	20,011	24,390
1990	38,825	30,070	37,966	21,278	24,960
1991	38,837	31,402	39,306	22,505	26,349

	New Zealand	Singapore	Hong Kong	South Korea	Taiwan
1992	39,105	32,352	41,921	23,285	27,686
1993	40,820	36,093	43,538	24,188	29,248
1994	41,217	38,825	44,770	25,425	30,647
1995	41,280	40,630	45,874	26,978	32,233
1996	39,704	42,588	45,141	28,267	34,114
1997	40,462	44,156	45,899	29,277	35,963
1998	40,675	43,172	44,018	28,838	37,149
1999	42,214	45,773	45,630	31,527	38,764
2000	42,640	45,432	49,148	33,189	40,576
2001	42,939	45,548	48,615	33,713	40,260

Source: Groningen Growth and Development Centre webpage (http://www.eco.rug.nl/ggdc/index-dseries.html#top)

APPENDIX F: RETURNS TO EDUCATION

Table 37: Estimates of Private, Fiscal and Social Rates of Return to Education at University Tertiary Level for Men and Women, 1995[262]

	Men			Women		
	Private [263]	Fiscal [264]	Social [265]	Private	Fiscal	Social
Australia	14	10	11	21	10	13
Belgium	14	9	9	8	13	9
Canada	14	7	9	21	7	11
Denmark	8	8	8	7	8	8
France	20	11	13	28	9	13
Sweden	–	6	9	–	4	7
United States	11	9	10	12	9	11

Source: OECD (1998), Table A4.3.

262 "–" indicates missing value or category not applicable.

263 Private returns are estimated on the basis of additional income of individuals for a given level of education over a working lifetime (to the age 64), including social transfers and non-labour income, and after deduction of income taxes and employee social security contributions, compared with additional private costs of tuition and forgone earnings for a given level of education.

264 Fiscal returns were based on the estimated value of additional income tax receipts and employee social security contributions less social transfers over a lifetime compared with the public costs of tuition and taxes on forgone earnings for a given level of education.

265 "Social" rates of returns are, thus a combination (or weighted average) of private and fiscal returns, but they exclude externalities or "spill-over" effects.

APPENDIX G: SURVEY OF R&D TAX INCENTIVES

Table 38: The Tax Treatment of R&D Around the World

Country (date enacted)	Definition of R&D for Tax Credit	R&D Depreciation Rate	R&D Capital Depreciation Rate	Tax Credit Rate	Base for Incremental Tax Credit	Carryback (CB) and Carryforward	Credit Taxable?	Special Treatment for SMEs	Foreign R&D by Domestic Firms	R&D by Foreign Firms
Canada (1960s)	Frascati, excl. soc sci. marketing, routine testing, etc.	100%	100% or 20% DB, 20% ITC, not buildings	20%	0	3 yr CB, 10 yr CF	yes	40% to R = C$200 grant if no tax liab., 35% cap eq ITC to $2 M	Kexpense no ITC, etc.	20% only?
France (1983)	Frascati, incl. patent dep. contract R, excl. office expenses & support personnel incl. upgrades, SW, overhead	100% or 5 yr cap.	3-yr SL (not buildings) accelerated	50%	[R(- 1) +R(-2)]/2 (real)	5-yr CF, 5-yrfor OL, TC refunded	no (recaptured)	yes TC < SOMFF	no accel dep unless cons. no credit	?
Germany	Frascati, incl. Develop- ment, improvements, software	100% cap. If acq.	30% DB, 4% SL - bldgs, cash grants?	none	NA	1/5 yr	NA	assistance via cash grant/ITC		25% on royalties
Italy	Frascati, incl. Software	100% or 5 yr cap.	accelerated	none	NA	NA	?	yes, ceiling		
Japan (1966)	Frascati, incl. depreciation of P&E, deferred charges benefit > 1 yr, incl. Software	100% or 5 yr cap.	accelerated 5% TC - bldgs	20% (max at 10% tax liab.)	max R since 1966	5-yr usual but credit limited to 10%	no	6% R instead (cap < Y100 m), 6% for envir./ disease	6% credit for coop with foreign labs	20% on royalties
UK	no special definition; treated as an expense, however	100%	100% if "scientific research"	none	NA	5-yr CF	NA			25% on royalties
US (July 1981)	excl. contract R (for doer), rev. engineering, prod. Improv., 35% contract R	100%	3-yr., 15-yr. for bldgs	20%	avg of 84-88 R	3/ 15 yr	yes	R&D to Sales 3% for startups	not eligible	same as domestic

Country (date enacted)	Definition of R&D for Tax Credit	R&D Depreciation Rate	R&D Capital Depreciation Rate	Tax Credit Rate	Base for Incremental Tax Credit	Carryback (CB) and Carryforward	Credit Taxable?	Special Treatment for SMEs	Foreign R&D by Domestic Firms	R&D by Foreign Firms
Australia (July 1985)	Frascati, excl. soc sci, some testing, marketing overhead, software	150%	3-yr SL (not buildings)	none	NA	3/ 10 yr	NA	ceiling; reduced credit for small R&D programs	up to 10% of project cost incl in 1995?	no special provisions
Austria	Dev. and improv. of valuable inventions	105%	accelerated	none	NA	5-yr CF	NA			
Belgium	incl. Software	100% or 3 yr cap.	3-yr SL 20-yr - bldgs	none	NA	5-yr CF	NA	10-15% addl capital deduction		
Brazil	R&D in computer ind.	100%	like investment	none 100% of comp.	NA	4-yr	CF			
China (PRC)	NA			none						
Denmark	Special tech programmes with EC researchers	100%?	100%	?	'?	5-yr	CF	?		
India	scientific research or knowhow	100%	100% except land	none	NA	?		NA		30-50% on royalties
Ireland	scientific research incl. software	100%	100% (not related), 15% otherwise	up to 400%?	??	?		??	TC ceiling of 525000	27% on royalties; tax treaties
Korea	experimental and research expenditure	100%	18-20% deprec, 5.6% - bldgs	10%, 25%	0 avg of last 2	yrs?		no	yes; special rules for startups	10-16% on no special royalties provisions
Mexico		100%	3-yr SL, 20-yr - bldgs	none	NA	?		NA		
Netherlands (1984)	Wages of R&D leading to prod. dev. (not services)	100% or 5 yr cap.	like investment	12.5-25%	0	8-yr	CF	no	yes; ceiling on ITC max on R&D wages	no tax on royalties
Norway	prod. dev., capitalized knowhow	100% cap if prod.	like investment	none	NA	10-yr (res.	CF reserve)	NA		no tax on royalties

Country (date enacted)	Definition of R&D for Tax Credit	R&D Depreciation Rate	R&D Capital Depreciation Rate	Tax Credit Rate	Base for Incremental Tax Credit	Carryback (CB) and Carryforward	Credit Taxable?	Special Treatment for SMEs	Foreign R&D by Domestic Firms	R&D by Foreign Firms
Portugal	usual	100% or 3 yr cap.		none	NA	?		NA		does not 0-27% on apply royal-ties
Singapore	excl. soc. sci., quality control, software	cap. except some R&D	deprec. as usual	addl deduction - 2	NA	?		NA	yes	
South Africa	scientific research development of tech.	100% for R cap. for D	25% dep for cap	none	NA	?		NA		
Spain	excl. routine prod. improve. incl. soft-ware	amortize over 5 yrs	100% or depre-ciate	15%/30%, 30% /45% on F.A.	avg of last 2 yrs (for higher rate)	5-yr 3-yr	CF-OL, CF-TC	NA		5-25% on royal-ties
Sweden (Discontinued 1984)		100%	30% DB, 4% SL - bldgs	none	NA	tax	liability	NA		
Switzerland	none incl. software	100% or 5 yr cap.	like investment	subcontracted research	?	2-yr	CF	?		35% on royal-ties
Taiwan	usual	100%	deprec. as usual	15%, 20%	2% revenue, 3% revenue	4-yr	CF	NA		3.75-20% on royalties

Source: Hall (2000:Table 1).

Notes

1. Situation in 1995 unless otherwise noted.

2. Abbreviations: R = research, NA = not applicable, KC = incremental tax credit, TC =tax credit.

APPENDIX H: ESTIMATED TFP GROWTH RATES

Table 39: TFP Growth Rates (per cent per annum)

	1972-84	1978-84	1984-93	1993-98	1972-98	1978-98
New Zealand						
Diewert-Lawrence Preferred	-0.35	1.8	0.07	1.47	0.81	1.26
Diewert-Lawrence with HLFS Hours	-1.19	1.18	-0.15	1.17	0.36	0.95
Official Database						
Preferred Base Case		1.19	0.76	1.46		1.09
Highest Estimate		1.28	1	1.48		1.25
Lowest Estimate		0.34	0.14	1.63		0.58
'ABS Equivalent' for NZ		1.12	1.35	2.38		1.56
Australia						
Diewert-Lawrence Australia	1.62	0.87	0.56	0.78	1.25	1.02

Source: Diewert and Lawrence (1999), Table 1.