Singapore's biomedical science sector development strategy: Is it sustainable?

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Abstract

This paper outlines the strategic efforts undertaken by Singapore to establish its national capability in the biomedical science sector, reviews the commercial base as a result of these efforts and compares Singapore's approach with the UK and US development models, discusses the challenges that Singapore faces and raises some questions on the long-term sustainability of the sector.

Although Singapore is a small country in terms of geographical size, its economic size is significant, with gross domestic product (GDP) and GDP per capita of US$112bn and US$25,200 respectively in 2002. For the past 40 years, the country has achieved an average annual GDP growth of 8.4 per cent by focusing on manufacturing and productivity improvements. Biotechnology has been earmarked as the next wave of technology that will sustain the country's economic growth. For almost two decades, Singapore has focused its efforts on building capabilities in the biomedical science area to exploit biotechnology and traditional chemistry-based technologies in drug discovery, development and production. The main principle of Singapore's strategy is to locate a sector targeted for growth and then to focus its efforts on building the key pillars to support the sector; identified in this case to be research, early stage funding and specialised infrastructure.

Keywords: *Singapore, biotechnology, cluster, strategy, business model*

INTRODUCTION

For the past 40 years, Singapore has achieved an average annual GDP growth of 8.4 per cent, based on its ability to renew its manufacturing base and increase productivity year on year. As Singapore has grown, the country has moved from low-value, high-volume activities, such as textile manufacturing, to oil refining and later disk drive production. Over the past two decades, Singapore has earmarked the biomedical science sector as one of the key pillars for economic growth as the country transformed itself from an export-driven manufacturing economy to one that is global and knowledge-based. The biomedical science sector is identified as a sector that comprises four industries, namely pharmaceuticals, medical technology, biotechnology and healthcare services. Singapore has focused its efforts on building capabilities in the biomedical science area to exploit biotechnology and traditional chemistry-based technologies in drug discovery, development and production. The driving force behind this initiative is Singapore's Agency for Science, Technology and Research (A*STAR) and the Singapore Economic Development Board (SEDB). By the end of 2003, the biomedical science sector contributed SGD11.3bn in manufacturing output to the country's GDP, a rise of 15.9 per cent over 2002.

DEVELOPMENT STRATEGY

Singapore's vision is to develop itself as the 'Biopolis of Asia' where companies will locate their research, development, production and headquarter activities, allowing Singapore to capture activities across the biomedical science value chain. The development strategy for the biomedical science sector in Singapore aims to strengthen Singapore's human intellectual and industrial capitals. This is

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done through establishing world class research institutions and specialised research infrastructure and providing funding for early stage businesses through a government-supported body.

Biomedical science research institutions

Singapore's strategy to grow the biomedical science sector is based on four focus areas: biotechnology, medical technology, pharmaceuticals and healthcare services and delivery (Figure 1). These four sectors share many synergies, facilitating the discovery, development and commercialisation of healthcare products and services to diagnose and treat human diseases, and are supported by research in genomics, molecular biology, bioinformatics, bioprocessing, bioengineering and nanotechnology and chemistry.

A*STAR, funded by the Singapore government, plans to invest SDG1.2bn in public biomedical sciences research

A*STAR, funded by the Singapore government, plans to invest SDG1.2bn in public biomedical sciences research through the following research institutions (Table 1).

Institute of Molecular and Cell Biology (IMBC)

IMBC was established in 1987. Currently, IMBC concentrates on the development of R&D capabilities in Singapore by concentrating on basic research in the following fields: cell biology, developmental biology, structural biology, infectious disease and cancer biology. The institute has 38 independent research groups with more than 400 staff members.

Bioprocessing Technology Center (BTC)

BTC was established in 1990 and aims to build a technology base to support commercial production of biopharmaceuticals. BTC is also tasked to develop personnel capabilities by providing training to the local talent pool. BTC's core strengths are in DNA, peptide and proteomic technology, gene expression and viral vector, cell culture, microbial fermentation, protein characterisation and purification. Currently, BTC has a cGMP facility designed to produce biologicals under US-FDA and EU regulatory guidelines.

Genome Institute of Singapore (GIS)

GIS was established in 2000 and pursues the integration of technology, genetics and biology towards the goal of individualised medicine. The scientific focus is to investigate post-sequence genomics, to understand the genetic architecture of pan-Asian populations with emphasis on cancer biology, pharmacogenomics, stem cell biology and infectious disease. There are currently 160 staff members in the institute.

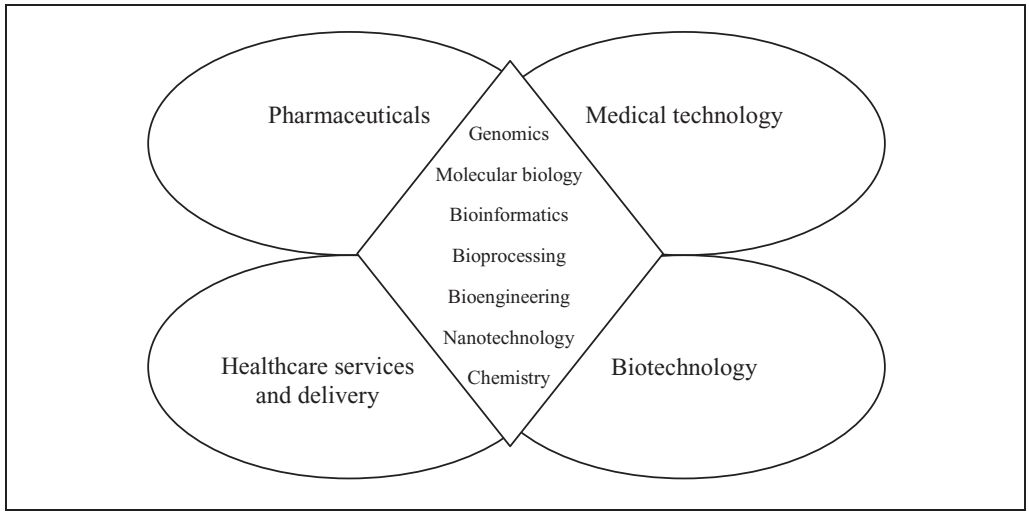

Figure 1: Singapore focus area in biomedical sciences
Source: Singapore Economic Development Board (SEDB)

Table 1: Establishment of research institutions and supporting infrastructure in Singapore

Year	Basic research	Clinical research	Downstream technologies
1987	Institute of Molecular and Cell Biology (IMCB)		
1988			
1989			
1990		Singapore National Eye Center (SNEC)	Bioprocessing Technology Center (BTC)
1991			
1992	Protein and Proteomics Institute (PPC)	National Skin Center	
1993	Center for Natural Product Research (CNPR)		Singapore Institute of Manufacturing Technology (SIMTech)
1994			
1995			
1996	Bioinformatics Center (BIC)		
1997	Institute of Materials Research & Engineering; Laboratories for Information Technology (LIT)	Lilly-NUS Center for Clinical Pharmacology, National Cancer Center (NCC)	
1998		Cancer Therapeutic Research Group (CTRG)	Institute of Chemical Sciences (ICS)
1999		John Hopkins Singapore (JHS), NUS Drug Study Center	
2000	Genome Institute of Singapore (GIS)	National Neuroscience Institute (NNI), National Heart Center (NHC)	Chemical Process Technology Center (CPTC)
2001	Bioinformatics Institute (BII)		
2002	Institute of Bioengineering and Nanotechnology (IBN)		
2003	Center for Molecular Medicine		

Sources: Wess,[1] SEDB

Specialised infrastructures for research and production activities are being built in Singapore as part of the country's vision to capture all aspects of the biomedical science value chain

BioInformatics Institute (BII)

BII was established in 2001. Its focus is building Singapore's capabilities in bioinformatics. BII's research focus centres around knowledge gained from biological data, exploiting high-end computing in biomedicine, advancing molecular imaging of biological processes, modelling of drug design and delivery, computational proteomics and systems biology. There are currently 80 staff members in the institute.

Institute of Bioengineering and Nanotechnology (IBN)

IBN was established 2002 and focuses on research at the interface of bioengineering and nanotechnology in the areas of nanobiotechnology, delivery of drugs, genes and proteins, tissue engineering, artificial organs and implants, medical devices, as well as biological and biomedical imaging.

Specialised infrastructure

Specialised infrastructures for research and production activities are being built in Singapore as part of the country's vision to capture all aspects of the biomedical science value chain. Through these facilities, Singapore aims to provide 'plug and play' facilities for both local and foreign companies. The two major components of this infrastructure are the Biopolis and Tuas Biomedical Park.

The Biopolis, an integrated R&D complex, represents the first stage of a SGD15bn project, One-North, that will span 15 years and aims to cultivate biomedical research and other research-based industries. Costing SGD500m, the Biopolis will be made up of seven buildings when completed, with a combined area of 185×10^3 m^2 (2 million square feet). Its three principal objectives are

- to be a focal point for scientific talents;
- to integrate and synergise the capabilities and resources of research institutes and to encourage cross-disciplinary research;

- to bridge the private sector and public sector research work by creating an environment that foster exchange of ideas and close collaboration.

Biopolis is being marketed by Singapore as a biomedical research hub with shared facilities that will bring economies of scale and operation efficiencies to its tenants. When completed the facilities will include specialised equipment and services such as flow cytometry, X-ray crystallography, nuclear magnetic resonance, electron microscopy, DNA sequencing, proteomics, histology, laboratory supplies, media preparation, glassware washing and animal resource centre. The current tenants of Biopolis include the five public research institutions, biomedical R&D companies, such as Norvatis Institute for Tropical Disease, Vanda Pharmaceuticals and Paradigm Therapeutics, and some of A*STAR's operations, such as the Biomedical Research Council (BMRC), Science of Engineering Research Council (SERC), Exploit Technologies Pte Ltd (ETPL) and EDB Biomedical Science Group (BMSG).

Tuas Biomedical Park is a specialised production area offering a 'plug and play' facility for companies

Tuas Biomedical Park is designed for production activities in the biomedical science sector. This specialised production area offers a 'plug and play' facility for companies. Tuas Biomedical Park represents Singapore's vision to capture the production aspect of the biomedical science value chain, in line with the country's intent to sustain production activities, which currently contributes 25 per cent to the country's GDP. Some of the world's largest pharmaceutical company, such as GlaxoSmithKline, Merck, Pfizer, Schering Plough, Aventis, Wyeth and Baxter, have already located their production base to Singapore.

Early stage funding

The Singapore government provides capital for start-ups in the biomedical science sector in the form of equity funding and government grants. This initiative is crucial to foster entrepreneurship and the development of the local commercial base.

*Bio*One Capital*

Bio*One Capital is the dedicated Biomedical investment arm of the SEDB. The objectives of Bio*One Capital are:

- to make strategic investments;
- to bring key scientific and economic contributions to Singapore's biomedical science sector; and
- to achieve the goals of generating highly skilled jobs as well as transferring technology and expertise to Singapore.

Under Bio*One Capital, a SGD1bn Biomedical Science Investment Fund (BMSIF) has been set aside to invest in Singapore-based joint ventures, overseas biotechnology companies and local start-ups over a period of five years (2001–2005). BMSIF makes direct equity investments in companies worldwide, co-invests in Singapore-based joint ventures, and invests in Singapore based companies/start-ups and in overseas biomedical sciences funds (Table 2). BMSIF started investing in US and European biomedical companies in 1987, usually with a minor participation of up to 10 per cent.[1] Bio*One Capital now manages funds in excess of US$650m and has strategic investments in over 80 companies worldwide (Table 3). In general this is a strategy to build up the critical mass for the science base in Singapore by asking the investees to commit themselves to set up a joint venture or a subsidiary in Singapore as soon as they are ready to expand.

The investment focus of Bio*One Capital has shifted over the years from overseas to a more local and strategic development focus now. As of year 2000, 77 per cent of the SGD1bn investment fund is invested in Singapore-based activities, compared with only 23 per cent in 1991 (Figure 2).

Table 2: Key selection criteria under BMS Inc. and BMSIF funding scheme

BMS Inc.	BMSIF
• Potential to produce commercially viable products and services in the field of biomedical sciences • Products and services that will differentiate the venture in the marketplace and provide competitive advantages • Solid propriety position supported by good scientific fundamentals • Substantial activities in Singapore that will entail the hiring of credible managers and research scientist over a specific duration, with intermediate milestones for verification • Clear development plan with specific milestone to be able to attract subsequent source of funding or partnering opportunities	• Cutting edge technologies • Outstanding management • Global opportunities • Sound business models • Singapore value – technology transfer, Industry development, creation of employment and opportunities

Source: EDB Investment

More than 50 companies are being incubated in Singapore

Seed capital

The Start-up Enterprise Development Scheme (SEEDS) aims to provide equity financing for start-ups in the seed stage of enterprise formation. This scheme is administered by the SEDB. Under the SEEDS scheme, SEDB will match dollar for dollar every third-party private sector cash injection to a company, up to a maximum sum of SGD300,000.

Biomedical Sciences Innovate N' Create (INC) an SGD25m fund under BMSIF, was created in 2002 to provide seed equity between SGD250,000 and SGD2m to promising local biomedical start-ups.

In 2003, a new Biomedical Sciences Proof-of-Concept Scheme (POC) was created to help scientists at local research institutes to develop early research ideas and to bring them to market. The scheme will provide funds up to SGD300,000 per project. However, at the point of application the scientist must secure an interested investor or industrial partner who can provide them with business or technical advice from concept through to commercialisation. The SEDB aims to support up to 20 POC projects over the next three years.

DEVELOPMENT OF THE COMMERCIAL BASE

Singapore's effort to strengthen the biomedical science sector has led to significant growth of its commercial base in the past few years. Its strategy has encouraged innovation among local institutions and formation of new ventures, and has also attracted established firms to the region.

Start-ups/new ventures

Currently, there are more than 50 companies being incubated in Singapore, of which more than half have foreign founders and have third party investors.[2] Among the most common routes to commercialisation of research ideas is the development of spin-offs from a research institute or university. In Singapore, companies that have been formed from local research institutions include the following:

- MerLion Pharmaceuticals originated from the Center for Natural Product Research (CNPR) which was established in 1993 in a collaborative agreement between GlaxoSmithKline and Singapore's Institute of Molecular and Cell Biology. CNPR was privatised in May 2002 to form MerLion, to form a discovery and development company. After its formation, MerLion embarked on formal collaboration in drug discovery and development with global player such as Fujisawa Pharmaceutical Co. Ltd, John Hopkins Singapore Pte Ltd and the National Cancer Center (Singapore). MerLion's privatisation is seen to represent successful privatisation of Singapore's research

Table 3: Bio*One portfolio companies

USA – West Coast	**Singapore**
CBR Systems, Inc.	Agrogen Pte Ltd
Forward Ventures IV LP	ES Cell International Pte Ltd
Genesoft, Inc.	MarinEx Pharmaceutical (Singapore) Pte Ltd
geneticXchange, Inc.	S*Bio Pte Ltd
Genomics Collaborative, Inc.	Attogenix Biosystems Pte Ltd
ISTA Pharmaceuticals, Inc.	ABio Pharma Pte Ltd
Lynx Therapeutics, Inc.	Merlion Pharmaceuticals (Singapore) Pte Ltd
Metrika Laboratories, Inc.	Merlin MD Pte Ltd
Oculex Pharmaceuticals, Inc.	
Optimer Pharmaceuticals, Inc.	
Perlegen Sciences, Inc.	**Europe**
Sun Biomedical Ltd	ML Laboratories Plc
Surromed, Inc.	Cyclacel Ltd
U-Systems, Inc.	International Biotech Trust Plc
Zyomyx, Inc.	Xenova Group Plc
Raven Biotechnologies, Inc	Paradigm Therapeutics Ltd
Fluidigm corporation	Aravis Venture I LP
Kadmus Pharmaceuticals Inc	Carnegie Fund II
Galileo Pharmaceuticals, Inc	International Life Science Fund III
Genospectra Inc	SpineVision
Kalypsys Inc	U3
Celscia Therapeutics	
Renovis Inc	**Israel**
	Powerpaper Ltd
USA – East Coast	
Acorda Therapeutics, Inc	**China**
Aderis Pharmaceuticals, Inc	Beijing Huayi Biotech Pte Ltd
Genzyme Corp (Biosurgery Division)	
Hybridon, Inc	
Idenix Pharmaceuticals, Inc	
MPM Bioventures II LP	
Therion Biologics Corp	
United Biomedical, Inc	
Viacell, Inc	
MPM Bioventures III LP	
Athersys, Inc	
Care Capital Investment II LP	

Source: SEDB

facility and Singapore's capability to create its home-grown biomedical commercial base.

- Attogenix Biosystems a microfluidics company is a spin-off from Nanyang Technology University (NTU) and Defense Science Organisation (DSO) Laboratory. The technology platform company focuses on the development of biochips for the biomedical sciences research and pharmacogenomics market. Attogenix Biosystem was a beneficiary of BMS INC seed capital in 2002.

- Promatrix Biosciences, a tissue engineering company which aims to market its technology in the form of a bioreactor for growing stem cells for research and application was spun-off from John Hopkins Singapore. Promatrix Biosciences was a beneficiary of BMS INC seed capital in year 2002.

- KOOPrime develops and markets a range of Enterprise Application Integration software products and services customised for the biomedical sciences industry is a spin-off from National University of Singapore (NUS). KOOPrime was a beneficiary of BMS Inc. seed capital in 2003.

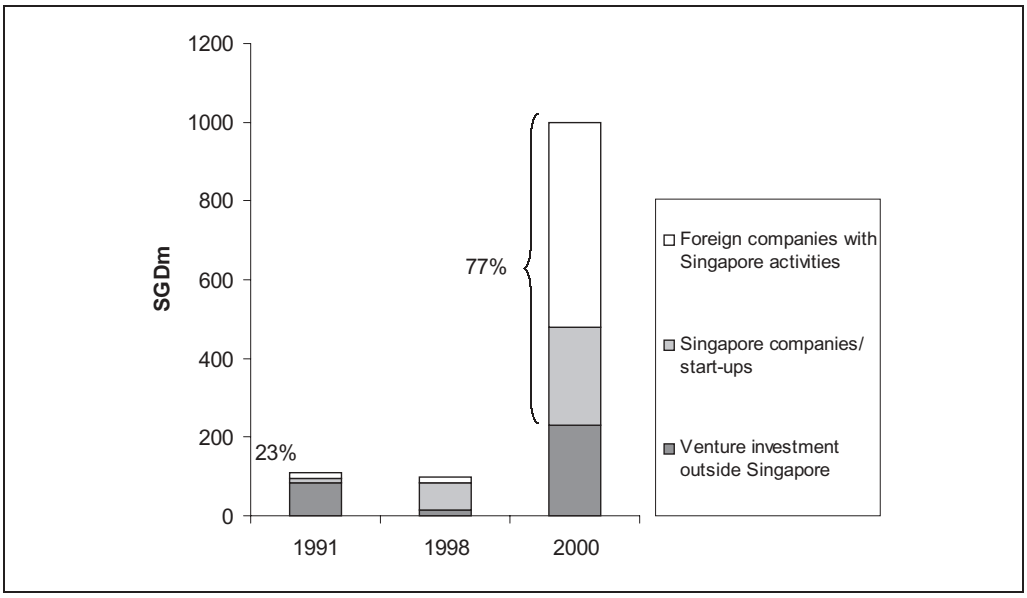

Figure 2: Investment Profile of Bio*One Capital – snapshot of cumulative investments of years 1991, 1998 and 2000
Source: SEDB

- A-Bio, a contract manufacturing company focused on production of monoclonal antibodies and mammalian cell culture technology, is a spin-off from BTC. A consortium of companies led by BMSIF is the investors behind A-Bio.

Apart from home-grown start-ups and spin-offs from local research institutions, other strategies to build the commercial base include attracting foreign companies and institutions to Singapore during this early stage cluster development where the present of a critical mass of players is crucial to ensure sustainability and further growth. For example, S*Bio is a result of co-investment by the Singapore government through Bio*One funds with a foreign party, Chiron Corp, to establish a commercial base in Singapore. Under the agreement, a core group of S*Bio scientists were sent to Chiron's US facility for training in drug discovery and genomics technologies. This arrangement is intended to jump-start S*Bio's scientific and research programmes.

Another example is ESI Cell International, which was formed by a joint investment between SEDB and ES Cell Australia Ltd. The company focuses on human embryonic stem cell development and has its headquarters in Singapore, with research undertaken in Singapore, Australia and Israel. More recently, Paradigm Therapeutics which is based in Cambridge, UK, has established a wholly owned subsidiary in Singapore. Bio*One capital invested in the parent company and as a result created a spin-off in Singapore. Paradigm Therapeutics is a drug discovery and development company focusing on the identification of new potential drug development opportunities through human genome. Another notable venture is the formation of the International Medical Center (IMC) in 2000 between National University Hospital (Singapore) (NUH) and John Hopkins.

The presence of large pharma will help increase the number of players in order to achieve critical mass . . .

Large pharma

Singapore is currently an operational base for a number of large pharma companies. The Singapore government continues to attract large pharma to set up operations in the country. This strategy is crucial to build-up the critical mass of expertise and corporate players for the Biomedical Science sector. The presence of large pharma will help to increase the number of players in order to achieve critical mass, and will also provide opportunities for cross-learning and formation of strategic alliance between large pharma and small biotech companies. As observed in most

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mature clusters, large pharma and small biotech companies interact to form profitable alliances and partnerships.

Historically, large pharma locate their operations to Singapore for cost competitiveness. For example, as early as 1970s, GlaxoSmithKline located its production facility in Singapore (SmithKline Beecham set up an antibiotics plant and GlaxoWellcome set up a chemical plant). For the past 2 years, a US$1.8bn incentive is budgeted to encourage large pharma to invest in Singapore in addition to attractive tax breaks.[3] In 2002, three key players – GlaxoSmithKline, Wyeth and Schering-Plough – built plants in Singapore.[3]

The main principle of Singapore strategy is to identify a sector targeted for growth and then to focus its efforts on building the key pillars to support the sector; identified in this case to be research, early stage funding and specialised infrastructure

More recently, large pharma has started to set up R&D facilities in the country. Schering-Plough Corp has established a clinical development centre. Eli Lilly and Co. set up a research institute known as the Eli Lilly Systems Biology Pte Ltd. Novartis AG established its Institute for Tropical Diseases, which will focus on the discovery of treatments for common ailments in the region such as tuberculosis and dengue fever.

A NEW APPROACH

The development of biotechnology commercial base in Europe and USA in the past 20 years has been driven mainly by independent research and industrial activities.[4] For this development trajectory to result, a few elements have to be in place. First is the existence of a developed and strong science base which is clearly evident in the UK and the USA. Second is the realisation of the commercial potential of the science and the willingness to take risks to commercialise a new technology.[4] In the UK and the USA the development of the sector is made possible by the existence of two main groups: first, scientists who became entrepreneurs and were willing to take the risk of exploiting the new technology. Secondly, venture capitalists (VCs) who were willing to invest in new technology and took risk in doing that.[4] An example of this development is the formation of the first biotechnology company, Genentech, in 1976. The company was founded by Swanson, a venture capitalist at that time, and Boyer, the scientist who invented rDNA technique. Genentech went public in 1978, raising US$35m. It has always been questionable if the Europe and US model can be transferred to other economies, especially where the prerequisite for the success of a science base sector is not present at the first place.

The strategy adopted by the Singapore government represents a different trajectory from the European and US cluster growth. In the case of Singapore, it is clear that the driving force behind the development of the biomedical sector is the government. The main principle of Singapore strategy is to identify a sector targeted for growth and then to focus its efforts on building the key pillars to support the sector; identified in this case to be research, early stage funding and specialised infrastructure. Although it may be too early to assess how successful this approach is, it is already evident that it has created a significant impact on the biomedical science sector in terms of the growth in the number of start-ups, the increasing presence of foreign pharmaceutical companies in Singapore and the growth in manufacturing output of the sector (see Table 4).

IMPLICATIONS FOR GLOBAL BIO-MANUFACTURING BUSINESS MODEL

Rapid early stage cluster growth

Currently, the commercial base of Singapore's biomedical science sector consists of a pool of start-ups, most of which benefit from government grants, as well as equity investment from publicly funded or private VCs. Singapore had its first fully integrated drug discovery company, S*Bio, established in 2000. In the span of less than four years, there are now over 50 companies incubated in

Table 4: Summary of BMS sector performance (nominal growth)

	Manufacturing output (SGDm)			Value-added (SGDm)			Employment		
	2002	2003	% growth	2002	2003	% growth	2002	2003	% growth
BMS total	9,763	11,312	15.9	5,876	6,922	17.8	7,343	7,596	3.4
Pharmaceuticals	8,055	9,532	18.3	4,892	5,892	20.5	3,203	3,589	12.1
Medical technology	1,708	1,780	4.20	983	1,029	4.6	4,140	4,008	(3.2)

Source: SEDB

Singapore. The establishment of a public funded VC is an innovative way to jump-start the sector, especially when the capital market within Singapore is still in its infancy.

Business focus (product v platform/services)

Currently, most local start-ups in Singapore are technology platform-based companies which focus on the discovery and development of a technology platform to aid product development. This business model aims to generate value through licensing fees, subscription and service fees of the technology platform.[5] Companies, particularly local start-ups such as Attogenix Biosystem, Promatrix Biosciences and KOOPrime, seem to adopt the technology platform business model. Platform-based business models are relatively easier to set up,[6] enable companies to operate in a lower-risk environment, but have lower return than a product-based company. However some critics point out that there is little scope for value generation in this model and that the technology that these companies rely on risks being commoditised. A common strategy is for companies to generate short-term revenues from platform technologies while simultaneously engaging in the lengthy and expensive product development. It is, however, unclear if the technology platform-based companies in Singapore are pursuing this path.

Global business network

Singapore's strategy location coupled with its extensive transportation routes to other parts of Asia offers companies a base to access the other parts of Asia that are underdeveloped compared with Singapore. With their main activities anchored in Singapore, companies could operate a global business network to complement their core activities in Singapore. For example, SciGen one of Singapore's biotechnology companies aims to tap into Vietnam, Philippines, Indonesia, China, India and Pakistan.

One of Singapore's challenges is to maintain the supply of personnel to sustain the growth of the economy

CHALLENGES

Personnel

With a population of four million and a declining birth rate, one of Singapore's challenges is to maintain the supply of personnel to sustain the growth of the economy. One potential pitfall is the lack of skilled staff. To address this crucial supply issue, the government is focusing on the education system, staff training and use of foreign talent. This supply issue is addressed through direct funding in education and training in the area of biomedical sciences and foreign talent policy to fill the immediate needs. For example, A*STAR supports individual researchers through a five year SGD500m National Science Scholarship initiative. This initiative supports students beyond PhD levels and is expected to train 600 research scientists in the area of biomedical sciences. Other educational-based efforts include promoting interests in biomedical sciences targeted both at teachers and students at the high-school level. For staff training, the BTC trains 60 MSc and BEng students every year. In addition, five polytechnic institutions in

Singapore are also training laboratory technicians.

Regional competition

Singapore faces strong regional competition from Malaysia, Australia, India, Hong Kong and China. These different economies are competing for inward investment from established firms abroad and the limited pool of talent to support the growth of the biotechnology sector. Government support and funding in the form of grants, benefits, incentives and tax breaks is a prominent feature throughout Asia. Almost every Asian government is planning to develop infrastructures and a commercial base in their respective countries.

Almost every Asian government is planning to develop infrastructures and a commercial base in their respective countries

One of the main issues faced by Singapore is the lack of experienced investors in the area of biomedical sciences which is key element for early stage cluster growth. The capital market in Singapore is relatively young and foreign VCs from the USA and the UK might be reluctant in investing outside their home base especially in young clusters. In contrast, companies seeking funding may find Hong Kong a better place and it has a stronger financial sector and the largest venture capital fund in Asia that companies can capitalise.

Compared with its competitors, Singapore's domestic market is small. Although companies could leverage its extensive transportation systems and proximity to other Asian countries, its local market may be too small to sustain the scale of production that the country hopes to achieve. India, for example, may be more attractive as a manufacturing base for companies that prefer to locate their production near to their markets. With a population of one billion and the availability of skilled workforce, India is definitely a competitor to Singapore when it comes to attractive direct investment.

CONCLUSIONS

The main principle of Singapore strategy is to identify a sector targeted for growth and then to focus its efforts on building the key pillars to support the sector; identified in this case to be research, early stage funding and specialised infrastructure. Although it may be too early to assess how successful this approach is, it is already evident that it has created a significant impact on the biomedical science sector in terms of the growth in the number of start-ups, the increasing presence of foreign pharmaceutical companies and the growth of manufacturing output of the sector.

Although the commercial base of Singapore's biomedical science sector consists of a pool of start-ups and a number of large pharmaceutical companies, the sector is still in its infancy and is growing. Currently, most home-grown companies are technology platform-based companies. To sustain the growth of the sector, Singapore will have to continue to compete against other regional players for direct investment as well as for foreign talents. It remains unclear which countries will benefit the most from their investments in the sector. The questions that remain are:

- Is the approach adopted by Singapore, which is heavily funded by the government, sustainable?
- Can Singapore compete successfully for talent and resources with its neighbours and other global players?
- Do the companies that are now being incubated in Singapore operate on sound business models for long-term value generation?

It will be interesting to track the evolution of the biomedical science sector in Singapore, the impact of the government's strategy to the growth of the sector and to compare that with other government's approach to this strategic area and the authors intend to keep the development of Singapore's Biomedical Science sector under review.

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