Competitiveness and Innovation Landscapes in the Tropics: A Comparison of Singapore and New Zealand during 1999-2008

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Abstract

Singapore-New Zealand bilateral relations are long-standing and based on a close political, economic and defense ties. Being small in economic size and population, both nations have undergone some challenges in a bid to improve their national competitiveness and innovation landscapes. This paper reviews both countries in terms of how innovative organizations are networked and organized so that they can be productive. It leads to a comparison of policies and governance orchestrating innovation. Through these instrumental cases and multiple data sources over a ten-year period, this paper concludes with some generalization and lessons for other small emerging economies, especially those small developing countries in the tropics.

1. Introduction

Competitiveness is about how human, capital, and physical resources are organized and deployed in a concerted and productive way to create fair and distributed economic benefits (Esposito and Tse, 2012). It is not to be mistaken for competition, which is concerned with how a country, region, sector or company can outflank its rivals on the basis of, for example, price, quantity, speed or location. Esposito and Tse (2012) argue that competitiveness in an economy is pertinent, as it betters the standard of living and creates the prosperity of a society as a whole.

But, competitiveness is also determined to a great extent by a nation's ability to innovate and develop areas of competencies (Doyle, Kuah and Shapira, 2010). Singapore and New Zealand are amongst the most competitive nations in the tropics, defined by countries lying in the belt of the Tropic of Cancer and Tropic of Capricorn. In the Global Competitiveness Report of the World Economic Forum, Singapore ranks 3rd out of 133 countries in 2009-10. It remains the highest-ranked Asian country in the index to-date[1]. New Zealand's ranking of 20th in 2009-10 is an improvement from the previous years. These countries support high wages for workers and help both their companies and industries achieve attractive returns.

[1] The scope of this study was between the period 1999 - 2008 where many of the data are aligned. In 2010-11 edition of the Global Competitiveness Report, Singapore and New Zealand were ranked 3rd and 23rd respectively; in 2011-12, 2nd and 25th; in 2012-13, 2nd and 23rd

Competitiveness is defined by the Global Competitiveness Report of the World Economic Forum to include a broad range of factors, policies and institutions that ultimately determine the level of productivity in an economy. Of which, there are twelve competitiveness pillars that are categorized into three main areas: (i) Basic Requirements; (ii) Efficiency Enhancers and (iii) Innovation and Sophistication Factors. The latter is more important as an economy becomes more developed and enjoys higher income, whereas developing economies require strengthening of its basic requirements and efficiency enhancers.

Yet moving beyond such indices, the debate on competitiveness and this paper focus on understanding innovation and macroeconomic policies supporting competitiveness:- What are the factor conditions needed to improve innovation? Why is the role of government in supporting innovation and competitiveness still important, and why are interventions still needed? As Singapore and New Zealand are small economies, it is easier to witness linkages of collaboration in innovation, and the role of state-firm relationships (or government interventions) in creating innovation. The two countries are selected as instrumental and collective cases as both are of similar economic size; both have implemented new measures to improve their competitiveness; yet, both are distinctly quite different in their performance.

In current turbulent times with limited resources from the public sector, and high expectations of the end-users, innovation is critical. Therefore this paper aims to (i) explore the innovation landscape and policy in supporting competitiveness; (ii) understand the determinants of innovation; and lastly (iii) provide generic policy recommendations that are generalisable for all small developing economies. This paper is organized as follows: Section 2 explores the antecedents of the nations' innovation and competitiveness; Section 3 elaborates on the case study approach; Sections 4 and 5 discuss the organization of research in Singapore and New Zealand respectively, in terms of the publications and patent organizations as well as their collaborations. Section 5 concludes.

2. Antecedents

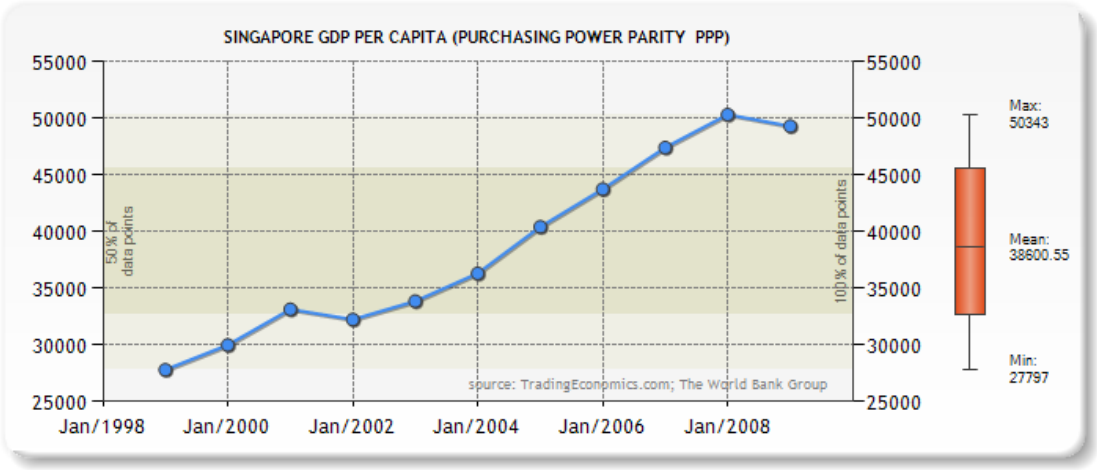
2.1 Historical Context

Singapore, a small nation-state that became independent in 1965, has enjoyed a sustained period of investment in infrastructure and education by the reining government, supplemented by the attraction of talented people and foreign direct investment (FDI) over the last forty years. FDI has been a key source of new technology for the domestic firms as the country reaped rewards from its industrialization program since the 1970s. The nation has grown in tandem with industrialization, shipping activities and the accelerated economic changes in South East Asia in the 1980s (Kuah and Day, 2010).

The country had recovered quickly from a 2001 recession to grow rapidly through to 2007. There was a slowdown in 2008-2009, but Singapore was not too deeply affected by the global financial crisis. Indeed, average quarterly GDP

growth was 7.6% between 2007 and 2010, a very strong performance, despite large quarterly fluctuations on a quarterly basis between 2008 and 2010 (Kuah and Doyle, 2010). The GDP per capita in Singapore averaged US$ 38,600 over that period, based on purchasing power parity (figure 1). Singapore has a highly developed and successful free-market economy. It enjoys a per capita GDP higher than that of most developed countries. The economy depends heavily on exports, particularly in consumer electronics, information technology products, pharmaceuticals, and on a growing service sector.

Figure 1: GDP per capita based on PPP in Singapore (1999-2008)

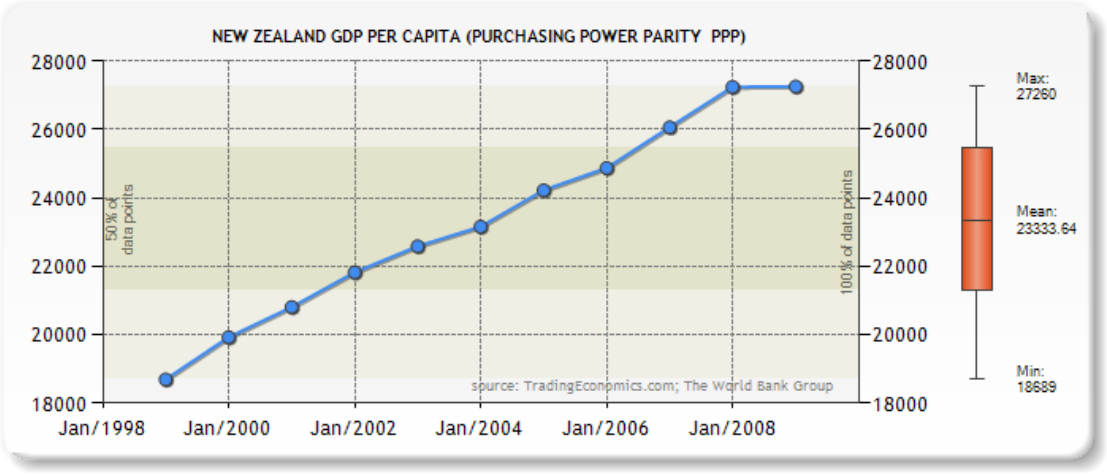


Source: World Bank; Trading Economics (http://www.tradingeconomics.com)

New Zealand had among the highest levels of GDP per capita in world in the 1950s. It became part of the Organization for Economic Co-operation and Development (OECD) countries in 1973. But in 1987 until 2010, New Zealand's average quarterly GDP Growth was only 0.57 percent reaching an historical high of 2.70 percent in September of 1999 and a record low of -2.60 percent in March of 1991 (OECD, 2007). The GDP per capita averaged US$ 23,333 between 1998 and 2009, based on purchasing power parity (figure 2). New Zealand fell to 22nd position amongst the OECD countries in 2007 (Kuah, 2012). Mawson (2002) notes that there was little formal emphasis on FDI, and stagnant productivity remained a concern.

New Zealand embarked on major economic reforms, including privatization and opening up of markets in the 1980s. Since then, the nation has overhauled its public sector, restructured its research institutes, fostered public-private new knowledge-exchange relationships, and liberalized its markets (Kuah, 2012). The government has transformed New Zealand from an agrarian economy dependent on concessionary British market access to a more innovation-oriented market-economy that can compete globally. Kuah (2012) points out that the open-to-competition attitude of the government has spurred institutions for collaboration spinning off from small companies and private partnerships influencing innovation and internationalization of products and processes.

Figure 2: GDP per capita based on PPP in New Zealand (1999-2008)



Source: World Bank; Trading Economics (http://www.tradingeconomics.com)

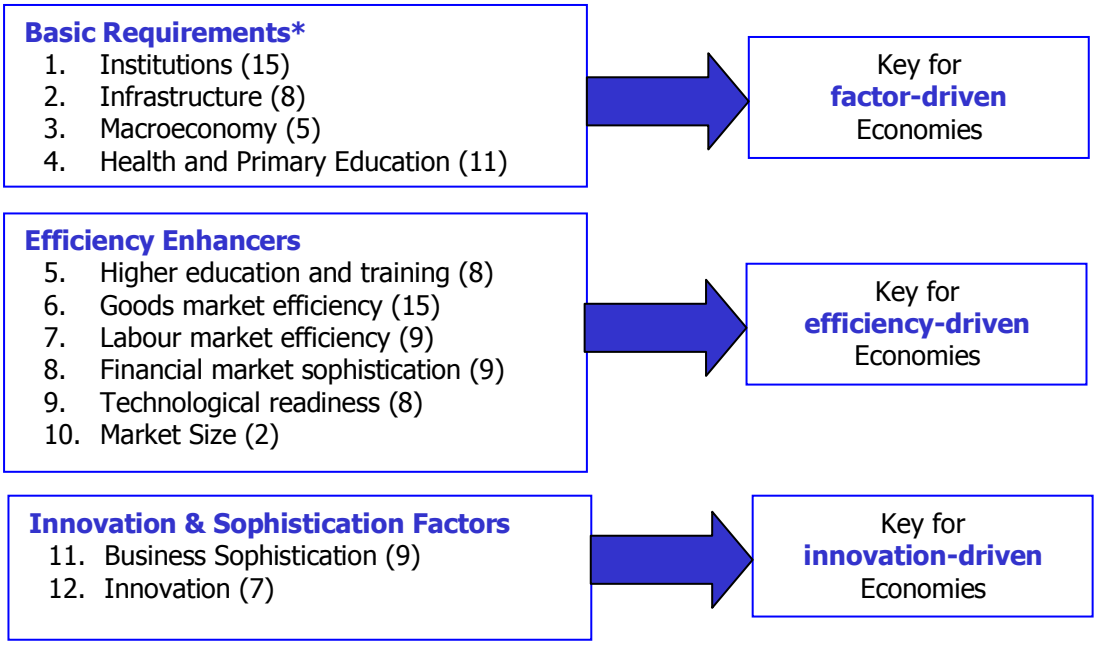
The Singapore-New Zealand relations are also long-standing. The Trans-Pacific Partnership (TPP) evolves from the Trans Pacific Strategic Economic Partnership Agreement (P4), a Free Trade Agreement between Brunei Darussalam, Chile, Singapore and New Zealand signed on 18 July 2005. The TPP grew in its strategic reach, as new members like the United States, Australia, Peru, Vietnam and Malaysia enters in partnership. The TPP is different from other trade agreements as it is exploring into ways to include cross-cutting horizontal issues amongst these nations - Transparency, SME, Development, Regulatory Coherence, and Competitiveness (Fergusson & Vaughn, 2011).

2.2 The Pillars of Competitiveness

The World Economic Forum has based its competitiveness analysis on the Global Competitiveness Index (GCI), a comprehensive index capturing both microeconomic and macroeconomic foundations of national competitiveness across twelve 'competitiveness pillars'. The twelve competitiveness pillars are arranged under three main categories to provide an indication of countries' relative positions in relation to (i) Basic Requirements; (ii) Efficiency Enhancers and (iii) Innovation and Sophistication Factors (Schwab, 2012).

Doyle, Kuah and Shapira (2010) point out that for the most developed or high-income economies such as Singapore and New Zealand, the weighting for innovation and business sophistication is highest (Weightings 30%). For the lowest-income economies the emphasis is on achieving Basic Requirements (Weightings 60%), while for middle-income efficiency-driven economies, basic requirements are weighted lower at 40% and this declines to 20% for the richest economies. For both middle and high-income economies, the factors grouped as Efficiency Enhancers account for a constant 50% in the weightings and the weightings of Innovation and Sophistication Factors are 10% and 30% for these economies respectively.

Figure 3: The Twelve Pillars of Competitiveness



Note: * Figures in parantheses indicate the number of measures used in measuring each pillar.

Adapted from Figure 1, Chapter 1.1 in the *Global Competitiveness Report 2007-8*, Palgrave Macmillan.

Singapore is consistently ranked in the top 3 countries covered in the survey by the Global Competitiveness Index (GCI). As a nation, it ranks in the top 3 for Basic Requirements - indicating its institutions, infrastructure, macro-economy and health and primary education support a productive economy, and similarly for Efficiency Enhancers – measuring higher-order productivity inputs including higher education, technological readiness and market efficiency.

Table 1: Singapore Competitiveness Index Measure[1]

	Competitiveness Pillars	2007-2008		2008-2009		2009-2010	
		Score	Rank	Score	Rank	Score	Rank
A	**Basic Requirements**	6.08	3	6.14	3	5.99	2
	Institutions	6.03	3	6.19	1	6.15	1
	Infrastructure	6.36	3	6.39	4	6.35	4
	Macro-Stability	5.68	24	5.74	21	5.24	35
	Health & Primary Education	6.24	19	6.24	16	6.22	13
B	**Efficiency Enhancers**	5.38	6	5.52	2	5.61	2
	Higher Education &Training	5.42	16	5.56	8	5.62	5
	Goods Market Efficiency	5.76	2	5.83	1	5.77	1
	Labour Market Efficiency	5.67	2	5.71	2	5.91	1
	Financial Market Sophistication	6.02	3	5.94	2	5.91	2
	Technological Readiness	5.36	12	5.64	7	5.90	6
	Market Size	4.06	50	4.41	41	4.53	39
C	**Innovation & Sophistication**	5.14	13	5.16	11	5.15	10
	Business Sophistication	5.19	16	5.25	14	5.20	14
	Innovation	5.08	11	5.08	11	5.09	8

Source: *Global Competitiveness Report*, annual editions 2007-2009, World Economic Forum, Palgrave Macmillan

Adapted from Doyle, Kuah and Shapira (2010)

Despite its stellar performance in the basic requirements and efficiency enhancers (see table 1), it is only in 2010 that Singapore entered the top 10 global rankings for innovation. According to the Global Competitiveness Report, despite good performance in business sophistication, weaknesses also remain. For example, there are poor local supplier quantity & quality, and there are weak controls of international distribution channels. Singapore performs relatively better on Innovation than Business Sophistication, corresponding to the commanding role played by the Singapore government in creating superior conditions in its business environment. While successful in creating an environment in attracting research scientists and supporting this element of the innovation system, government agencies may inadvertently have created barriers to the creativity and approach to risk-taking required for greater commercialization of discoveries according to Doyle, Kuah and Shapira (2010).

Likewise, New Zealand's weak performance has been observed for innovation and business sophistication, and the gap in performance relative to the other two categories has widened over time. Local supplier quantity is problematic in New Zealand with cluster development gaps, whilst local companies do not enjoy a broad value chain presence. Focusing on innovation in particular, New Zealand exhibits weak performance in innovation and business sophistication relative to their basic requirement and efficiency enhancers (see table 2).

Table 2: New Zealand Competitiveness Index Measure[1]

	Competitiveness Pillars	2007-2008		2008-2009		2009-2010	
		Score	Rank	Score	Rank	Score	Rank
A	**Basic Requirements**	5.33	17	5.58	19	5.58	16
	Institutions	5.80	9	5.81	8	6.03	5
	Infrastructure	4.52	33	4.37	42	4.64	35
	Macro-Stability	5.36	36	5.72	25	5.24	33
	Health & Primary Education	6.45	4	6.42	5	6.43	4
B	**Efficiency Enhancers**	5.10	18	5.07	17	5.11	15
	Higher Education &Training	5.53	12	5.40	15	5.49	11
	Goods Market Efficiency	5.35	9	5.17	17	5.20	8
	Labour Market Efficiency	5.17	9	5.10	10	5.12	11
	Financial Market Sophistication	6.02	4	5.87	3	5.69	3
	Technological Readiness	4.82	23	5.09	22	5.24	23
	Market Size	3.69	59	3.78	60	3.89	59
C	**Innovation & Sophistication**	4.42	25	4.26	28	4.37	27
	Business Sophistication	4.75	29	4.57	37	4.64	34
	Innovation	4.09	25	3.95	26	4.10	23

Source: *Global Competitiveness Report*, annual editions 2007-2009, World Economic Forum, Palgrave Macmillan

Adapted from Doyle, Kuah and Shapira (2010)

Although New Zealand's scientific and research institutions rank highly, the limited availability of scientists and engineers (being a small country) hinders innovation. Also, according to the business survey conducted by the WEF, the New Zealand government is not purportedly acting as a sufficiently sophisticated and demanding purchaser of advanced technological products to incentivize local businesses operating in that space. To address the gaps requires some fundamental adjustment to business competition, which can support a move

towards more niche-type strategies where premium products and services are the object of firms. Over-focus on low-end products limits the capacity for improvement according to Doyle, Kuah and Shapira (2010).

2.3 Determinants of Innovation

Innovative capacity is a core determinant of competitiveness since they are likely to have limited ability to generate increased output from further investments in capital (the efficiency-driven stage). Furman, Porter and Stern (2002: 899) point out that an economy's innovative capacity represents "the ability ... to produce and commercialize a flow of innovative technology over the long term". The difference in the ability of nations to produce new-to-world technologies is striking. Some countries consistently outperform others by a wide margin. For example, Canada, the US, Finland, Switzerland and Japan produce well over 100 patents per year per million of population (in 2008), while most advanced economies average approximately 60 patents per million (Kuah and Doyle, 2010). Another group including Spain, Portugal, New Zealand and Italy may all be considered to 'underperform' with less than 25 patents per million. Furman, Porter and Stern (2002) echo a strong patenting bias in those countries with a history of patents production such the US and Switzerland due to path dependency and the importance of the history of resource commitments.

Table 3: Population, economy, and R&D statistics for selected countries

Statistics	New Zealand	Singapore
Total Population (thousands)[a]	4,142	4,401
Gross Domestic Product – GDP (million current PPP$)	108,607	207,153
Gross Domestic Expenditure on R&D - GERD (million current $)	1,826[c]	4,582
GERD as a Percentage of GDP	1.7	2.2
Total R&D personnel (FTE)	23,178[c]	30,129
Researchers (FTE) per million population	4,207[c]	5,713
Publications (1999-2008)	37,639	42,832
Publications (1999-2008) per million population	9,087	9,732
Publications per $ billion GDP	347	207
Publications per $ million GERD	20.6[c]	9.3
Publications per 1000 R&D workers	1,624[c]	1,422

Notes: all figures in US dollars except as indicated. [a]Population, GDP, GERD, and their relation to publications are based on values for year 2006, except as indicated. [b]Gross Value Added (GVA) by component of income at current basic prices by region. [c]As of 2005. [d]Estimated from NISRA, Research & Development Statistics 2007. Sources: GDP data: OECD Main Science and Technology Indicators (MSTI): 2008/2
Source: Adapted from Kuah and Doyle (2010)

Doyle, O'Connor and Kuah (2010) find that existing patents were a major factor in determining both current and future patent output of a country. Using a database of 23 small economies around the world, a ten percent increase in the accumulation of patents resulted in approximately a two percent increase in further patent production. Research and development (R&D) expenditure is also a very significant determinant of innovative activity: a ten percent increase generates a 4.8% increase in patenting (Doyle, O'Connor and Kuah, 2010). They

find *Legal Structure and Security of Property Rights* and the *Openness* of an economy to international trade are also significant explanatory factors for patent production. The number of R&D Personnel has been an explanatory variable in Furman, Porter and Stern (2002) studies, but show to be insignificant in the 23 small economies under this study once R&D expenditure is included.

As a comparison, both New Zealand and Singapore share a number of similarities in its population in 2006 (table 3). Singapore has a higher R&D intensity: Gross Expenditure on R&D (GERD) as a percentage of GDP is 2.2% in Singapore compared with 1.7% in New Zealand; Singapore has a large number of R&D personnel (all sectors, including industry as well as higher education and government). By publications per billion GDP, New Zealand leads Singapore, suggesting that researchers in New Zealand are more oriented towards producing publications than in Singapore.

2.4 Taking Competitiveness Though Global Development

For Singapore and New Zealand, there is a central challenge of maintaining competitiveness under intense global competition, while improving living standards and creating new jobs. Often national policy instruments and programs reflect this. For developing countries, the challenge may be to create institutions and to train public managers that are able to design and implement economic and democratic conditions for supporting sustainable economic growth (Kuah and Vecchi, 2012).

The role of government can be important to the development of national competitiveness. However, the cluster policy dimension remains controversial (Andersson, Serger, Sörvik, and Hansson, 2004), as no single policy instrument applies to all cases. Broker policies, demand side policies, special promotion of international linkages, training and framework policies, may all generate substantive benefits but are also associated with challenges (Andersson et al., 2004).

Governments can adopt a laissez-faire approach and accept the 'free market' view of the economy, with a desire to protect or restore free market regimes in areas that are not self regulating (Piore and Sabel, 1984: 8). A diminished role, according to Porter (1998: 184), is not favourable in shaping the context and institutional structure surrounding firms to create an environment that stimulates competition and innovation. Porter (1998: 185) proposes that the role of the government should be to amplify the conditions of the Diamond (Porter, 1990) and creating a favorable environment for its industries. He also points out that government may be an interventionist or an essential supporter of the industry.

However, policies (e.g. subsidies, protection and arranged mergers) with a short-term benefit or those that retard competition and innovation may hurt firms in the long run. Countries can no longer protect their industries through trade protection or subsidies as in the past; they must seek to maintain

competitiveness through a broad range of economic, internationalization and innovative measures that improve human capital, knowledge, productivity, innovation, and the performance of institutions (Porter, Sala-i-Martin and Schwab, 2007).

3. Methodological Approach

Methodologically, the case approach uses multiple sources of data to present a mutually consistent evidence of the unit (Yin, 1994), which in this case is the innovation landscape. Swann (2006: 153) places the case study method as an intensive examination of the unit using multiple data sources to present mutually consistent evidence or to preserve anomalous views. Instrumental cases can provide an insight into an issue and allow the drawing of generalization, whereas collective cases consisting of instrumental studies extend to investigate a phenomenon better through replication logic (Stake, 2000). Histories, on the other hand, contribute to understanding 'possible causes, determinants, pathways, processes and experience' that may lead to a particular outcome (Hakim, 2000: 64).

This comparative case study is conducted over space and time, In this paper, Singapore and New Zealand are analyzed over a 10 years period with the case design placed in a common framework or protocol consisting of (i) historical antecedents; (ii) patents and publication production capabilities; (iii) international and industry collaboration between 1999 and 2008, to help in understanding the institutions and innovation landscapes in both countries. Together with these, interviews were also conducted around 2009 with policy makers, business advisory agencies, industry and academic experts and business practitioners from both countries.

Yin (1994) argues that case observations need not strictly be representative of the population or follow a sampling logic. The case approach uses selected observation points for the object of study (Yin, 1994). Hence, the sampling logic is not of primary concern in case studies. Twenty-two interviews were conducted in New Zealand in November 2009: 6 with ministries and research foundations, 9 with private sector companies, 5 with universities or crown research institutes, and 2 with non-profit or business organizations. In total, 31 people were interviewed in New Zealand. To supplement the knowledge on the evolving landscape in Singapore, seventeen interviews were conducted: 6 with ministries and statutory boards involved in economic development, international trade and business support; 8 with companies in different sectors; a manager of Science Park II; and finally, informal discussions with an eminent Singapore professor and a Member of Parliament. In total, 25 participants were interviewed in Singapore.

The understanding of innovative capabilities is complemented with the linkages of publications and patents grants published between the period from 1999 to 2008. Data sources for scientific publications is extracted from the ISI Web of Science and Scopus, while patent data are drawn from USPTO, EPO, and WTO.

The use of publications, as a proxy for innovative capabilities, is established by the fact that innovative breakthroughs, discoveries, and research results are rapidly published in scientific journals. The use of patent grants is important as they signify that an invention is novel, non-obvious and has utility. This secondary approach provides a clearer picture of the innovative capabilities of countries and its key insitutions. Finally, this paper provides some insights to how policies and state-firm relationships can promote or hinder innovation and innovative capabilities.

4. Organization of Research in Singapore

The Ministry of Trade and Industry (MTI) is responsible for promoting economic growth and job creation. Key agencies within the MTI include the Economic Development Board (EDB), International Enterprise Singapore (IE), SPRING amongst others, and the newly established Agency for Science, Technology And Research (A*STAR). The EDB acts as a central conduit for FDI and purportedly enjoys direct access to all government ministries. EDB supports FDI by maintaining close contact with businesses needs. SPRING is responsible for productivity and supports small medium sized businesses. IE encourages and provides support to high potential domestic firms for outward investment.

The national investment in an R&D framework is made possible after 15 years gradual investment, as claimed by MTI officials. Singapore's R&D plan continues towards commercialization and exploitation, as explained by A*STAR officials. A*STAR oversees about 14 research institutes and 9 research consortia/centers. There are schemes to allow companies to cut R&D costs by co-sharing expensive facilities and accelerate the development timeline. Monies are ring-fenced by the Singapore Government for investment in infrastructure and R&D. The Science and Technology Plan covers a 5-year cycle, the most recent being 2006-2010. The country is committed to doubling spending to S$13.55 billion over this cycle (Doyle, Kuah and Shapira, 2010).

R&D expenditures remain high in Singapore. Singapore has a larger number of R&D personnel (all sectors, including industry, higher education, and government), with about 5713 workers per million population and higher spending on R&D (Gross Domestic Expenditure on R&D – GERD is US$4582 million). As of 2006, the percentage of GERD measured against GDP is 2.2%. Singapore is now closing the gap with other developed economies to target 3% of GERD/GDP ratio, as revealed by A*STAR officials.

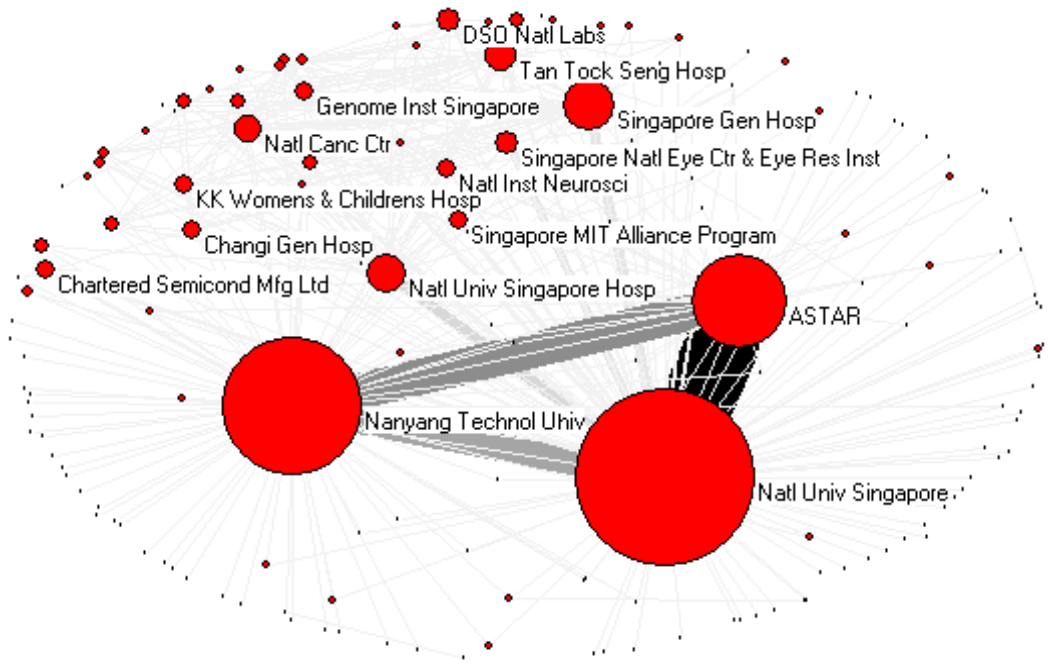
4.1 Scientific Publications

Singapore produced 42,832 scientific publications between 1999 and 2008 in total. The huge incremental spending in R&D (both in quantum and percentage) resulted in 9,732 publications per million population. The data reveals that scientific research in Singapore is concentrated in two academic organizations. These are the National University of Singapore and Nanyang Technology

University, which co-authored 80 percent of all research publications, with major shares of 51.5% and 31% respectively. A prominent third organization in Singapore's top-20 list is A*STAR, a network of public research institutes that conduct research in specific niche areas in science and engineering and in biomedical science that contributed with 14.4 percent of all scientific publications.

Although more than 56 percent of the organizations undertaking research in Singapore are companies, they produced a meager 4 percent of the country's publications in the period 1999-2008. Chartered Semiconductor Mfg Ltd has concentrated almost one-fifth of all corporate publications during the period 1999-2008. It is the only company among the top-20 research organizations in Singapore, with a share of 18.8 percent of corporate publications and only 0.7 percent of all scientific publications. Novartis Singapore Pte Ltd and Singapore Utilities International Pte Ltd are among the top-3 companies producing research papers (see figure 4).

Figure 4: Research collaboration networks in Singapore (1999-2008)



Source: ISI-WoS database, Science Citation Index Expanded (SCI-EXPANDED), using Pajek software.
with research assistance provided by Luciano Kay

4.2 Patents

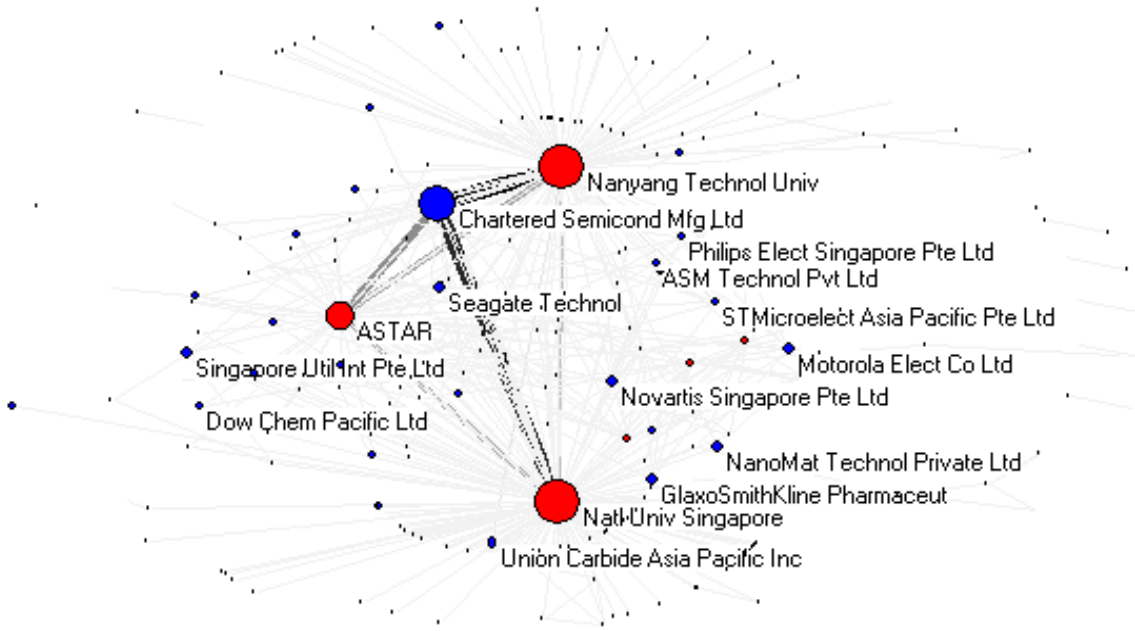
There are more than 160 patent authorities worldwide, yet patents granted by the United States Patent Office (USPTO), European Patent Office (EPO), and Japan Patent Office (JPO) are usually considered of particular value. The USPOT accounted for 51% of Singapore's granted patents, whilst the second most common patent authority was the local office (IPOS), with almost 27 percent of granted patents, and the third was the Taiwanese Patent Office (TIPO), with 6.4 percent of grants.

The top-20 patent assignees concentrate a 69 percent share of all patent grants, with more than one thousand remaining assignees contributing to the remaining 31 percent of patent grants in the same time period. The top assignee is Chartered Semiconductor Manufacturing Ltd., which held 22 percent of the Singapore's granted patent for the period 1999-2008 (more than 1,600 patents). This leader mo doubles the share of the second assignee, Avago Technology Ltd, another semiconductor company until 2005. The third main assignee is A*STAR, a governmental organization comprising a network of public research institutes. There were also two universities in this list, including the largest National University of Singapore, with a 6.6 percent share of grants. Singapore's patent grants are related to Semiconductor, Electronics, and Computing technologies. The top-3 IPC classes (Basic Electric Elements, Computing, and Electric Communications) contributed to almost 51 percent of the patent grants.

4.3 International and Industry Collaborations

The USA is the main international partner in scientific research for Singapore, representing about 12 percent of the total publications for the period 1999-2008. The geographic proximity of Singapore to China is reflected in scientific collaboration as well, representing 12 percent of Singapore research articles for that period. England, Australia and Japan were other significant research partners of about 3%.

Figure 5 Corporate research collaboration networks in Singapore (1999-2008)



Source: ISI-WoS database, Science Citation Index Expanded (SCI-EXPANDED), using Pajek software.
with research assistance provided by Luciano Kay

Companies in Singapore are more likely to collaborate with universities and other academic organizations (see figure 5). There are about 497 companies publishing scientific articles. Almost 54 percent of these are co-authored by at least one company and one university. Only 28 percent of corporate publications

were co-authored between companies. Companies co-authored a significant share of publications with government organizations (13.7 percent) in Singapore. In this case, the three universities took the lead in supporting industry and corporate research, and the critical mass of research resides in the universities for the case of Singapore.

5. Organization of Research in New Zealand

The recent reforms in New Zealand's R&D landscape included having former public research institutes being amalgamated and privatized into eight Crown Research Institutes (CRIs) with mandates to undertake commercially-oriented research and to collaborate with industry. The Crown Ownership Monitoring Unit of the New Zealand Treasury oversees CRIs. In 2009, the combined revenues of all CRIs (from public and private sources) totaled NZ$625 million (£286 million) and they employed about 4,400 researchers and staff (Kuah, 2012).

The Ministry of Research, Science & Technology is responsible for science and technology advice. For universities, policy advice occurs in the Ministry of Education. Economic development is located in the Ministry of Economic Development. Funding decisions are located in a separate set of agencies, with R&D funding allocations being the responsibility of the Foundation for Research, Science and Technology. Higher education funding (including for research) is allocated through the Tertiary Education Commission, with the Health Research Council funding medical research. Implementation lies with a third category of organizations. Governance is multi-tiered in the public sector, while planning and coordination seem to be disconcerted.

New Zealand has 4207 R&D workers per million population and Gross Domestic Expenditure on R&D (GERD) of only US$1826 million during the time period. The percentage of GERD against GDP is only 1.7% in 2006. OECD (2007) suggests that one of the factors contributing to poorer performance is New Zealand's low gross expenditure on R&D, which at 1.16% of GDP (in 2005) is about half the average level for the OECD countries (2.23% in 2005).

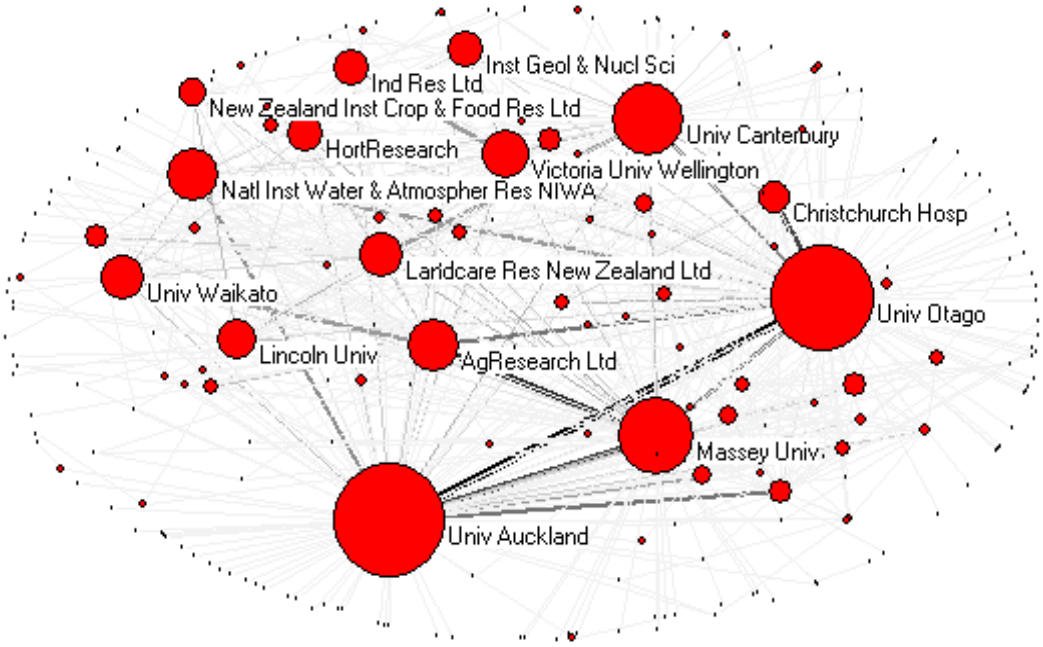
5.1 Scientific Publications

New Zealand produced 37,637 scientific publications between 1999 and 2008. This amounts to 9,087 scientific publications per million population over the 10 years period. New Zealand has a high proportion of government/public organizations (22.2 percent) publishing scientific articles. Seven public universities co-authored 69.7 percent of all scientific publications. The top-4 organizations are the University of Auckland, the University of Otago, Massey University, and the University of Canterbury. A major role in scientific research in New Zealand is also performed by independent, Crown-owned research and development companies - AgResearch Ltd., a company undertaking research in

Agriculture & Environment, Applied Biotechnologies, and Food & Textiles, is in the 5th position with a 5 percent share of all publications.

A good share of scientific research by companies is observed in New Zealand, where this type of organizations co-authored more than a quarter (28.1 percent) of all publications. There are eight Crown-owned companies and research institutes among the top-20 corporate publishers in New Zealand. There is also concentration of publications among companies. The top-7 companies in terms of publications, all Crown-owned research companies, co-authored more than 75 percent of the corporate publications and more than 21 percent of all publications. The top-3 are: AgResearch Ltd, National Institute of Water and Atmospheric Research Ltd (NIWA), and LandcareResesearch Ltd, with shares of 17.9 percent, 17.6 percent, and 13.3 percent, respectively In relative terms, New Zealand has relatively lower academic organizations in the publication of scientific research (only 9 percent are universities).

Figure 6: Research collaboration networks in New Zealand (1999-2008)



Source: ISI-WoS database, Science Citation Index Expanded (SCI-EXPANDED), using Pajek software.
with research assistance provided by Luciano Kay

5.2 Patents

In the case of New Zealand, most of the country patent grants were obtained in the local patent authority (IPONZ), which represents almost 45 percent of all grants. The United States Patent Office (USPTO), European Patent Office (EPO), Great Britain (IPO UK) took up 31.5%, 7.0% and 3.5% respectively.

The list of top-20 patent assignees includes several private companies, a few crown-owned companies, and two universities. Fisher & Paykel Appliances Limited, a large manufacturer of home appliances, is the leading assignee with 8.1 percent of all patent grants. The second assignee is Auckland UniServices

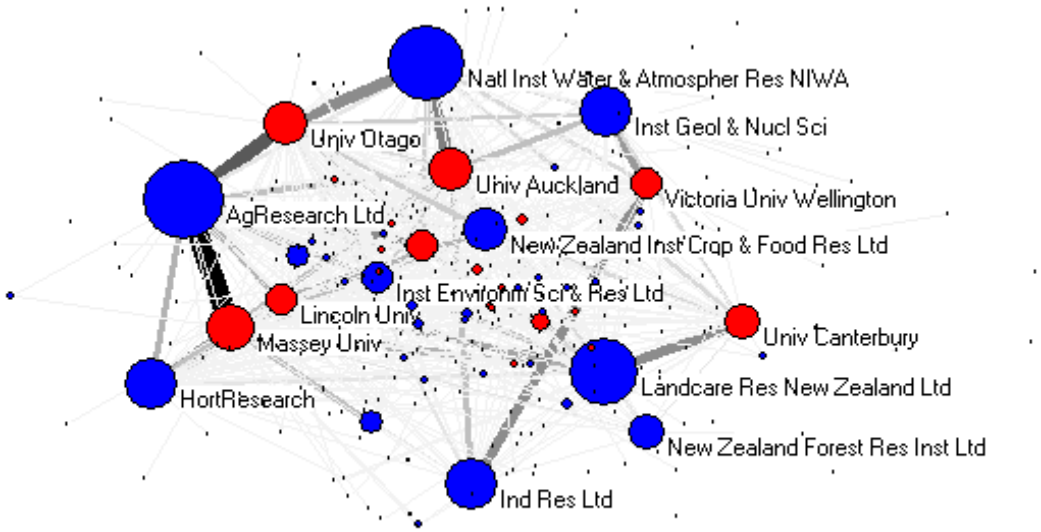
Limited, the commercial research and knowledge transfer company of the University of Auckland, with 3.5 percent of patent grants. Among the Crown-owned companies are Industrial Research Ltd, AgResearch Ltd, and Horticulture and Food Research Institute of New Zealand Ltd. Massey University, the only academic institution within the top-20 list, obtained less than 1 percent of the grants. Overall, these top-20 organizations contributed almost 40 percent of all patent grants for this economy.

For New Zealand patents, the leading foreign assignees are Trimble Navigation (USA provider of global positioning solutions, 2.5 percent share) and Warner-Lambert Company LLC (the US pharma company acquired by Pfizer, 1.7 percent share).

5.3 Industry and International Collaborations

The USA is the main international partner in scientific research for New Zealand representing about 15 percent of the total publications for the period 1999-2008. Besides the USA, the top partners in scientific research are Australia and England, with 11 and 8 percent of publications co-authored, respectively during the period. Germany and Canada are other key research collaborators.

Figure 7: Corporate research collaboration networks in New Zealand (1999-2008)



Source: ISI-WoS database, Science Citation Index Expanded (SCI-EXPANDED), using Pajek software.
with research assistance provided by Luciano Kay

Companies co-authored only 29.2 percent of their publications with universities in New Zealand. Many of the collaboration actually take place between companies (34%) in New Zealand. There are about 642 companies publishing scientific articles and more than 78 percent of those have collaborating partners. In New Zealand, there is a larger share of companies collaborating with other organizations, and there are many more research organizations of other types

(university, government, etc.) that collaborated with those companies. The number and size of corporation undertaking research is higher, with the role of universities taking the lead being less significant.

6. Conclusion & Recommendations

The twin cases present different façades to institutions and companies participating in the innovation landscapes of Singapore and New Zealand. To an extent, they reveal the policy and organization for research in these two small advanced economies to differing levels of successes. Through an evidence based policy approach, this section continues the discussion to understand the policy dimensions and determinants of innovative capacities that may be generalizable for small developing economies.

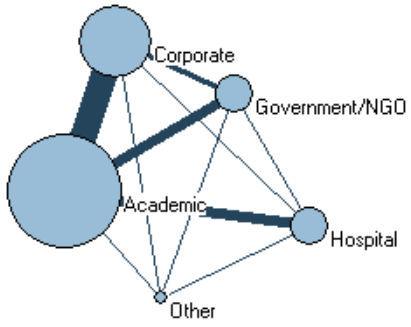
6.1 Innovation Landscapes

Field observations suggest that New Zealand successfully transformed its former public research institutes into privatized commercial corporations, while Singapore demonstrated a model of powerful government agencies (MTI, EDB and A*STAR) collaborating with public universities and research laboratories.

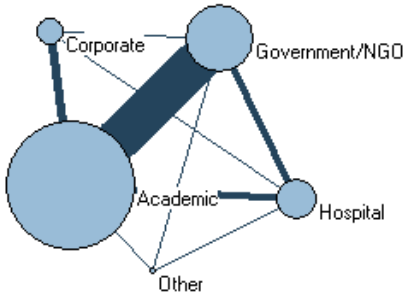
Singapore is closing with gap with other developed economies to target 3% of GERD/GDP ratio, and the national investment has been gradual and incremental over the last 15 years. Evidence shows that Singapore has entered the top 10 in the global ranking for innovation.

On the other hand, New Zealand has a wealth and history of innovation, being an earlier developed economy; New Zealand seems to have depended much on the accumulated capacities in innovation but has now pushed for greater private sector participation. However, New Zealand exhibits weak performance in innovation and business sophistication relative to their basic requirements and efficiency enhancers. The New Zealand government is not purportedly acting as a sufficiently sophisticated and demanding purchaser, nor an interventionist government in this case.

Figure 8: Nodes of Collaboration in New Zealand and Singapore (1999-2008)



New Zealand



Singapore

While both countries have substantial number of companies publishing scientific articles (497 in Singapore and 643 in New Zealand), New Zealand more than triples the number of collaborating organizations of other types (268 versus 68 organizations in Singapore). This implies that there is a greater diversity of research-intensive entities in New Zealand. In Singapore, a larger proportion of companies maintained collaborations with one research partner and many with one of the three public universities. Figure 8 (simplified from figures 5 and 7) illustrates this. The Singaporean government plays a more active role in the innovative landscape, as seen from the size of the node (depicting the number of institutions). In New Zealand, private sector participation in R&D is stronger and more diverse, as the government plays a laissez-faire role.

6.2 Policy and Governance

New Zealand's open and transparent governance are important dimensions in the development of competitiveness and innovation policy and programs. Field interviews reveal that consultation on new policies is undertaken at the policy formulation stage, with engagement from business, academia, local governments, and other stakeholders. This active public-private exchange is important in developing strategies for targeted sectors in New Zealand. New Zealand also appears to make effective use of non-profit organizations and associations to facilitate exchange and networking between private sector representatives and policymakers. Public programs related to productivity, innovation and competitiveness are typically subject to formal evaluations, as well as to benchmarking and performance reviews. At the same time, there is a high level of sharing of information and insights with the public.

Singapore, on the other hand, often saw orchestrated involvement of powerful government ministries and agencies (e.g. MTI, EDB and A*STAR) working systemically like business units. The Government of Singapore stresses that sustained national investment is important and long-term goals are adhered to. Singapore exhibits a "top-down" structure which integrates various aspects of policy and governance. The Prime Minister and key ministers take a great interest in economic development and innovation. Building on earlier experience with tripartism (by government, employers and unions) in developing economic policy, the government has continued to build institutional and social capital to support economic development and innovation thus far. The civil service has been used explicitly to guide Singapore's development strategy with a shared outlook and approach evident between higher civil servants and government-political leadership. While the public sector and its agencies remain dominant, its role has transitioned away from a regulatory stance more towards a facilitative stance in recent years. However, evaluations of policies remain largely internal and unpublicized.

6.3 Determinants of Innovation

There are evidences showing that R&D spending and past successes in patent production are determining factors for innovation and patenting activity. This may present a barrier or a deterrent to many developing nations, due to their

lower base of R&D spending (GERD) and lack of innovation records (patents/ publications). Yet through gradual and consistent build-up of R&D spending, as well as attracting an external pool of companies and scientists over two to three decades, Singapore demonstrates that being a smaller nation neither strengthens nor weakens potential ability to produce innovation. It is therefore possible to override this path dependency and to rapidly accumulate patents even from a historically low level, as the case of Singapore illustrates.

International collaboration with leading nations in research, such as the USA, may be necessary. Both cases illustrate a similar pattern. More than 15 percent of the outputs in New Zealand, and 12 percent in Singapore involved the leading partners in the USA. As figure 8 illustrates, public universities must nonetheless play a key role on national innovation and research agenda to lead research with the industries. This role is even more important for small countries, given the fact that domestic companies often lacks the critical mass.

6.4 Recommendations

The open and transparent governance structure in New Zealand can be a double-edge sword. The benefit of New Zealand's public institutions appears to be less bureaucratic, with multiple agencies working in parallel and alongside each other to support economic and business growth. The broad engagement nature works well in the small economy of New Zealand. In understanding that New Zealand's firms are often small and quite entrepreneurial, it can be noted that Singapore's companies may be *too* familiar with the Government's promotion and intervention. With pluralism (in the form of MNCs and foreign companies) and less intervention may come greater diversity in innovation and the need to delve more into succeeding against the open competition in the global economy.

Secondly, what is clear in this paper is that industry partnerships should bring mutual benefits and cross-fertilization in the area of innovation, which leads to national competitiveness. This paper presents two models: New Zealand and her Crown Research Institutes, and Singapore with her A*STAR setup. Both are relatively new interventions and the institutions are actively pursuing partnership with industry. Whether these will bear fruition and serve as a model for other small economies, remain unknown.

Finally, determining the direction for economic growth must be done in careful consultation with local stakeholders who understand local conditions and forecasts. Due to the nature of investigation, it is not clear how these have been identified in New Zealand and Singapore. The lack of multiple stakeholder engagement in Singapore, including NGOs, is a unique phenomenon in Singapore – although it has to be qualified that the Government of Singapore has selected and engaged top industry practitioners in her economic planning and review cycles. What Singapore can learn from New Zealand is perhaps more transparency in open evaluation and communications, especially if public funds are used in programs

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