

Reproduced from *From Traders to Innovators: Science and Technology in Singapore since 1965*, by Goh Chor Boon (Singapore: ISEAS – Yusof Ishak Institute, 2016). This version was obtained electronically direct from the publisher on condition that copyright is not infringed. No part of this publication may be reproduced without the prior permission of ISEAS Publishing. Individual chapters are available at <<http://bookshop.iseas.edu.sg>>.

From
Traders
to Innovators

ISEAS – Yusof Ishak Institute (formerly the Institute of Southeast Asian Studies) was established as an autonomous organization in 1968. It is a regional centre dedicated to the study of socio-political, security and economic trends and developments in Southeast Asia and its wider geostrategic and economic environment.

The Institute's research programmes are the Regional Economic Studies (RES, including ASEAN and APEC), Regional Strategic and Political Studies (RSPS), and Regional Social and Cultural Studies (RSCS).

ISEAS Publishing, an established academic press, has issued more than 2,000 books and journals. It is the largest scholarly publisher of research about Southeast Asia from within the region. ISEAS Publishing works with many other academic and trade publishers and distributors to disseminate important research and analyses from and about Southeast Asia to the rest of the world.

From
Traders
to **Innovators**

*Science and Technology
in Singapore since 1965*

GOH CHOR BOON

First published in Singapore in 2016 by
ISEAS Publishing
30 Heng Mui Keng Terrace
Singapore 119614

E-mail: publish@iseas.edu.sg
Website: bookshop.iseas.edu.sg

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the ISEAS – Yusof Ishak Institute.

© 2016 ISEAS – Yusof Ishak Institute, Singapore

The responsibility for facts and opinions in this publication rests exclusively with the author and his interpretations do not necessarily reflect the views or the policy of the publisher or its supporters.

ISEAS Library Cataloguing-in-Publication Data

Goh, Chor Boon.

From Traders to Innovators : Science and Technology in Singapore since 1965.

1. Technology—Social aspects—Singapore—History.
2. Entrepôt trade—Singapore—History.
3. Singapore—Economic conditions.

I. Title.

II. Series: Modern economic history of Southeast Asia.

HC445.8 G615 2016

ISBN 978-981-4695-78-7 (soft cover)

ISBN 978-981-4695-79-4 (e-book, PDF)

Typeset by International Typesetters Pte Ltd
Printed in Singapore by Markono Print Media Pte Ltd

CONTENTS

<i>List of Abbreviations</i>	vii
<i>Introduction</i>	xi
1. From Dependency Theory to Creative Innovation	1
2. Surviving and Catching Up in the 1960s and 1970s	28
3. Developing a Technological Growth Trajectory in the 1980s	51
4. State Intervention and Technological Change	86
5. Nurturing a Scientific Culture	110
6. Sociocultural Attributes and R&D	140
7. Towards a Technologically Creative Society	168
8. Conclusion: Power of a Service-Brokerage Culture	196
<i>Bibliography</i>	213
<i>Index</i>	223
<i>About the Author</i>	232

ABBREVIATIONS

A*Star	Agency for Science, Technology and Research
AAS	American Association for the Advancement of Science
APEC	Asia Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
B2C	business-to-consumers
BIM	building information modelling
BMS	biomedical sciences
CADD	computer-aided design and drafting
CIMOS	Computer Integrated Marine Operations System
CITOS	Computer Integrated Terminal Operations System
CPF	Central Provident Fund
DJHS	Division of Biomedical Sciences, John Hopkins in Singapore
DSO	Defence Science Organisation
EAEC	East Asia Economic Caucus
EAEG	East Asia Economic Grouping
EDB	Economic Development Board
EIU	Economist Intelligence Unit
EOI	export-oriented industrialization
ESC	Economic Strategies Committee
EWIPO	Environment and Water Industry Programme Office
FDI	foreign direct investment
FSTI	Financial Sector Technology & Innovation
GCI	Global Creativity Index
GDP	gross domestic product
GERD	gross expenditure on R&D
GIS	Genome Institute of Singapore

ICT	information and communications technologies
IES	Institution of Engineers
IMB	Institute of Medical Biology
IMCB	Institute of Molecular and Cell Biology
IP	intellectual property
IPOS	Intellectual Property Office of Singapore
ISI	import substitution industrialization
JCCI	Japanese Chamber of Commerce and Industry
JHM	Johns Hopkins Medicine
LIUP	Local Industry Upgrading Programme
MAS	Monetary Authority of Singapore
MIT	Massachusetts Institute of Technology
MNC	multinational corporations
MPA	Maritime and Port Authority of Singapore
NAFTA	North American Free Trade Area
NIE	National Institute of Education
NIE	newly industrializing economy
NPI	Nature Publishing Index
NRF	National Research Foundation
NSTB	National Science and Technology Board
NTP	National Technology Plan
NTU	Nanyang Technological University
NUS	National University of Singapore
OECD	Organisation for Economic Cooperation and Development
OHBC	overhead bridge cranes
P&G	Procter & Gamble
PAP	People's Action Party
PCT	Patent Cooperation Treaty
PISA	Programme for International Assessment
PLC	product life cycle
PSA	Port of Singapore Authority
PSC	Public Service Commission
PUB	Public Utilities Board
QCC	quality control circles
R&D	research and development
RCOC	Remote Crane Operations & Control
RIE	Research, Innovation & Enterprise

RSE	research scientists and engineers
S&T	science and technology
SGH	Singapore General Hospital
SISIR	Singapore Institute of Standards and Industrial Research
SIT	Singapore Institute of Technology
STEM	science, technology, engineering and mathematics
STN	Singapore Tissue Network
SUTD	Singapore University of Technology and Design
TEA	Total early-stage Entrepreneurial Activity
TEU	twenty-foot equivalent units
TFP	total factor productivity
WIPO	World Intellectual Property Organisation

INTRODUCTION

In recent years the small island city-state of Singapore has gained the world's attention for its aggressive policies in enticing the international scientific community and corporate entities to relocate and contribute to its agenda of building a world-class research and development (R&D) hub. The Singapore Government has also been making concerted efforts to encourage young Singaporeans to think "science and technology", to motivate science and engineering graduates to pursue their interests in the field of R&D, and to propagate the rise of a critical mass of technopreneurs. At the national policy level, Singapore's science and technology (S&T) policy has shifted from the traditional wholesale adoption of Western technology of the 1970s and 1980s to a policy that aims to promote indigenous technology development through an integral dynamic innovation-systems perspective for stimulating innovation. Singapore is ploughing 2.3 per cent of its gross domestic product (GDP) into R&D, which brings it closer to other countries famed for their focus on research, such as Denmark and Switzerland. Singapore targets to raise R&D spending to 3.5 per cent of GDP by 2015, which would place the small city-state among the top five research-intensive countries, including Israel, Sweden and Japan.

Singapore's determined move to integrate science and technology into its overall economic strategic plan has been largely influenced by many changes. The desire to close the technological gap also reflects the prevalent ideology to survive and to catch up in view of the dynamic changes in economic relations between countries, in which technology has become a dominant competitive force. Singapore's economic growth now centres on an innovation-driven, industrial strategy. Innovation is more than simply new technologies; it involves

how business processes are integrated and managed, how services are delivered, how public policies are formulated, how markets are developed and, more broadly, how the society could benefit from creativity and innovation. It is also the case that in a global, knowledge-driven economy, technological innovation — defined as the transformation of new knowledge into products, processes and services of value to society — is critical to competitiveness, long-term productivity growth and an improved quality of life. Among the major factors determining the city-state's global competitive position, a well-planned science and technology policy and technology infrastructure can be considered as important pillars. They serve to provide indigenous firms with opportunities to upgrade, innovate and commercialize their R&D efforts. Whether the country can achieve the successful transition from the imitation of to the creation of technology remains to be seen. One can argue that the availability of an excellent technology infrastructure and a pool of foreign scientists and research engineers alone do not guarantee success. One can also argue that the availability of research funds and monetary incentives is a significant key to achieving technological excellence and self-reliance. However, the creative adaptation of imported technologies and the subsequent transition to the level of indigenous technological innovations — as seen in the case of Japan, South Korea and Taiwan — can only take place within a historical and cultural context of exposure to technological change and transformation. For Singapore, the reality is that it has yet to develop an indigenous, self-reliant technological base capable of producing innovations that can cater to world markets. A major problematic issue is the acknowledged lack of indigenous technological entrepreneurs, research engineers and scientists.

In explaining why some small countries — such as Sweden, Finland, Switzerland, Japan, South Korea and Taiwan — are able to create and commercialize indigenous technological innovations and others are not, the answer seems to lie in the historical traditions, the role of the state, and the sociocultural motivations, attitudes, interests, mindsets and behaviours of the people within a society. Rising from the devastation of the Pacific War, Japan became an economic powerhouse, driven by its technological creativity. But while Japan was successful in its technological leapfrogging strategy, the Chinese (at least during the twentieth century) were not able to meet with

the same type of success. This is especially interesting given that the Japanese have borrowed so heavily from Chinese culture in the past. It has been suggested that the Japanese have exhibited a greater willingness to borrow from other cultures and to learn new ways of doing things, whereas in China, where Confucianism was more rampant and respect for the past and one's elders more ingrained, the establishment of science and technology was stifled. In the case of Singapore, viewed from a historical and sociocultural perspective, the book's central argument is that the city-state faces an uphill challenge in generating a self-reliant, indigenous technological base, capable of producing its own scientific and technological products and processes.

As a British colony, Singapore's role was largely to support the trade and commerce of Great Britain in Asia. Scientific explorations and experimentations were the least concern of the colony's British administrators. A scientific and technological culture was never germinated. Instead, *entrepôt* colonialism in Singapore had successfully transferred and nurtured commercial, financial and brokerage institutions and practices to local entrepreneurs. When full independence was given to the people of Singapore in 1965, Lee Kuan Yew and his political comrades wasted no time in lamenting the bleakness of a newborn nation's ability to survive without an economic hinterland in Malaysia. Neither had they the intention to exploit the situation for their own benefits or, in the words of Lee Kuan Yew, "perpetuate ourselves by renaming streets or buildings or putting our faces on postage stamps or currency notes".¹ The country inherited from an era of British colonialism (close to 150 years) a world-class port infrastructure, a modern city, the use of the English language and an upright civil service. It also inherited an entrenched but viable trading, service-oriented and middleman economy which allows Singaporeans opportunities to accumulate wealth. The political pioneers set about to develop social and economic measures — what many foreign observers would see as draconian and autocratic — that would ensure the survival of a multiracial, multi-religious and multilingual nation. Multinational corporations (MNCs) and their imported technologies were (and are) enticed to set up their manufacturing bases in the strategically located city-state. The constraints facing the government to nurture the growth of a technological culture can be partly attributed to the effective

social engineering strategies it employed to achieve political and social stability. While the national ideological obsession with excellence and the accumulation of wealth serve as a motivating force for the people to work hard, it has also created the pragmatic, *kiasu* (a local dialect word which means “afraid to lose out”) ethos of the people which has further inhibited technological creativity and innovativeness. However, notwithstanding the lure of the financial, property and services sectors which have provided the best opportunities for Singaporeans to accumulate wealth, there are signs that in recent years an increasing number of Singaporeans are venturing out as technological entrepreneurs (or “technopreneurs”, for short).

The “miraculous” growth of Singapore as an Asian newly industrializing economy (NIE) has been analysed from several perspectives, but few, if any, of the existing studies have centred primarily on the technological dimension of its development experience. This study addresses this gap in the literature of Singapore’s economic history by examining the processes and problems of the nation’s technological development from a historical and contemporary perspective. Notwithstanding the importance of economic considerations, this study attempts to explain technological change in the context of Singapore’s historical and sociocultural orientations. This emphasis has been taken for two reasons. First, today’s developed and developing nations are often ranked according to the level of their technological development. This narrow view, however, overlooks significant historical, social and cultural differences among nations. These factors must be taken into account when studying the relationship between technology and development. Second, all too often the economic history of Singapore has been seen purely from the economist’s point of view. It would be particularly refreshing to document Singapore’s economic development from a technological perspective; in this case based on an examination of the relationship between technological change and the country’s historical and sociocultural institutions and practices.

This book hopes to contribute to the growing literature on the city-state’s bold initiative to make a mark in scientific and technological excellence and creativity. Can a nation of traders, middlemen and shopkeepers be transformed into a nation of scientific and technological innovators? Can an economy with an inherited brokerage culture

be transformed into one that thrives on scientific and technological creativity? How can young Singaporeans be enticed to take up careers in research? Admittedly, these are broad questions and it is not easy to speculate on the potential outcome of Singapore's aggressive strategies to develop its research and development capabilities. By tracing the evolution of science and technology and emphasizing the importance of historical and sociocultural factors, this book aims to provide useful insights into the developmental process of how the small city-state has attempted to shake off its traditional comprador-trading image and embark on a pathway of technological and scientific learning.

This study does not purport to any extensive interpretation of existing or new primary sources relating to science and technology in Singapore. Specific references to the subject of science and technology are scarce and the sources here are largely drawn from various official reports, personal interviews conducted by the author, views on science and technology by individuals as reported in printed media such as the *Straits Times*, and the few secondary works done from a "science, technology and society" perspective and centring on the role of science and technology in the development of Singapore since 1950. This book is based on my PhD dissertation entitled *The Role of the State and Society in the Development of Science and Technology in Singapore: A Historical and Socio-cultural Perspective* (1995). Personal interviews with twenty scientists, inventors and R&D managers were conducted in March and April 1994. In addition, a questionnaire survey was administered to 347 engineering undergraduates and 56 professional engineers. Although the fieldwork is dated, interestingly, much of the comments made in the mid-1990s are still very much valid twenty years on, especially when triangulated against the comments made by scientists and entrepreneurs in the media since the start of the new century and in interviews conducted by the author recently.

Chapter 1 anchors the book on the theoretical constructs concerning the process of technological change and development and related issues like "catching-up" and "technological leapfrogging", "creative innovations" and the role of the state and society in bringing about technological change. It examines the changing paradigms from the 1970s and 1980s to the present, which serves to explain how developing

countries, particularly the so-called Asian “tigers”, have attempted to achieve technological excellence. One of the most pressing problems confronting developing nations today is the fear of the widening technology gap between them and the industrialized economies. One way of catching up is to leapfrog the existing state of the art in the development of a new technology that is still in its pre-standardization stage, or even at a more fundamental exploratory stage when its commercial potential is largely untested. The ultimate objective of such a strategy is to achieve technological self-reliance. For Singapore, implicit in this catching up and technology learning processes are crucial roles of various actors, such as multinational corporations, government agencies that plan and roll out science and technology policies and initiatives, research institutes and universities.

Chapter 2 covers the historical forces that shaped the young nation’s industrialization policy from the 1950s to the 1970s. Since the 1950s, industrialization was widely acknowledged by the pro-capitalist, independent states of Southeast Asia as the key to survival and economic growth. But the task was not easy, as long periods of colonialism had produced imbalanced economic structures which confined the rising indigenous capitalist class to comprador trading activities and limited small-scale manufacturing and processing. In the case of Singapore, by the late 1950s it remained primarily an *entrepôt*, with 70 per cent of its GDP derived from *entrepôt* activities. The country had a small and limited industrial base. The predominant industry was the shipbuilding and repairing industry, which was largely in the hands of governmental and public bodies such as the Singapore Harbour Board and the British Naval Base. When Singapore gained her independence in August 1965, the newly elected leaders adopted a “catching-up” mandate, emphasizing export-oriented industrialization (EOI) as its growth model in the 1960s and 1970s. Recognizing that the long period of colonialism had produced a trading community, the government adopted an open-door policy and looked to MNCs to provide — and hopefully to transfer — high levels of technology and management skills to local businesses.

While the EOI strategy involved the development of science and technology, Chapter 3 argues that the closing of the technological gap was easier said than done. There were mismatches between Singapore’s industrial development and the development of the

technological competence of the people. It examines the government's concerted attempt in the 1980s to introduce a "technological trajectory" aimed at helping the city-state enjoy its "second industrial revolution". By the 1980s Singapore had achieved the status of a "newly industrialising economy". Singapore's economic growth purportedly centres on an innovation-driven, industrial strategy. This was done (and continuing the pro-MNC policy of the 1970s) largely through attracting foreign technologies. The desired outcome is to achieve some level of independent capacity for technology absorption and adaptation. But Singapore's model of technological leapfrogging through the aegis of MNCs had its limitations. There were also issues relating to the training and development from the 1960s to the 1980s of a scientific and technical manpower base to support the nation's drive towards technological excellence.

Nevertheless, by the 1990s it was obvious to the economic planners that the adoption and assimilation of foreign technology is crucial to achieving sustainable growth pathways. At the same time there is an urgent need to develop the country's indigenous technological base. Given this scenario, a national blueprint for S&T policy in Singapore was formulated. Chapter 4 discusses the role of R&D in achieving national goals and the initiatives towards the construction of a technological infrastructure. Unlike developmental work, pure scientific research could not be placed on a high pedestal within the very pragmatic S&T policy. The general consensus then was to adopt the strategy of tying product development to profits and marketability. It was also clear that the realistic goals of Singapore's R&D strategists were concerned chiefly with the "development" side of the R&D equation.

Chapter 5 documents how the government has introduced measures to cultivate a scientific culture, particularly among the young. At the outset of its attempt to formulate and implement a national science policy in the early 1980s, basic research was not a priority. Within this rather narrow research framework the Singapore scientific community faced problems. It is wrong, however, to assume that the government failed to appreciate such issues. Throughout the 1980s and into the present, Singapore has welcomed visits made by prominent scientists and has taken cognizance of their recommendations of how to establish a suitable climate for basic scientific research. Today, large

amounts of resources are set aside for basic research. But the generous availability of funding and pro-research policies does not necessarily mean that the people could now be more ready to “think science” and get involved in R&D. The cultural attributes and mindset have to be considered.

The impressive economic performance of Asian NIEs has gained not only the attention of economists but increasingly social scientists as well. While not rejecting altogether economic explanations, these scholars have attempted to link the macroeconomic dynamism of Asian NIEs with cultural factors inherent in the societal systems of these countries. Chapter 6 examines the cultural context in which science and technology develops in Singapore. Essentially, it sets out to answer the question: Does Singapore’s cultural system help or hinder technological creativity? One plausible argument is that within the highly regulated society, capped by the government’s constant ideological emphasis on survival, catching-up and excellence, dominant beliefs and behavioural norms of Singapore society are such that much effort will be needed to persuade Singaporeans to delve into research in science and technology and for the society to develop a free-wheeling, non-conforming and Silicon-valley type bohemia.

Nevertheless, by the new millennium Singapore had successfully projected itself with the image of a high-tech city, with its advanced information technology infrastructure, a well-planned science park and technology “corridor”, cutting-edge research institutes and foreign multinationals who themselves are technological leaders in their respective fields. Singaporeans have shown their creativity and skill in the planning, development and management of infrastructure construction in areas such as urban renewal; public housing; industrial, science and technology parks; and the transportation network. Certainly, in the provision of financial, trading and sourcing services, Singaporeans have shown great ingenuity and resourcefulness. More significantly, recent years have seen an increasing number of Singaporeans who would actually venture out as technological entrepreneurs. But to sustain this technology climate, more success stories of major innovative breakthroughs that could put Singapore on the R&D map must be forthcoming. Indeed, there are some useful innovative technological projects being developed by Singaporeans. These developments are covered in Chapter 7.

However, despite the rising emergence of technological start-ups, the impact of Singapore's historical role — strongly reinforced by its geographical advantages — as an international commercial transaction and brokerage node is still all-pervasive and provides opportunities for many individuals to accumulate personal wealth.

As a traditional society modernizes it also experiences changes, involving the breaking down of older cultural patterns and usually the adoption of new ones. However, the beliefs, values, traits or behaviours of people within a society are also very resilient to change. As the concluding chapter, Chapter 8, argues, despite the government's agenda to transform the city-state into an R&D hub, Singapore's is still very much a trading and commerce node. Its traditional service-brokerage culture, germinated and nurtured during the colonial era, is still the driving force towards wealth accumulation in the city-state. This was the case particularly in the years when the government's pro-MNCs policy resulted in local entrepreneurs given little guidance or incentive to be involved in advanced manufacturing, and so continued to consolidate their positions in the tertiary sector — in commerce, finance and speculative operations. At the same time, making use of the island's pivotal geographical position, the government adopted measures to strengthen Singapore's traditional roles — as the hub of monetary and brokering activities in Asia and the world at large. One other important factor that contributed strongly to the preservation of its trading and brokerage economic activities is its historical role as a centre of a transnational overseas Chinese business networks. The island's geographical position, its excellent telecommunication infrastructure and a very stable political environment motivated many large Chinese business families to make Singapore one of their bases and to develop profitable commercial and financial activities there.

In the final analysis, this book reiterates that Singapore's quest for the growth and development of an indigenous, innovative and self-reliant scientific and technological base is one of the most challenging tasks facing the government today. There are hurdles to overcome, one of which is creating the mindsets and developing the aptitude of young Singaporeans to take up careers in R&D. There is also the issue of a lack of a critical mass of local R&D personnel with the appropriate postgraduate qualifications. Moreover, there are the

historical continuities of a strong service-brokerage culture, with its “comprador mentality”, which has produced a large pool of wealthy Singaporeans. It seems remotely possible that the country could produce an individual in the mould of Bill Gates or an enterprise in the mould of Samsung. It is also likely that the country will continue to be dependent on the presence of foreign suppliers of new technologies, scientific knowledge and skills. It is obvious to the government that a culture of technological and scientific innovation cannot be created overnight. But the crucial development is that the government is already making a start — and a forceful one too.

Note

1. Lee Kuan Yew, *From Third World to First: The Singapore Story 1965–2000* (Singapore: Straits Times Press, 2000), p. 67.