National Innovation Systems: The Cases Of Singapore And Finland

Hans C. Blomqvist

INTRODUCTION

In an increasingly borderless world, a good deal of interest is still devoted to the performance of countries. The attention paid to various measures of international competitiveness of countries is a witness to this. According to conventional wisdom, countries can gain through engaging themselves in the international division of labour, specialising in goods they can produce relatively cheaply. While this is still part of the truth, it is today, of course, too narrow a view. Although much international exchange is still based on traditional comparative advantages – which emanate from different relative endowments of factors of production – the relative success of nations in terms of sustainable growth is increasingly dependent on competitive advantage based on their ability to innovate. This implies much more than just coming up with new technologies, products or production processes. There must also be capability to utilize and commercialize them. Thus, management and marketing knowledge must be there, as well as suitable financial channels. It may even be maintained that ability to adapt existing technical know-how to new applications and to take it all the way to marketable products is at least as important as technical progress in itself. However, even this may not suffice. There also has to be an entrepreneurial drive that contributes to the dynamism required.

Due to the developments in the information and communication sector (ICT), knowledge and innovation are now created and diffused as a very globalized process. Still, through understanding how the innovation process works, a national government may be able to detect means for enhancing innovation activity in a country (OECD, 1997). Hence, this is a field of business policy where the nation state is still relevant. This paper will scrutinize the innovation systems of Finland and Singapore, two countries that may seem rather disparate at first thought.

Traditionally, evaluations of a country's innovative performance have used either measures of input, such as research and development (R&D) expenditures or R&D personnel, or output, such as the number of patents per year, etc. However, as pointed out by the OECD, these measures are rather static by nature and do not necessarily give a good picture of where an economy is going in terms of productivity and growth because innovation goes beyond R&D, because resource inputs may be utilized more or less efficiently (OECD, 1997: 9, 41) and because patents give a limited view of the results of innovation activity. Nevertheless, they provide some useful information as a starting point for discussion.

The concept, *"innovation system"* has increasingly been used for the complicated interaction between players and institutions, 'rules of the game', necessary for churning out innovations. While some of those institutions, such as property rights, must arguably be upheld by the state, the extent to which an innovation system is market or government led may vary. The message of economic theory, that government intervention is justified only when there are market imperfections, obviously applies in this case as well. In the case of innovation, there are obvious externalities involved in creation and application of new knowledge. Funding innovation-generating activities may be a problem because of missing or deficient markets, externalities and information asymmetries, which may then be a reason for state intervention. R&D is risky business where the ultimate results are difficult or impossible to predict. Moreover, results typically take a long time to materialize (Koh, 2006). Both in Finland and Singapore, the state plays an important role as a financier, not only of R&D but also of the commercialisation of the results. Apparently, national innovation systems are path-dependent and tend to follow 'trajectories' determined by their unique combinations of players and institutions in the past (OECD, 1997: 13). Typically, the 'hardware' of the system consists of a number of government and semi-governmental agencies, universities as well as private companies and organisations. Usually, there is a limited number of industrial clusters with high innovative activity. But it has been stressed that it is the 'software' of the system, in terms of interaction and linkages between various players – firms, research institutes, universities and the government – involved in innovation that is the crucial factor. Such a characterisation of an innovation system is still very loose and general, however, and there is an obvious need to be more specific. Some alternative definitions are listed in the OECD report cited above (OECD, 1997: 10) but none of these seem to be entirely satisfactory for the purpose at hand. In particular, they

***Professor of Economics*, Hanken School of Economics and Business Administration, Vasa, Finland. Email Address: hblomqvi@wasa.shh.fi

do not always distinguish clearly between players and institutions, i.e., incentive structures. Hence in this paper, the following definition will be used: *A national innovation system is the network of players and institutions that create, modify, apply and diffuse new, economically significant knowledge.*
The objective of this paper is to outline the structure and logic of the innovation systems in Finland and Singapore using written documentation, and to compare and pinpoint key differences in these systems. The so-called Triple Helix model will be used as a general frame of reference. How the relevant players interact and communicate in practice is beyond the scope of this article and has not been dealt with. The paper discusses the macro level only, and does not delve into the knowledge management of firms.

THE 'TRIPLE HELIX' MODEL OF INNOVATION SYSTEMS

A national innovation system can be regarded as a part of a wider national strategy aiming at promoting a country's potential for sustained economic growth. For small countries, in particular, it is paramount to stay agile and adaptable in a rapidly changing, globalising world. Perhaps, this is why the concept of national innovation strategies has been more in the foreground in small countries than in big ones. This point has also been emphasized over and over again by the governments of both Finland and Singapore.
The Triple Helix model is a simple way of conceptualising the interaction between the different players, i.e., university, industry and government, in a national innovation system. The general idea is to create a network of interaction between the players that would be able to propel the economy through innovations (see *Chart 1)*. The overlapping fields between the players' core activities are supposed to be instrumental in this process, as scientific discoveries need to be merged with market perspectives in order to result in an innovation. These fields in practice may be created through setting up, for example, science parks, incubators and entrepreneurship centres with inputs from all three types of players. Institutions for facilitating the interaction may be needed as well, for example to take care of IPR issues. The role of the players is thus widened from a traditional one and they may also switch roles at times (Leydesdorff and Etzkowitz, 2001).
Both in Finland and in Singapore, the position of the government in the tripe helix is rather dominant, both as a general setter of the agenda but also because the university system in both countries is part of the public sector. As far as the company sector is concerned, there are big differences. In Finland, the multinational firms play a marginal role as even the leading one, Nokia, is firmly rooted in Finland and Finnish management culture. In Singapore, the MNCs dominate in the manufacturing sector, and play a crucial role in the innovation system as well. Thus, in Singapore, it seems adequate to divide the 'industry' pillar into two interacting ones: domestic industry and MNCs.

SINGAPORE AND FINLAND – SOME BACKGROUND COMPARISONS

A comparison between Singapore and Finland is interesting, not least because of the similarities in the basic characteristics of development, and maybe also because of the feeling of vulnerability to external disturbances prevalent in both countries. Both were, more or less, created 'by accident', via wide-reaching geopolitical upheavals. Both have small populations, and both are late industrializers[1], which caught up and integrated themselves with the developed world very quickly, with the government taking on a substantial role. Heavy investments were made, especially in the education sector in both countries. This was important because developing basic capabilities for absorbing knowledge and new technologies is a precondition for an innovative business climate. For countries that are catching up, it is essential to be able to acquire and modify existing technologies, not only to develop new ones. In their national innovation systems, the government and semi-governmental bodies play a crucial role, both in Finland and Singapore while the relative lack of new entrepreneurs has been regarded as a problem. In both cases, this may reflect a relative neglect of the small and medium sized enterprises (SME) sector. Both countries systematically started developing knowledge-based activities rather late, but caught up very quickly with the leading nations. As it happens, both countries have recently shown a great interest in developing their biotechnology industry.

[1] In Finland, about half of the active population was employed in the primary sector as late as in 1950, while Singapore had virtually no manufacturing industry at independence in 1963.

However, many differences also exist. Finland is a big country area-wise, and is located in the periphery of Europe, while Singapore is a city-state with a pivotal location in Southeast Asia. Hence, location is a problem for Finland but an asset for Singapore. Singapore has no natural resources while Finland is relatively resource-rich. Finland's population has been little affected by (recent) immigration, while Singapore is a society of immigrants, where the majority of people still can trace their roots to China or India. Even now, Finland is reluctant to receive immigrants, while immigration to Singapore is encouraged, especially in the form of so-called foreign talent. This policy has been a success (see Koh, 2006), although the long-run commitment of recent immigrants represents a challenge for the future. Likewise, foreign companies play a key role in Singapore's innovation system, while their importance in Finland is marginal, although the country is equally open for foreign investment. Singapore has wholeheartedly embraced globalisation, while Finland has been more reluctant in terms of attitudes (see Blomqvist, 2005a). Because of these differences and also probably by pure chance only, the leading industrial clusters in the two countries are rather different. In Finland, the forest and heavy metal manufacturing and engineering clusters are important besides the newer telecommunication and electronics cluster; in Singapore, electronics are dominating but chemicals, engineering and life sciences, including biotechnology are also prominent.

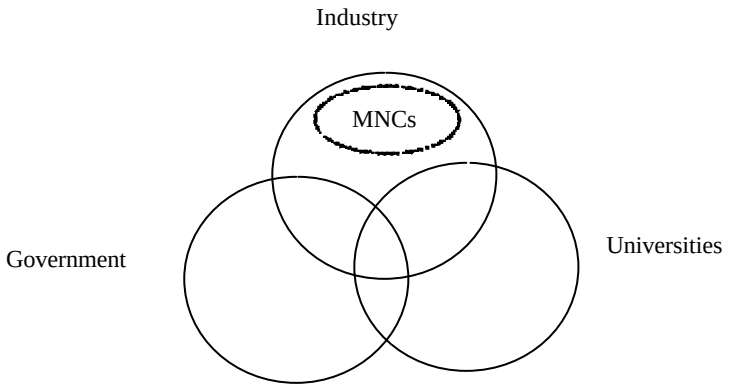
Table1: Economic Performance and R&D Input

	1980		1990		1995		2004	
	Finland	**S'pore**	**Finland**	**S'pore**	**Finland**	**S'pore**	**Finland**	**S'pore**
GDP/cap, constant 2000 USD	15341	8934	19970	14478	18637	19111	25146	24544
GDP/cap, PPP, current USD	9214	5265	18246	12041	19396	17969	29951	28860
Hi-tech exports, % of manuf. exports	..	..	8	40	15	54	21	59
R&D expenditure, % of GDP	..	..	..	..	..	..	4	2
Researchers in R&D (per million people)							7832	4999

Source: World Bank: World Development Indicators (2006).

Table 1 provides some key information on Finland's and Singapore's economic performance and investment in R&D. The figures convey surprisingly similar pictures of the two countries. While Singapore started out at a lower level of income, its economy grew faster during the period covered here and at the end of the period, the income levels were virtually the same. The share of high-technology products in the export of manufactures is much higher in Singapore. This can be explained by Singapore's role as an exporter of electronics, with most of these exports produced by multinational companies located in the country. The Finnish high-tech exports also consist mostly of electronics, mainly ICT related products, but the bulk of these exports originate in 'domestic' companies[2]. Finland seems to invest a good deal more in R&D both in terms of expenditure and manpower. However, it should be added that Singapore also does well in international comparison and is likely to catch up in the next few years. Despite these similarities, a closer look will reveal that there are big differences in the innovation system of the two countries.

Chart 1 : The Triple Helix Model



FINLAND

The Finnish industrial sector was built up after the World War II, with a strong input from the government, and

[2] Some of these companies are now predominantly foreign-owned, although they are based in Finland and are run by mostly Finnish management.

was dominated by the heavy forest and metal sectors and was quite export-oriented. The importance of innovation and openness to change has been recognized, at least rhetorically, by Finnish policy makers since a long time as compared to most European countries. Finland was ranked as the most innovative country in Europe along with Denmark, Sweden and Switzerland on the European Innovation Scoreboard 2006 (MERIT, 2006). This is certainly remarkable, given the country's short history as a high-tech producer, although this type of ranking always has to be interpreted with care[3]. The backdrop to this emphasising of know-how is, of course, the insight that Finland cannot remain internationally competitive in the long run unless it upgrades its industrial structure. (See, for example, Valtioneuvoston kanslia, 2004). Moreover, the peripheral situation and the smallness of its companies were regarded as problems as far as locating R&D in the country was concerned, an observation that no doubt added to the sense of urgency in terms of promoting 'the knowledge-based society'. Apparently, the important role of the government in this context was never questioned. A recent example of the general official attitude- the government programme for the period 2003-2007 stresses strongly the use of science and technology as a means for developing the national society and economy (http://www.research.fi/en). This emphasis recurs in the present government programme as well.

Given that scarce resources should be concentrated on a limited scope of activities, it was felt that strong innovative clusters, as well as networking of small companies were a precondition for creating a more attractive environment for investing in R&D (Ahlbäck, 2005: 46). Somewhat paradoxically, the increase in publicly funded R&D was especially strong in the 1990s, during and after the severest recession in Finnish economic history, when proceeds from privatized government-linked companies were invested in R&D (Ahlbäck, 2005: 6). Similarly, the importance of co-operation between the education system, research institutes and the enterprise sector, which was rather frowned upon before, has now been understood and as a result, it has become much more prominent than before. During recent years, international co-operation and internationalisation has become a catchword, both in the university and polytechnics sector and in other R&D contexts (http://www.research.fi/en, Ahlbäck, 2005: 8). The general view is that networking, in the national and international context, has enhanced technology transfer and has resulted in many new innovative SMEs (Ahlbäck, 2005: 17). Tax holidays or other targeted tax incentives have not been used in Finland, not even before its EU membership[4].

Public funding of R&D is the highest in Finland of all EU countries (in relative terms). It was 1.06 percent of the GDP in 2006 (http://www.research.fi/en). However, it comprises of only about 30 percent of the total funding and one company alone, Nokia, in fact, spends more on R&D than the Government. Of the private R&D funding, more than half is allocated to the electro technical industry (http://www.research.fi/en).[5]

R&D is only a part of the innovation process, however, it is an essential part of that process. The rest of the processes, which in some industries takes a long time, have to be financed, too. Some government agencies offer help here but as to private venture capital, essential for the successful development and commercialisation of new knowledge, the situation has been less than satisfactory. However, according to Maula et al. (2007), some improvement has taken place.

The education system is a crucial foundation for a successful innovation climate. In Finland, as in Singapore, tertial education is given by universities and polytechnics. Universities naturally concentrate on basic research but are also increasingly involved in more applied work, usually with funding from some of the government agencies mentioned below and sometimes, in collaboration with business enterprises. External funding contributes about 50 percent of total university outlays on R&D, but the bulk of this 'external' funding is still government money, channelled through some of the bodies mentioned below. Polytechnics are supposed to pursue applied research but their research activities are still in their infancy.[6] Together, the system of higher education enrols some two-thirds of the age group, obviously a very high figure (http://www.research.fi/en). The higher education sector has expanded very quickly and consequently, it is arguably severely underfinanced. Thus, there are reasons for concern despite the bright first impression of the system. Although the general level of technological

[3] Actually, the country was ranked number one in the world on a different set of indicators.

[4] Any measure of this type is now complicated by strict EU regulations.

[5] The origin of the Finnish ICT industry goes back to the 1970s, to research done at the initiative of the Finnish military and the national railway company (VR) (Ahlbäck, 2005: 9).

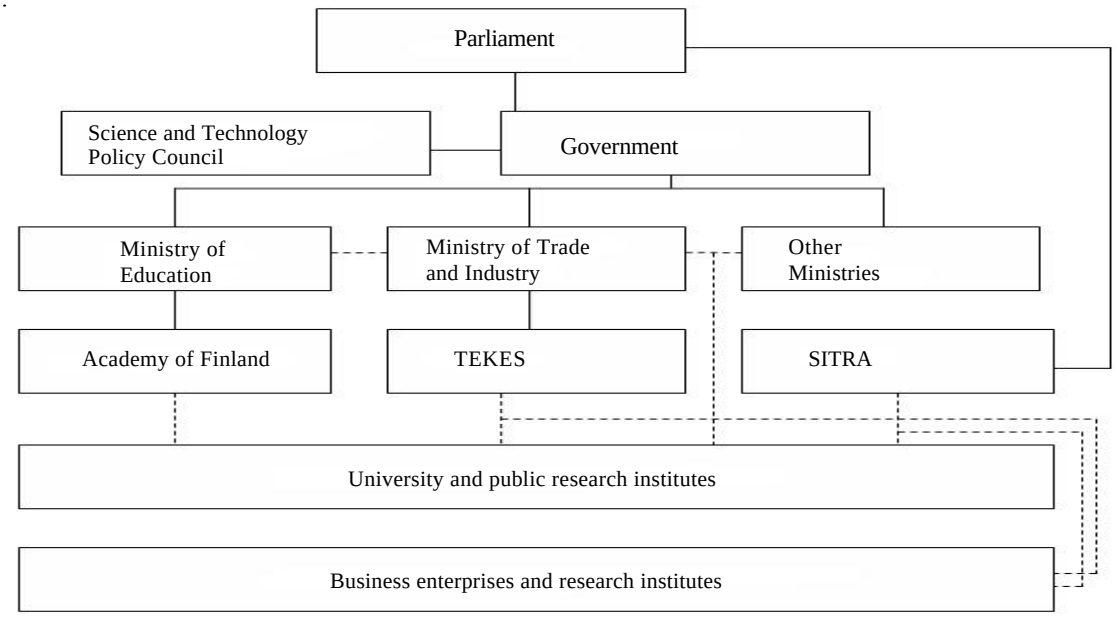
[6] This is mainly because polytechnics are a recent addition to the Finnish tertiary education sector.

know-how is good, some observers believe that Finland is actually lagging behind the cutting edge in technical research (Ahlbäck, 2005: 47). It is also 'common knowledge' that Finnish university graduates are not very entrepreneurial, although this appears to be less of a problem today than it used to (cf. Maula et al., 2007: 9). In comparison to Singapore, the share of science and engineering graduates, at the Masters level, is lower (This figure was 31 percent in 2007 http://kotaplus.csc.fi:7777/ online/Etusivu.do)[7].

The main players in Finland's innovation system are depicted in Chart 2 Public support for R&D is channelled mainly through the ministries of education; trade and industry; social and health; and agriculture and forestry. These ministries account for about 90 percent of the total funding over the state budget. The Council for Science and Technology, chaired by the Prime Minister fulfils the role of an advisory board. Sitra is an independent foundation, whose funding is not part of the state budget, although it is supervised by Parliament. It concentrates on funding business start-ups, development of new business ideas and technologies, as well as on research and inquiries. Sitra played a crucial role, for instance, in the development of the Finnish ICT cluster (http://www.research.fi/en).

Other central funding bodies are the Academy of Finland and Tekes (the technology development central) whose fund allocations go through the government budget and the ministries. The Academy of Finland finances mostly basic (academic) research, including salaries and training of researchers. The funding is granted on a competitive basis, using peer evaluation. Tekes, established as early as in 1983 (Ahlbäck 2005: 5) finances applied R&D of industrial or commercial projects. The research may take place in firms or as collaboration projects between firms and universities or research institutes. There are 20 government research institutes, which pursue applied research.

Chart 2 : The Finish Innovation System : The Main Players



Source: Adapted from Ahlbäck (2005).

Moreover, there are organisations like Finpro (an association that supports Finnish firms in matters like international trade and internationalisation), Finnish Industry Investment Ltd. (a significant contributor of venture capital) and Finnvera (a state-owned financing company specialising in export credits and other internationalising of business, as well as promoting domestic activities of Finnish firms through providing venture capital etc.). The aim is, ultimately, to develop the Finnish industrial structure and to create new jobs. (http:// www.research.fi/en, Maula et al., 2007: 45). Finally, there is a number of so-called innovation intermediaries, science and technology parks. These parks provide premises, infrastructure and, above all, a congenial environment for new high-tech enterprises. Particularly, part of that environment is technology transfer companies that assist with further commercialisation of research results emanating from e.g., universities and 'technology incubators'

[7] A comparison should be made with caution as differences in classification principles may affect the figures.

that assist with developing start-ups but also support more established companies in their effort to reach out to bigger markets (Alhlbäck, 2005). An interesting example of encouraging commercialisation of university research is the annual Venture Cup contest, where participants compete on developing business ideas and, at the same time, get assistance at refining their ideas (for more information, see http://frontpage.venturecup.org). Regionally, the TE-centres (regional employment and development centres, i.e., joint regional offices of the Ministries of labour and trade and industry) are important. The centres engage in promoting SMEs, supporting export activities and facilitate technological development within firms (Ahlbäck 2005: 19). Finnvera has regional offices as well.

Despite all facilities, problems seem to persist in establishing start-up companies and commercialising new inventions, as well as raising funds for these activities. Private investors (particularly the big institutional investors) are very cautious when it comes to investing in new and risky ventures, for instance through venture capital funds (Ahlbäck, 2005: 47, Maula et al., 2007: 37). Start-ups, whose technological foundation is in academic research, such as biotechnology, are more dependent on public funding than others. They also need more 'patient' capital than most, because the period needed to achieve profitability is typically long in these cases. Public funding, in turn, runs the risk of conveying a negative signal to the market, if a criterion for providing funding is that no-one else is willing to do so (Maula et al, 2007: 51-52). A particular problem appears to be the funding of large and ambitious ventures, where the aim is achieving a leading position on the global market (Maula et al., 2007: 25). The alleged lack of focus has also been criticized; instead of deepening existing activities, efforts have often been directed to developing new ones or enlarging the fields covered by existing players (Ahlbäck 2005: 47). The system is, moreover, fragmented and difficult to get an overview of, especially for new, inexperienced companies (Maula et al. 2007: 59).

In terms of funding, the bulk (about 70 percent) of R&D funding in Finland emanates from the private sector. The predominant clusters today are ICT and heavy engineering, including forestry technology. However, biotechnology and nanotechnology are rapidly growing clusters as well, although their importance in terms of industrial applications is not yet that great. Combining technology and industrial design is lifted up as a priority through the Designium network, based at the University of Art and Design in Helsinki (Knee and Meyer 2007: 3). There are presently plans to create an international top-of-the-range university in the Helsinki region by unifying the Helsinki University of Technology, the Helsinki School of Economics and the University of Arts and Design.

It is noteworthy that foreign direct investments (FDI) have not been an important channel for technology transfer in Finland. Nor have foreign MNCs chosen to set up research centres in Finland, despite a good supply of well-trained engineers and scientists. In fact, most inward FDI in Finland have been mergers and acquisitions, giving the investor access to technology developed there (Blomqvist, 2005a). The country's somewhat peripheral location in Europe is a likely reason for this.

SINGAPORE

Even if government initiative was of considerable importance in Finland's industrial development, particularly during the first decades after World War II, this was the case to an even greater extent in Singapore. Even today, the Singapore economy is very government-led, not only through policy initiatives but also directly through government-linked companies and statutory boards[8]. The government itself has been keen to adopt new technologies, especially in the ICT sector and in this way, it has functioned as a catalyst for transferring these technologies to a wider group of users (Blomqvist, 2005b: 9, Koh, 2006). While always taking a long-term view in its approach to development, the country has also shown great agility when it comes to adopting new, sometimes risky, strategies and policies. However, it has also been quick to abandon those of them that have not proved workable, a feature that is likely to promote innovativeness. The need to be prepared for change and to continuously upgrade its industrial structure has been a leading theme in the industrial policy of Singapore from the very beginning (Blomqvist, 2005b: 3, 8). As a centre for innovation, Singapore is a newcomer, however, but one that has made fast progress. According to the European Innovation Scoreboard's international comparison, Singapore is in the leading group (in 5th place) (MERIT, 2006).

[8] The statutory boards are quasi-governmental organisations, mainly in the field of public utilities.

There are thousands[9] of MNC (multinational companies) subsidiaries in Singapore and FDI has played a unique role in the industrial development of Singapore and is a crucial channel for technology transfer even today. The fact that about three-quarters of the industrial output in Singapore is produced by MNC subsidiaries (Wong, 2001) gives an idea of the importance of these companies. Another channel for technology transfer is the labour market, where Singapore applies a very liberal policy as to allowing immigration of well-qualified foreigners, 'foreign talent' (see, e.g., Low, 2001). The labour market is also a key to transferring know-how from the foreign affiliates to the domestic sector, especially as the government has assisted foreign subsidiaries in training of their employees. Similarly, the MNCs have been linked up with domestic suppliers in order to assist the latter with training of their workforce (Blomqvist, 2005b: 46).

A major problem in Singapore's quest for innovative excellence has always been the relative scarcity of domestic entrepreneurs. Whatever the reasons for this may have been (they are discussed by the present author in, e.g., Blomqvist, 2005b: 9, 37-38), the situation is improving, and supporting fledgling domestic entrepreneurs is now a priority in Singapore's industrial policy. The Economic Development Board (EDB), a key player of the government-led development of the Singapore economy, in the late 1990s set a target of building at least 50 knowledge-based 'world-class' companies by 2010 (Blomqvist, 2005b: 40). In this context, a 'technopreneurship' programme was set up as an initiative to promote innovative new SMEs (Parayil, 2005) providing many incentives, grants and other services. There does not seem to be any documentation as to whether the goal of 50 companies is being achieved or not, now when the deadline is drawing closer.

Although Singapore is a very small country, it is one that hosts one of the largest stocks of FDI even in absolute terms (Blomqvist, 2000b: 20). In order to attract FDI to the country, a number of incentives have been applied (for a brief summary, see Blomqvist, 2005b: 30-32). The importance of upgrading the industrial structure, not least because of rapidly increasing industrial capabilities of the neighbouring countries, was understood at an early stage, and in 1991, the National Science and Technology Board (later renamed A*STAR for Agency for Science, Technology and Research) was established. National science and technology plans have been the strategic backbone of the government activities towards promoting innovation (Blomqvist, 2005b: 34; see also Koh, 2006). The scope has not been just the domestic players. Also in this context, Singapore has strived at utilising its connections to leading MNCs and trying – often successfully – to engage them in R&D activities in the country.

The Asian economic crisis in 1997-98 made it clear to the decision makers that earlier development policies had to be overhauled. The report of the Committee on Singapore's Competitiveness from 1998 and the recommendations of the Economic Review Committee appointed in 2001, after another severe recession, were the start of a major revision of strategies. Singapore is now apparently moving towards a new industrial policy approach: From being very investment-led and dependent on FDI, the country is now going for a knowledge and entrepreneur-driven approach which includes facilitating horizontal networks and encouraging start-up SMEs. Apparently, the economic setbacks in the context of the Asian economic crisis in 1997-98 and at the bursting of the IT bubble in 2001 have underscored the risks of being too dependent on the region, on the one hand, and on the electronics industry, on the other (see Parayil, 2005). The education sector (especially the universities) plays a much greater role than before as a provider of the knowledge base for innovations. However, there are problems with commercialising inventions, just like in Finland. In particular, funding at the stage when a new firm is to be established seems to be difficult to come by. Some funding is available through the SPRING Singapore agency (Kotilainen, 2005: 58).

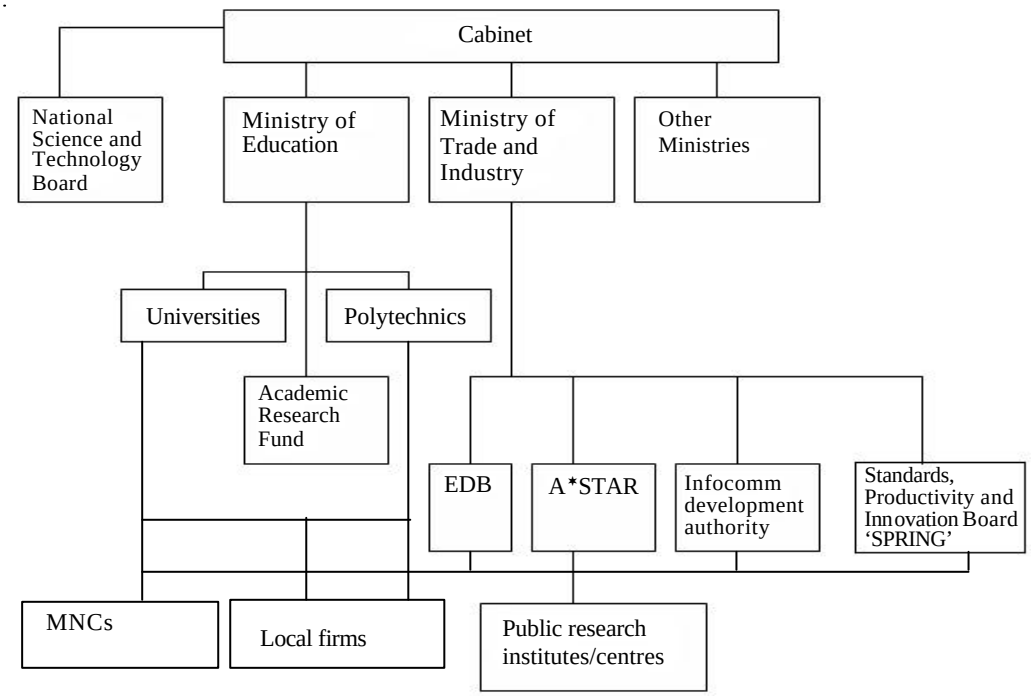
Singapore today has three universities, one university catering to adult learners (the SIM University) plus a number of foreign universities and institutes offering programs in the country (Some of the latter are physically present in the country, some are not). In order to promote more creativity, the state universities were recently granted much more autonomy than they used to have. Funding for basic research has been increased considerably as well during the last few years (Koh, 2006). The share of graduates in sciences and technical subjects has been relatively large; in 2006, the percentage was 50 (http://www.singstat.gov.sg/stats/themes/people/edun.html)[10]. In excess of this, there are also several polytechnics and vocational institutions catering to the need of technical expertise. The universities are now expected to play a much greater role than before in supporting entrepreneurship

[9] A figure recently mentioned is over 7,000 (http://www.singapore-sme.com/resources.asp).
[10] The figure includes postgraduate diploma and higher degree courses.

among its staff, including incubating start-up enterprises. They already engage in commercialisation and start-up support of enterprises based on university research and is run by university staff (Kotilainen, 2005: 56-57). The international contacts and collaboration projects with high-level foreign universities is also increasing rapidly.

The innovation system in Singapore is outlined in Chart 3. The most important ministries are the Ministry of Education, which is in charge of the university and polytechnics sector[11], and the Ministry of Trade and Industry, under which are organized a number of statutory boards, among them the EDB and A*STAR. The EDB is the oldest and most prominent of the government's tools for industrialisation. Traditionally, its main task was attracting FDI to Singapore through providing first-class infrastructure and a congenial business climate. Nowadays, the EDB is strongly engaged in the effort of developing the country's innovation system. Recently, the Science and Technology 2010 Plan was launched with the backing of SGD 8.5 billion (http://www.edb.gov.sg/edb/sg/en_uk/index/news_room/news/2006/ges_2006_gala_dinner.html) and with the aim of enhancing private sector R&D activity. Also, the HOTSpot concept (see below) and provision of enterprise incubators, seed financing etc. are examples of that (Kotilainen, 2005: 58). A*STAR is the national science and technological agency, under which a large number of government research institutes operate (Kotilainen, 2005: 55. Details on the institutes can be found at http://www.a-star. edu.sg/astar/about/action/ about_institutes.do). The funding of these institutes grew very rapidly in the 1990s (Wong, 2001). The agency also provides R&D funding to the two state universities as well as to the state hospitals (Kotilainen, 2005: 56). The Infocomm Development Authority (IDA) aims at cultivating 'a vibrant and competitive infocomm industry in Singapore – one that attracts foreign investment and sustains long-term GDP growth through innovative infocomm technology development, deployment and usage in Singapore – in order to enhance the global economic competitiveness of Singapore (IDA, 2007). A very extensive ICT infrastructure was built up in the 1990s (see Chia, 2001). In 2007, the National Research Foundation was set up with a funding of SGD 5 billion over the next five years (http://www.nrf.gov.sg/).

Chart 3 : Singapore's Innovation Systems



Source: Adapted from Kotilainen (2005: 48).

Within the industry element of the innovation system, the interaction between foreign MNCs and the large, usually government-linked domestic companies has always played a big role. What is new is the role the SME sector is assumed to play, as well as the more central role of the university system. The co-operation between the public research institutes and industry could be developed as well (Wong et al., 2003). Moreover, the emphasis

[11] The aim is to instil a sense of entrepreneurship in the lower education system as well. Since the Singapore school system is not known for its emphasis on creativity and independent thinking, this is something of a challenge.

of the system has changed from one of absorbing and leveraging leading technologies from MNCs to creating and management of new knowledge. The role of foreign companies is expected to be more concentrated on R&D than before, while low-end industrial production may not necessarily be retained in the country. This is supposed to eventually make Singapore a leader, not a follower in development of technology. Biotechnology (as well as life sciences in general) is the industry particularly targeted in this context (for details, see Parayil, 2005 and Koh, 2006), a bold and risky choice, as Singapore did not have much research capacity in this field to begin with. In Singapore, industry accounts for just over 60 percent of R&D, of which some originates from abroad (Kotilainen, 2005: 48). While comparatively little direct government funding goes to the private sector, the indirect support of the government is very significant. Tax incentives, grants, loans and other forms of assistance traditionally abound in Singapore. On the other hand, universities do not benefit much from company funding, although again, the indirect benefits may be considerable. With the new governance model of the universities, where their autonomy is much greater than before, they may now be in a better position to engage industry in their research activities.

The key to understanding the system is not just recognising the players but identifying how they interact. Singapore's vision is to forge alliances between government agencies, (large) companies, universities and research institutes, and newly established enterprises that are often spin-offs from academic projects (Parayil, 2005). Moreover, the linkages between these players and players located in other countries' innovation systems play an important role (Wong, 2001). Networking appears to be a key to innovativeness as an innovation is often dependent on knowledge created in other organisations (Wong and Ho, 2007). To achieve this, statutory boards such as the EDB have been restructured, problems related to intellectual property rights have been addressed and government support to R&D has been strengthened. A new science park devoted to the biotechnical sciences, the 'Biopolis', was established close to the National University of Singapore in 2002. (Parayil, 2005). Apart from government funding agencies, Biopolis accommodates five research institutes, two academic research groups; research units of foreign MNS and domestic SMEs (Knee and Meyer, 2007: 4).

In a collaborative effort between the public and the private sectors, ten so-called HOTSpots have been established. The idea is that physical proximity helps sharing and exchange of ideas. The HOTSpots (where HOT stands for Hub of Technopreneurs) are a network in a programme linking together ten technological centres and more than 500 hi-tech firms (Kotilainen, 2005: 54).

The strong role of the state, while probably necessary in building up a new innovation system, also carries the danger of being a stifling factor in the long run and may have to be redesigned (cf. Low, 2003). Another weak link in the innovation system is, according to a study by Wong et al. (2003; see also Wong, 2001), insufficient co-operation between public research institutes and universities on the one hand and industry on the other. Spontaneous organisation and reorganisation of the interaction between the players of the system is likely to be important for the sustainability of the momentum of the system. So-called social capital is likely to be a crucial asset as well. If it is not there, any funding or physical infrastructure may not help (Low, 2003).

CONCLUSIONS

Both Finland and Singapore are newcomers in the elite league of innovators. In both cases, the government input is very significant and growing, both directly and through the public education system. Furthermore, the engagement of the higher education sector in the national innovation system at a wider scale, beyond technical education, is relatively recent. Although they share many traits of their innovations system, there are distinct differences as well. The biggest one is perhaps the role of multinational companies, which is crucial in Singapore but very marginal in Finland. In fact, in Singapore, the interplay between MNCs and local firms is extremely important and actively promoted by the government. However, in both countries, the innovation system is evidently successful. Thus, different systems may apparently produce good results.

One important question is, nevertheless, how far a government-driven innovation system can take a country. What if the system becomes too co-ordinated and orchestrated and because of this, it suffocates curiosity and creativity? This is a relevant question to be posed to both countries, and maybe to Singapore in particular, as the role of the government has been even stronger there. And what if too much attention is paid to the applied part of the innovation chain, neglecting basic education and research? While this is a risk in both countries, the Finnish

system presently seems to be more vulnerable. Finally, the judgement is still out when the 'superiority' of one system over the other is concerned. There is no unambiguous way of measuring this. Moreover, today's innovation system may have consequences that can only be seen in the long run.

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