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Bonn 2005

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Center for Development Research

Department of Political and Cultural Change

Research Group
Culture, Knowledge and Development

universitätbonn

Zentrum für Entwicklungsforschung
Center for Development Research

ISSN 1864-6638

ZEF Working Paper Series, ISSN 1864-6638
Department of Political and Cultural Change
Center for Development Research, University of Bonn
Editors: H.-D. Evers, Solvay Gerke, Peter Mollinga, Conrad Schetter

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Strategic Groups in a Knowledge Society: Knowledge Elites as Drivers of Biotechnology Development in Singapore[1]

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Abstract

The objective of this paper is to examine whether the 'Strategic Group concept' is useful in understanding the evolution and rapid development of Singapore's biotechnology industries. We briefly describe the history of this new knowledge-intensive industry in Singapore, why and how it was propagated and current achievements in terms of outputs. We do also a closer look at the various organizations and actors who are involved in this ambitious state-led development initiative and the various (strategic) groups which they represent aimed at identifying some of their characteristics and patterns. The analysis suggests that the development of the industry is enabled by various more or less heterogeneous players such as (i) the Government, leading politicians, experienced civil servants and state bureaucrats with vast experiences in Singapore's powerful government-linked companies (GLCs) who are not seldom engineers by training, (ii) foreign biotechnology and life sciences experts from various countries (US, Europe) with specialized expertise and key competencies in areas such as molecular biology, chemistry, biomedicine etc. who are able to link local players with their own global networks etc. and (iii) representatives of biotechnology and life sciences industries. While the social dynamics of this vast network are poorly understood and strategic imperatives keep on shifting, it seems that the broad strategic goals outlined by Singapore's Government, namely to put Singapore's biotech cluster on the global map, are more or less shared by those involved. While more research is required to identify the antecedents and sequential patterns of strategic group formation in Singapore's biotechnology sector (i.e. network drivers such as shared interests, communication adequacy, trust and so forth), we argue that the different groups at work in this knowledge-intensive industry cluster have managed to set up an effective (temporary) strategic network alliance to achieve their various goals.

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[1] Paper to be presented at the 'International Conference on Strategic Groups' organized by Prof Thomas Heberer at the University Duisburg-Essen, Faculty for Social Sciences, Dept. of Political Studies & Politics of the People's Republic of China, June 17-18, 2005, KWI Essen.

1. Introduction

Both developed and emerging economies are currently trying to harvest the vast potential of global biotechnology research and development. Many European and Asian countries are eager to catch-up with the United States whose biotechnology sector started earlier, is better capitalized, produces more revenues and has more product innovations in the pipeline. Policy-makers of several emerging economies have initiated ambitious development programmes to tackle the great diversity and capability gaps which exist between countries and regions with regard to the development, application and governance of biotech products.

The Government of Singapore is investing more than US$1.8 billion over the next five years to establish the small dynamic city-state at the southern tip of the Malay Peninsula as the place for research into cancer, immunology, tissue engineering, and stem cells. The so-called “one-north project” aims to be home to 15 world-class biomedical companies by 2010 and to double the sector's current output, to over US$7 billion by 2005. At the center of their initiative is “Biopolis’ or “city of life”, a center for biomedical sciences which covers 18.5 hectares and includes seven buildings at a cost of some US$290 million. Officially opened at the end of October 2003, this big research complex is designed to employ more than 1,500 scientists. Specialist knowledge and biotechnology experts have become transnational. An extensive international scientific recruitment drive has been initiated some time ago to attract them. Singapore's drive to attract high-calibre researchers from around the world emphasizes the government's commitment to science.

At the same time there are increasing calls to conserve and sustain the use of genetic resources and traditional knowledge (e.g. about the healing attributes of tropical plants) in developing countries, to ensure the equitable sharing of benefits arising from them, incl. compensation via intellectual property protection. As the Cartagena Protocol suggests, developing countries need appropriate administrative, legislative and regulatory measures to ensure effective use of biotechnologies in line with their national development imperatives. Support for local communities is vital to conserve indigenous knowledge and genetic resources in the South (Neubert and Elisio 2002).

The importance of knowledge in future-oriented industries such as the biomedical sciences rests on the assumption that knowledge has replaced industrial organization and production as the major source of productivity. In what management guru Peter F. Drucker has called the post-capitalist knowledge society, "the central wealth-creating activities will be neither the allocation of capital to productive uses, nor 'labor'...Value is now created by 'productivity' and 'innovation', both applications of knowledge to work" (Drucker 1994:8). In fact the largest share of value added in modern computer technology does not rest on the value of the material used or the input of labor and capital, but on the knowledge embedded in the final product. In the current phase of the economic revolution, knowledge has taken its place as the most important factor of production passing capital, land and labor. Universities, research institutes, R&D divisions of corporations and last not least "think tanks" (Stone 1996) have become important factories of knowledge, which is then transferred or sold to other productive units. Knowledge and not just ICT (Information and Communication Technology) is increasingly recognized as the main promoter of the new economy (Evers, Kaiser and Mueller 2003).

New knowledge is produced at an unprecedented pace (Knorr-Cetina 1999; Menkhoff, Evers and Chay 2005). According to so far unconfirmed estimates knowledge in terms of publications, reports and patents is doubling every 10 years. The growth of scientific knowledge, supported by advances in information and computer sciences, has been primarily responsible for the explosive rate of increase in global knowledge production. The global knowledge base of life sciences and biotechnology is rapidly increasing, opening up new opportunities in health care, agriculture and food production, environmental protection (Sepulveda-Torres, Huang, Kim, Criddle 2002), as well as new scientific discoveries - associated with serious challenges in form of ethical concerns, insufficient risk governance, ineffective patent (IP) protection, global-local scientific capability gaps between developed and developing countries and so forth.

We conceptualize the rising knowledge production in the biotechnology sector as an increase in "reflexive modernization" to use a term coined by Beck (1992). Industrial society has evolved into a "risk society" where the gain of techno-economic 'progress' is increasingly overshadowed by the production of risks. There are indicators that the current discourse on biotechnology, life sciences etc. in Asia is following trends of respective research in the global arena. At the same time we can observe attempts to localize global biotechnology knowledge, e.g. to find cures for dengue fever.

The potential and innovative wealth-creating capacity of the new sciences is widely acknowledged. New scientific disciplines such as genomics and bioinformatics and novel applications, such as gene testing and regeneration of human organs or tissues have emerged. The expanding knowledge base has led to the occurrence of new enterprises, offering specialized jobs for highly skilled knowledge workers in emerging knowledge-based economies.

2. Turning Singapore into a Life Sciences Hub

Singapore launched its state-led start into a knowledge society (based on high value added, high-tech industries and a knowledge-based service sector) in the early 1990s after an initial phase of export-oriented industrialization (Rodan 1989). A recent report on the state of the economy describes the road map to Singapore's future as follows: "As the Singapore economy develops it can no longer rely on the accumulation of capital and labor to sustain economic growth. Singapore needs to further develop its KBE (knowledge-based economy), deriving its growth from the production, dissemination and application of knowledge" (Toh, Tang and Choo 2002). Earlier the foundation of a National Science and Technology Board in 1991 had marked the beginning of a massive government-led drive to improve the technology base of the Singaporean economy. A Strategic Economic Plan of 1991 identified strategic clusters of manufacturing and services earmarked for government support. The Singapore Science Park was set up to facilitate research and development and to host the R&D activities of high-tech corporations and agencies. Various scholarship schemes were launched to train young scientists abroad. The National Information Infrastructure (NII), which was started in 1992 with the objective to employ a broad-band national network, has meanwhile been implemented (Low and Kuo 1999).

During the Asian financial crisis it became clear that standard technology, like the production of mass storage devices, could no longer be sustained in the face of competition from China. Singapore has to concentrate on new, innovative technologies to maintain a competitive edge. This would only be possible, if the knowledge base of the economy would be further strengthened. The idea that knowledge had become the major factor of production was picked up quickly by Singaporean economists and the planners of the powerful Economic Development Board (EDB). The drive for a broader defined knowledge-based economy per se was outlined in government documents in 1999 (Singapore 1999). A ten-year plan (Industry 21) showed the path to "develop Singapore into a vibrant and robust global hub of knowledge industries in manufacturing and traded services, giving new emphasis to knowledge-based activities as the frontier of competitiveness" (Chia and Lim 2003). The situation became more urgent, when in 2001-2 the knowledge-intensive semiconductor producers experienced a downturn.

The Singapore government reorganized and re-named the statutory boards that had been responsible for the development of a high-tech industrial base. The National Science and Technology Board (NSTB) was re-organized and became the Agency for Science, Technology and Research (A*STAR). This organization established two research councils, The Biomedical Research Council and the Science and Engineering Research Council to support private sector research and development. It also formed Exploit Technologies Pte. Ltd. to safeguard and market intellectual property and the patents created by its research institutes. During the 1990s and into the new century a massive recruitment drive brought in foreign nationals that by 2001 made up about a quarter of the knowledge workers engaged in R&D (A*STAR 2002). The percentage of foreigners in the research institutes is even higher. This may be interpreted as an indicator of Singapore's high degree of globalization, but has also raised concern over Singapore's increased dependence on foreign talents.

There was also massive investment in institutions of higher learning. The two older universities NUS (National University of Singapore) and NTU (Nanyang Technological Universities) were complemented by a new government financed, but privately run institution, the Singapore Management University with an undergraduate training programme modelled after the famous Wharton School (USA).

In 2004 the construction of the "Biopolis" complex (http://www.nstb.gov.sg/astar/biopolis/action/biopolis.do) was completed. This "biomedical city" is situated at the Buona Vista Science Hub. Tenants include the Genome Institute of Singapore (GIS), a research institute affiliated to A*STAR, together with the Singapore Institute of Molecular Biology, the BioTechnology Center, the Bioinformatics Institute, the Institute of Biomedical Engineering and other R&D organizations. Biotechnology represents one of the four pillars of a knowledge-based economy prioritized by the Singapore government[2]. The GIS promises to develop a culture of excellence and innovation that is "conducive for collaboration between scientists from diverse cultural and social backgrounds" (Institute Prospectus). The multicultural environment is a theme that is emphasized in government position papers since the mid 1990s.

The output of the emerging knowledge-based economy of Singapore so far has been impressive. The number of patents filed has increased from 902 in 2000 to 1,096 in 2001; about half of them were filed in cooperation with other countries. 41% of the patents filed with others were the result of cooperation with the USA, a country Singapore depends more and more in the sphere of knowledge governance.

[2] In the Singapore context, future growth industries include biotechnology/biological sciences, microelectronics, robotics & artificial intelligence, information technology, laser technology & electro-optics, and communications technology.

Table 1: Biomedical Sciences Industry Statistics (2004*)

The Biomedical Sciences (BMS) industry includes biotechnology, medical technology, pharmaceuticals, and healthcare services.

Total Manufacturing Output:	S$179.9 billion (US$109 billion)
Total Manufacturing Value-Add:	S$47.1 billion (US$28.5 billion)
BMS Manufacturing Output:	S$15.8 billion (US$9.6 billion) (8.8% of Total Manufacturing Output)
BMS Manufacturing Value-Add:	S$10.1 billion (US$6.1 billion) (21% of Total Manufacturing Value-Add)

* US$ figures are based on an exchange rate of US$1.00 = S$1.65

Source: Economic Development Board

Table 2: Biomedical Sciences Manpower Figures

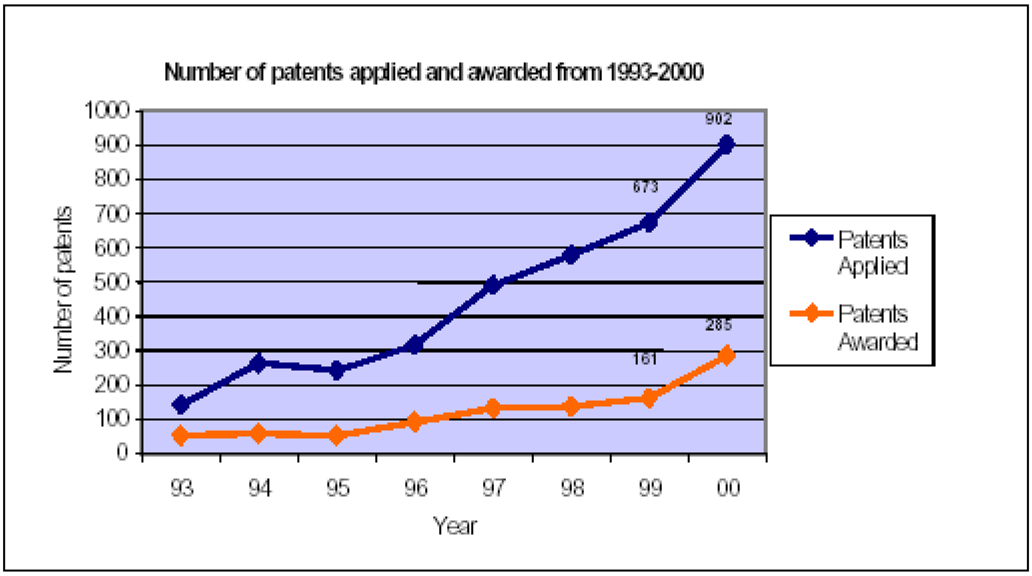
Cumulative Employment Figures for Manufacturing** (as of December 2004)

Pharmaceutical	3,851
Medical Technology	5,374
Total BMS	9,225
Value-added per worker (Manufacturing):	S$1.09 million (US$ 0.7 million)

**Projected figures. Figures for Biotechnology and Healthcare Services are not available.

Source: Economic Development Board

Figure 1: Number of Patents, Singapore 1993-2000



(Source: A*STAR 2000 National Survey of R&D in Singapore)

By now Singapore has a very well developed knowledge infrastructure in terms of ICT, research institutes and knowledge workforce (Toh et. al. 2002).

Table 3: Patents Developed by BMRC's Institutes (2004) and Staff Strengths

	BII	BTI	GIS	IBN	IMCB	CMM
Director	Dr Santosh Mishra (Executive Director)	Prof Miranda Yap (Executive Director)	Prof Edison Liu (Executive Director)	Prof Jackie Ying (Executive Director)	Prof Sir David Lane (Executive Director)	**RM**: A/Prof Edward Manser **SOG**: Prof Axel Ullrich
Year of Establishment	2001	1990	2000	2002	1987	2004
Staff Strength (as of Nov 04)	123	80	207	107	387	33
No. of publications (as of Dec 04)	34	13	57	32	115	-
No. of patent applications filed (as of Dec 04)	28	9	50	61	328	-
No. of patents granted (as of Dec. 04)	-	-	-	-	36	-
Areas of Research	- Computational Biology - Systems Biology - Structural / Functional Genomics - Computational Genomics - Medical Informatics	- Proteomics Technology - DNA/Peptide Technology - Gene Expression/Viral Vector Technology - Cell Culture/Microbial Fermentation Technology - Protein Characterisation / Purification Technology	- Cell Biology & Physiology - Pharmacogenom-ics/Molecular Pharmacology - Molecular Epidemiology/Po-pulation Genetics - Comparative Genomics/Model systems - Expression Genomics - High Throughput Sequencing & Genotyping - Bioinformatics - Genomics Structure - Molecular Pathology - Proteomics	- Tissue & Cell Engineering - Biomedical Imaging - Biomaterials & Scaffolds - Medical Devices - Nanotechnology	- Apoptosis - Infectious Diseases - Signal Transduction - Cell Cycle Control - Cell Structure and Function - Developmental Biology - Genomics	- Regenerative Medicine - Immunology / Virology - Cancer - Metabolic Medicine

BII - Bioinformatics Institute
BTI - Bioprocessing Technology Institute
GIS - Genome Institute of Singapore
IBN - Institute of Bioengineering and Nanotechnology
IMCB - Institute of Molecular and Cell Biology
CMM - Center for Molecular Medicine
RM - Regenerative Medicine
SOG - Singapore Onco Genome Laboratory

Source: A*STAR & EDB, Biomedical Sciences Fact Sheet, www.biomed-singapore.com

Considerable research is being conducted by scientists and researchers in Singaporean institutions of higher learning and research centers, esp. in the areas of biotechnology and the life sciences in line with the blueprints of the Singapore government aimed at staying economically competitive in the knowledge-based economy (Singapore Economic Development Board 1999). Universities, like NUS, NTU and SMU strive for recognition as world class research centers, and institutions like A*STAR and affiliated organizations carry out cutting-edge applied research.

If we look at local knowledge production in terms of the level of patenting activities (Figure 1), we will see a 34% increase in the number of patents applied in Singapore between 1999 and 2000, and a 77% increase in the number of patents awarded during the same year period. Table 3 provides an overview about the patents developed by Singaporean institutes under the auspices of A*STAR's Biomedical Research Council (BMRC).

3. Knowledge Elites as Strategic Groups – The Singapore Case

Like Singapore's early export-led industrial growth in the 70s and 80s, Singapore's current progression into a knowledge-based economy is driven by various groups of individuals, professionals and experts (Vennewald 1993; Menkhoff 1998). We conceptualize these politicians, planners, technocrats etc. as ***knowledge elites***. They comprise several powerful subgroups of knowledge workers, e.g. consultants who are tasked by other powerful strategic groups with the development of master plans and blue prints as elaborated elsewhere (Tsui-Auch 2004; Evers and Menkhoff 2005, Evers 2005a). Policy papers and recommendations prepared by reputable experts with their authoritative language help to legitimize investment and other strategic decisions, e.g. in the field of biomedical sciences. An example is arguably the document "Development of Molecular Biology & Biotechnology in Asia & the Pacific Rim, Report of the Priority Needs Commission for Singapore 2000" (http://policy.biotec.or.th/new/page/biotech%20status/biotech%20). Industry interests and inputs are crucial in such planning exercises as the commercialization of R&D results in form of new product innovations is a key performance indicator.

As outlined in another paper (Evers 2005b), in a knowledge society new occupational groups emerge, that are essential for the production, dissemination and application of knowledge. We expect that they eventually realize their common interest in gaining a share of the new wealth, prestige and power, created by the utilization of knowledge as a productive force. In other words a new strategic group will merge and either join hands with other strategic groups like the state bureaucracy and big business or will compete with them in structuring society in such a way as to maximise their chance for appropriating wealth and power during the implementation of a knowledge society:

"Strategische Gruppen bestehen aus Personen, die durch ein gemeinsames Interesse an der Erhaltung oder Erweiterung ihrer gemeinsamen Aneignungschancen verbunden sind. Diese Appropriationschancen beziehen sich nicht ausschließlich auf materielle Güter, sondern können auch Macht, Prestige, Wissen oder religiöse Ziele beinhalten. Das gemeinsame Interesse ermöglicht strategisches Handeln, d.h. langfristig ein „Programm" zur Erhaltung oder Verbesserung der Appropriationschancen zu verfolgen (Evers and Schiel 1988:10)".

There are overlaps and omissions in Table 3, which is designed to reduce the complexity of a knowledge society to manageable proportion and aid the design of research projects or the construction of indicators. The most obvious strategic group are, of course researchers and their supporting staff. They partly overlap with lecturers and other university staff who are also doing research, and also publish their results. But also creative artists are important knowledge producers. They set artistic standards they may interpret history and everyday life in their novels and create values that influence the flow of social change.

Table 3: Strategic Groups of Knowledge Workers

Institutions	production	dissemination & utilisation
Higher Learning and research	researchers research staff	teachers lecturers
Business and industry	R&D scientists technicians	experts, consultants managers
Media	journalists artists	publishers editors

The strategic groups of a knowledge society are bound together by networks of communication. They form "communities of practice" with vague boundaries. Their networks extend beyond national boundaries of Singapore or the USA, even if they are firmly embedded in the local political and social processes of their own society. In a way they are pirates on the sea of knowledge, acquiring (or at times pirating) knowledge wherever they can. Because of their critical minds they are looked upon with both admiration and suspicion, as the case may be, by politicians or other strategic groups.

We argue that the 'Strategic Group concept' is useful in understanding the evolution and rapid development of Singapore's biotechnology industries. An interesting categorization and analysis of strategic groups in the Singapore context can be found in Vennewald (1993:36-181):

"Es ist dieser Kreis von Technokraten aus Politik (Kabinett, Regierungsbank, ZK), Verwaltung (Administrative Service) sowie den Statutory Boards und Government-Linked Companies (GLC) die im Laufe der 80er Jahre zur führenden strategischen Gruppe avanciert. Wie einst die Professionals um Lee Kuan Yew, bestimmt nun diese weitaus größere Gruppe mit ihrem Entwicklungsverständnis die politische, wirtschaftliche und gesellschaftliche Entwicklung des Landes".

The efficiency of Singapore's technocrats and bureaucracy is well-known and has been recognized by foreign observers as a key competitive advantage of the city-state as future BMS hub. Let us try and systematize key official agencies and individuals involved in the development of Singapore's biomedical sciences sector.

4. Strategic Groups of Government Representatives, State Bureaucrats, Technocrats and Scientists

Singapore Economic Development Board (EDB)

Singapore's powerful EDB is the lead agency that plans and executes strategies to turn Singapore into a compelling global hub for business and investment. In 1999 it launched its economic blueprint Industry 21 to develop Singapore into a vibrant and robust global hub of knowledge-driven industries based on the 'twin engines of growth', namely its manufacturing and services sectors. Under this plan, Singapore's manufacturing and services sectors will be further developed with a strong emphasis on technology, innovation and capabilities. Singapore will also be made more attractive for multi-national corporations to anchor more of their key knowledge-intensive activities in Singapore. At the same time, local companies will be encouraged to embrace more knowledge-intensive activities, with "promising" local companies evolving into world-class players.

One of the pillars of the "Industry 21" initiative is the biomedical sciences under the auspices of EDB's Biomedical Sciences Group (EDB BMSG). This group works closely with A*STAR's Biomedical Research Council (BMRC), Bio*One Capital and other agencies to develop human, intellectual and industrial capital in Singapore so as to support the Biomedical Sciences industry (http://biomed-singapore.com).

Singapore aspires to be a leading centre of competence in knowledge-driven activities and a "choice location" for company headquarters, with responsibilities for product and capability charters. "Leveraging on other hubs for ideas, talent, resources, capital and markets, while developing its own world-class capabilities and global reach", represent other goals. The Government expects that this will ultimately help to create high value-added jobs for knowledge and skilled workers.

Agency for Science, Technology & Research (A*STAR)

A*STAR's mission is to foster world-class scientific research and talent for a vibrant knowledge-based Singapore. It is Singapore's lead agency for scientific research and development under the aegis of the Ministry of Trade and Industry. A*STAR is organized into two research councils: (i) the ***Biomedical Research Council*** (BMRC) and (ii) the ***Science and Engineering Research Council*** (SERC). It also comprises a scholarship administration unit, A*STAR Graduate Academy (A*GA), a Corporate Planning and Administration Division (CPAD) and a commercialization arm, Exploit Technologies Pte. Ltd. (ETPL).

The two research councils fund and oversee 12 public research institutes (see Appendix) in areas such as bioinformatics, genomics, molecular biology, bioengineering, bioprocessing technology, chemical sciences, materials, high performance computing, information technology and communications, manufacturing technology, microelectronics and data storage.

A*STAR also initiates and promotes societal awareness of biomedical research through outreach programmes (http://www.a-star.edu.sg).

The organization is one of the key players behind the development of Singapore's 'Biopolis' developed by Singapore's Jurong Town Corporation (JTC).

Strategic Organization of Singapore's Biomedical Research Thrust

A*STAR's Biomedical Research Council (BMRC) and its International Advisory Committee (see Appendix) was set up by EDB to steer Singapore's biotechnology development. The BMRC is overseen by a ***Ministerial Committee*** that is chaired by ***Deputy Prime Minister Tony Tan*** and includes the ***Ministers of Trade and Industry, Health and Education***. Mr. Philip Yeo, Chairman of A*STAR and Co-Chair of EDB, heads an ***Executive Committee*** that includes senior representatives from the Universities, Ministries of Trade and Industry, Health, Education and Finance and the Attorney-General's Chamber. The Executive Committee draws on the combined experience of renowned (foreign) scientists in the Biomedical Sciences International Advisory Council (see Appendix).

The tentative analysis of the data presented in the appendix leads us to the following preliminary conclusions.

5. Preliminary Conclusion: Strategic Groups and Singapore's KBE/BM Strategy

The brief description of agencies and actors involved in Singapore's state-led biotechnology and life sciences development (see Appendix) indicates that there are a different strategic 'players' involved:

- powerful Government representatives in form of key politicians such as Deputy Prime Minister Tony Tan and Ministers of Trade and Industry, Health and Education who play 'trusted' roles;
- top civil servants and state bureaucrats with vast experiences in Singapore's public sector (e.g. as Permanent Secretary in the Ministry of Defence) and powerful government-linked companies (GLCs) such as EDB's Chairman Mr Teo Min Kian or A*STAR's Chairman Philip Yeo. Many of them hold several board memberships in strategically important organizations and are professionally trained engineers;
- top foreign (and a few local) biotechnology and life sciences experts (researchers, scientists) as members of councils and advisory boards as well as Directors of institutes and labs with professional degrees and vast experiences in critical areas such as molecular biology, biophysics, medicine, chemistry, physiology, epidemiology, genetics, physics etc. obtained at top US (MIT, Columbia, Princeton, Harvard etc.) and European (UK, France, FRG, Switzerland) BMS institutions able to link Singaporean players with their own global networks as well as
- representatives of the biotechnology and life sciences industries such as big MNCs (e.g. MNC GlaxoSmithKline) and a few 'local' firms.

Our ongoing analysis confirms to a large extent the structural-functional specifics of strategic groups in the Singapore context as argued by Vennewald (1993), political decision, control and supervision patterns via high-level R&D committees and networks as well as the increasing importance of technocrats and scientists for the further development of the city-state.

The continuous legitimacy of Singapore's local strategic groups is based on several factors such as their track record, power and command over resources, ideological dominance etc. The 'official' discourse about the urgent need to build up and to attract new growth drivers such as biomedical sciences in view of the rapidly changing environment and the emergence of new competitors such as China and India 'makes sense'. It seems that there is no other alternative development path, i.e. respective policy measures are perceived as 'rational' and legitimate. Singapore's survival and national interests serve as ideological justifications of technocratic policy measures and provide meaning for those in charge (Mannheim 1936/1960).

The strategic group concept is useful in understanding the evolution of Singapore's biotechnology sector as this new thrust is obviously successfully driven by several powerful groups as highlighted above.

What's new is the emergence of foreign biomedical scientists with their competencies and professional experiences in critical areas such as molecular biology, biophysics, medicine, chemistry, physiology, epidemiology, genetics, physics etc. obtained at top US (MIT, Columbia, Princeton, Harvard, California) and European (UK, France, FRG, Switzerland) institutions. While little is known about their interactions with Singapore's technocrats, it can be assumed that these experts are very powerful in charting Singapore's biotechnology and life sciences development roadmap as they are the one's who possess crucial domain-specific knowledge assets and resources 'to make things happen', understand global market trends etc. More research is needed to examine their relationships to Singapore's power elites and technocratic strategic groups as well as corporate players such as multinational biotech firms. Will Singapore's strategic groups succeed in developing a healthy scientific environment in a culture of self-control and risk aversion? Will we see the emergence of a strong indigenous BMS knowledge elite / strategic group?

What are the motives and aspirations of those foreign experts who collaborate with Singaporean institutions in the area of biotechnology and life sciences? Available data suggest that many of those recruited foreign talents (molecular biologists etc.) do support the Government's mission and vision of this future-oriented sector which is so critical for Singapore's sustained development due to various reasons such as biographic constellations (many of the top scientists are at the peak of their careers and see the job in Singapore as a welcome change and challenge), the kind of support they get in form of state-of-the-art lab equipments etc. provided by A*STAR, social capital, restrictive and bureaucratic research regimes back home etc. As Prof Axel Ullrich (Director, Molecular Biology, Max-Planck-Institute for Biochemistry; since 2004 Director of Singapore's Onco Genome Laboratory) said in a recent interview:

> "Mit A*Star und EDB haben wir hier Organisationen, denen sehr daran gelegen ist, die Abläufe nicht zu bürokratisieren ... Hier hat man den Mut etwas zu tun, was radikal ist. In Deutschland war es ein großes Problem Forschungen zu betreiben, die mit Stammzellen zu tun haben – alle Bemühungen waren halbherzig. Man sucht ständig nach dem am wenigsten riskanten und billigsten gemeinsamen Nenner" (Aktuell Publishing 4/2005:44).

Do these foreign (and increasingly transnational) BM scientists and their organizational entities form a strategic group? It's probably too early to answer this question with regard to Singapore as the industry is quite young and the various groups are still evolving. The entire cluster is still in the forming stage and we can't really speak of a fully established 'community of biotechnology and life sciences practice' which is one of the defining characteristics of the strategic group concept. Furthermore we are not sure how far support personnel, consultants and suppliers join in the support of a common strategy and can therefore be regarded as part of the new knowledge strategic group. More research is necessary to understand the social dynamics of this global BM network. While strategic imperatives (e.g. the move away from agricultural biotech research to more life sciences oriented R&D works) keep on shifting, it seems that the broad strategic goals outlined by Singapore's Government, namely to put Singapore's biotech cluster on the global map, are more or less shared by those involved. The different groups at work in Singapore's global knowledge-intensive industry cluster have managed to set up an effective (temporary) strategic network alliance to achieve their various goals.

Future research questions include: What are the antecedents and sequential patterns of the strategic group formation process in Singapore's BM sector (i.e. network drivers such as trust, shared interests, communication adequacy and so forth)? Where there any critical fault lines in the past and what was done by whom / which group to overcome them? Did any particular group try to wield more influence and to 'overpower' another? Who has the final say in charting the development strategy of this sector? How about the role of competing factions within each strategic sub-group? What is the role of industry and technoentrepreneurship in this rapidly changing landscape of biotechnology and life sciences R&D? How does Singapore's Government manage to develop this sector in terms of (good) governance and to negotiate with big industry players (e.g. GlaxoSmithKline) for mutual benefit? To what extend does the BMS development blueprint approach resemble previous successful approaches (e.g. export-led industrialization) implemented by policy-makers? Is there any particular counter-strategic group which would challenge the mainstream development blueprints? If yes, what was done to co-opt this group (if any)? If not, why not? What about the civil society public discourse about the risks and ethics of BMS in Singapore? Why is there no counter-strategic group on the horizon?

In bringing up these issues we have at least proven the point that new knowledge creates ignorance, i.e. poses more unresolved questions than giving answers (Evers/Menkhoff 2005:145). Strategic group analysis may not have evolved into a polished theory, but at least into a viable tool for analyzing complex social situations and throwing up interesting research problems.

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