

THE INNOVATIVE ACADEMIC:  
EXPLORING THE ROLE OF UNIVERSITIES IN THE  
NATIONAL SYSTEM OF INNOVATION OF  
SINGAPORE



A thesis submitted to the  
School of Social Sciences  
Nanyang Technological University

by

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in partial fulfillment of the requirements for the degree of  
Doctor of Philosophy

2018



# Acknowledgements

To Family, To Mentors, To Friends, To Loves, To Life  
Thank you for everything.



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# List of Abbreviations

A*STAR	Agency for Science, Technology and Research
ARISE	Ageing Research Institute for Society and Education
CePHAS	Centre for Population Health Sciences
CQT	Centre for Quantum Technologies
CSI	Cancer Science Institute of Singapore
DSO	Defense Science Organization
EDB	Economic Development Board
EOS	Earth Observatory of Singapore
ESC	Economic Strategies Committee
GLC	Government-linked Companies
IP	Intellectual Property
IPOS	Intellectual Property Office
IPR	Intellectual Property Rights
IWB	Innovative Work Behavior
KPI	Key Performance Indicators
MBI	Mechanobiology Institute

MCI	Ministry of Communication and Information
MCRD	Ministerial Committee on Research & Development
MEWR	Ministry of Environment and Water Resources
MiNDEF	Ministry of Defense
MNC	Multinational Companies
MND	Ministry of National Development
MOE	Ministry of Education
MOH	Ministry of Health
MTI	Ministry of Trade and Industry
NIE	Newly Industrialized Economies
NMRC	National Medical Research Council
NRF	National Research Foundation
	Basis Function Network
NSI	National Systems of Innovation
NTU	Nanyang Technological University
NUH	National University Hospital
NUS	National University of Singapore
OECD	Organization for Economic Cooperation & Development
QAFU	Quality Assurance Framework for Universities

R&D	Research & Development
RIE	Research, Innovation, Enterprise
RIEC	Research Innovation and Enterprise Council
SCElse	Singapore Center for Environment & Life Sciences Engineering
SGD	Singapore Dollar
SIT	Singapore Institute of Technology
SME	Small & Medium sized Enterprises
SMU	Singapore Management University
STI	Science, Technology & Innovation
STS	Science & Technology Studies
SUTD	Singapore University of Technology & Design
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UGF	University Governance & Funding
WIPO	World Intellectual Property Organization
WTO	World Trade Organization



# Abstract

Using Singapore as a case, this dissertation expounds the role of universities in National Systems of Innovation (NSI). This dissertation has three essays addressing important and related aspects on the evolving role of universities in knowledge economies.

In essay 1, the origin of the concept of innovation in STI policy design in Singapore, its development, and current status (1965-2015) is traced by drawing on the social construction of technology approach. While the state sets the direction for innovation, academia produces it, within a political sphere constructed by technical/technological machines. Using interviews with public university academics and key policymakers in Singapore, I explore the subjectivity of innovation that exist between these two groups of actors. In doing so, I contextualize the state of innovation in Singapore and expose gaps that need to be addressed for efficient innovation system planning.

Essay 2 addresses university-industry linkages (UILs) which are an important strategy for innovation for universities, industries, as well as governments. Extant literature identifies the various barriers to such collaborations and suggests ways to improve them, but does not sufficiently describe how academics, the key decision-makers who drive the formation of UILs, perceives these barriers and how it affects their realities and daily practices. A mixed-methods approach is used to provide a rich description of barriers to UILs in Singapore from the academics' perspective. By providing a comprehensive analysis of the nature of and barriers to UILs across Singapore from the academic's perspective, this paper fills this gap in literature.

Essay 3 looks at the academic experience of funding in Singapore's knowledge race. Singapore is an interesting case study as it has a highly market-oriented university system and there is an evident push towards the more utilitarian or applied research on the part of the government which funds almost 90% of academic research. Using interviews and

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archival research, I describe how academics in Singapore perceive and deal with current funding systems thereby opening up debate and discussion on the evolution of universities in the South East Asian region.

# Chapter 1

## Introduction

### 1.1 Research Background

### 1.2 Main Objectives

This research aims to explore the role of universities in the National System of Innovation (NSI) of Singapore. Special attention is paid to the evolution of innovation policy design, as well the university ecosystem since the formation of the state of Singapore in 1965 till 2016. Following the innovation systems literature in general, this research analyzes how academics in universities as actors of National Systems of Innovation, make sense of the changing innovation policies of the nation and the expectations placed on them. The research addresses changes at the university as well as the national levels.

This dissertation considers Singapore's national directives to transform the nation into a knowledge-economy in the context of other similar newly industrialized economies (NIEs) in Asia. By studying the main aspects of the NSI approach in Singapore from the academics' perspective, this work opens up debates on the evolution of universities in the region.

Universities, through major contributions to fundamental knowledge production, are now considered to be important sources of technological advancements. Universities are set to play a key role in knowledge-economies not only in training the right manpower, but also as a sources of innovation. The central argument has been that what works in post-industrialized economies should also work in newly industrializing economies (NIEs). The blueprints of established policy frameworks in developed nations are being replicated

by the developing nations globally. But how does the specific socio-political and historical precedents of the NIEs impact such policy initiatives? Both domestic and international forces shape political economy of nations which has serious implications for the development of innovative capacity and innovation systems. Thus, the unique factual conditions of specific nations should be examined. This thesis seeks to study this through the eyes of the academic in Singapore.

Singapore, while, consistently ranks high in all innovation indices year after year, innovation inputs are higher than innovation outputs (Index, 2015, 2016). Clearly, having a dedicated government and stable politics have helped Singapore invest in innovation endeavors which puts in high up on the rankings. But the story does not translate to the ground-level. This is in part what motivated to undertake this study, to understand how specific actors in the NSI responds to innovation policies.

This thesis addresses three theoretical aspects of NSI, namely

1. Social construction of innovation in Singapore
2. University-industry linkages (UILs)
3. Funding and its impact on academic innovation

Probing these questions will lead us to examine features of the national innovation system in Singapore and its relationship with the university sector in the context of knowledge-economy.

## **1.3 The Singapore Context**

### **1.3.1 Development of the National System of Innovation of Singapore**

After attaining independence from the British on 9 August 1965, Singapore wasted no time in its race to development. As a tiny (700 sq.km), poor, tropical island completely devoid of natural resources and any hinterland, the transformation this city-state has had to a global hub in a short fifty years is impressive. This success can be attributed to the evolution of a strong, state-dominant, National System of Innovation (NSI)

Nanyang Technological University (NTU) and National University of Singapore (NUS) are not just universities catering to the education of the youth of Singapore, but also key strategic players in the making and re-making Singapore in the global race for innovation. In this section, I will attempt to chart the history of innovation policy in Singapore, while describing the development of higher education policies tangentially. The developmental state of Singapore has been analyzed in contemporary studies (Neo and Chen, 2007; Parayil, 2005; Wong, 1995). Early history of Singapore, much like her Asian neighbors, is part of the colonial legacies. Singapore was a British colony from 1819 to 1942. In the Battle of Singapore, during World War II, the Japanese occupied the nation after defeating British and Malaysian garrisons. This lasted until 1945 when Japan surrendered to the Allies and Singapore went back to being a Crown colony. Singapore joined Malaysia for a short three years from 1963-1965, after the colony was dissolved. Social and political instability continued and Singapore left Malaysia to form the Republic of Singapore on August 9, 1965 with Yusof bin Ishak as the first President. The history of the Republic of Singapore (hereafter referred to simply as Singapore) is a short one spanning just five decades. Self-admittedly, Singapore was a poor tropical island completely devoid of natural resources and hinterland. Singapore was a trade center, and entrepot trade was its only survival mechanism during the colonial era. Once it broke off from the Malaya Federation, political unrest and unemployment was rampant. The Political Action Party (PAP) had ascended into power in 1959 with Lee Kuan Yew as the first PM of the city-state. Under his patronage, Singapore soon started the industrialization of its economy. The development of Singapore is seen to have happened over five distinct phases as described by Wong (1995). The five phases spans the five decades since its independence and Singapore celebrated its fiftieth anniversary in 2015.

### **1.3.1.1 1960s**

Soon after independence, the fledgling nation faced many challenges. Wedged between two unfriendly nations - Malaysia and Indonesia, Singapore lacked any infrastructure or clean water and had poor sanitation. A majority of its population of 3 million were unemployed. The entrepot trade was not sufficient for economic expansion, and under Lee Kuan Yew's tutelage, Singapore started its industrialization. With no industrial

tradition, the majority of Singaporeans were in low-end trades and services. A huge and nation-wide industrialization program was launched and the Jurong industrial estate was created, followed by smaller estates in Kallang Park, Tanjong Rhu, Redhill, Tiong Bahru, and Tanglin Halt (EDB, 2015). The government strategized that provision of maximum employment would quell most social and political upheavals that the new nation was facing (Choy, 1985; Goh, 2005; Tan, 1995). Labor-intensive industries producing textiles, toys, wood products etc. (Goh, 2005) were the mainstay of these states. Additionally, two capital and tech-intensive companies also developed in the period viz. Shell Eastern Petroleum and the National Iron and Steel Mills. Singapore's experiments with globalization, inspired by Israel's success, began in this decade. Singapore welcomed foreign investors with open doors and employment protection policies were set in place to make the nation more business-friendly. The PAP consolidated all the dispersed and independent trade unions under the National Trade Union Congress (NTUC) and remains the sole representative to date. Corruption and narcotic trade was eliminated through punitive laws of death penalty. For international investors, Singapore became a highly desirable port city to expand out of as compared to its highly politically unstable neighbors. The Singapore Economic Development Board (EDB) was established in 1961 and underwent a revamping in 1968 to assist foreign companies to move their manufacturing facilities to Singapore, and thereby, to increase exports. Innovation was not a priority, nor was it desirable. Trade unionists were highly suspicious of large-scale innovative projects as it was assumed to lead to more unemployment (Goh, 2005). Development of an innovative work-culture was not encouraged; rather a labor-intensive industrialization was pursued. A system of co-operation was established between the state, employers, and trade unions and this led to the country's successful development.

### **1.3.1.2 1970s**

Singapore's small domestic market was not sufficient to create rapid economic growth even though the nation had a built an industrial base by the 1970s. Industrial policies of this decade focused on building productive capacity by attracting foreign direct investments (FDI) from developed countries (Chew and Goh, 1996; Choy, 1985). As a result, Singapore achieved trade surplus and the economy developed through an export-oriented

strategy (Rosenberg and LE Jr, 2008; Rugman, 1983). Political stability and good governance ensured Singapore's development into a harmonious and well-equipped trading center with excellent physical infrastructure and a generally skilled work-force (Goh, 2005). Many multi-national companies (MNCs) expanded their businesses into Singapore and by mid-1970, 25% of manufacturing firms in Singapore were foreign-owned with Japan and USA as the majority investors (EDB, 2015). The manufacturing sector diversified with more value-added outputs; the government began investing in electronics such as semiconductors, integrated chips (IC), computer hardware, silicon wafers, software packages etc. (EDB, 2015). Until the global recession in 1975, Singapore enjoyed double-digit GDP growth rates (Goh, 2005). A quick economic restructuring was done with more focus on capital-driven investments, technology acquisition and modified educational policies to provide technical and skills-based education to the growing work-force. The government resumed its interventionist approach by pushing to root MNCs in the nation and manufacturing sector became the largest contributor to GDP by the end of this decade.

### **1.3.1.3 1980s**

By 1980, unemployment was not a pressing issue and Singapore was enjoying a GDP growth of 8.5% in the early years of this decade (Goh, 2005). Electronics parts manufacturing, construction, logistics, and banking had become mainstays of the Singaporean economy. In 1985, a global economic recession that shook the world, also affected Singapore. The industrialized nations of the world, especially USA, was slumping and other South East Asian nations were bypassing Singapore as an entrepot thereby negatively impacting Singapore's trades (Chan, 1986). Singapore's ship manufacturing industry was also a poor performer due to competition from others in the region (Rigg, 1988). Tony Tan, the current President, who was then the Minister of Trade & Industry, chartered an Economic Committee in 1985 to set new directives for the nation. The committee was led by Lee Hsien Loong, the Minister of State for Defence and Trade and Industry and the PM of Singapore today. Numerous cost-cutting measures were introduced such as rebates on personal, corporate, and property tax, government fees; and interest rates for loans were reduced. As part of re-orientation to a new reality, a policy of privatization

and de-regulation was adopted and the private sector was clearly marked as the driver of economic growth (Lee, 1987). By the end of 1986, Singapore bounced back with a GDP growth rate of 1.8% (Goh, 2005) thus restoring the nation's status as the most cost-competitive in South East Asia.

#### **1.3.1.4 1990s**

The realization that Singapore is susceptible to the rise and fall of global export markets as long as its dependent on export and trade surplus was a shocking wake-up call. Singapore also significantly lost its cost competitiveness by this decade, as its neighbors like China, India, Malaysia, Vietnam and Thailand were able to offer cheaper manpower coupled with abundant natural resources. As a result, the leadership decided to change its growth orientation. The model that Singapore followed later came to be characterized as the East Asian Growth model with strong central planning (Goh, 2005). Enterprise development became the new focus to put Singapore on the map, and to differentiate it from its neighbors. Singaporean companies were encouraged to move up the value chain, and technology uptake was of particular importance. Instead of banking on MNCs and manufacturing, Singapore decided to support key sectors like engineering, electronics, and chemicals (EDB, 2015). The government increased public sector investments in these areas and private sector spending was also encouraged through various incentive programs (Goh, 2005). Singapore also started several investment programs to develop the biomedical sector with the aim of securing Singapore as the 'Biopolis of Asia' (Clancey, 2012).

#### **1.3.1.5 2000s and the Five-year Plans**

The political leadership was convinced of the success of Silicon Valley development model and its counterparts in Israel, that by the 2000s, gaining more technological edge became a priority for Singapore (Wong, 2001). A Technopreneurship Startegy for the 21st century (T21) was initiated by the president, Tony Tan, in 1998 to promote the establishment of more knowledge-based start-ups. Starting with this initiative, there were many others aimed towards making Singapore more independent in terms of its technological capabilities and innovative capacities.

A turn to this started with the establishment of the National Science and Technology Board in 1990 and the launch of the first National Technology Plan (NTP) in 1991. It had a budget of \$2 billion to be invested in the setting-up of an R&D base in the nation. Poh Kam Wong, from NUS, notes that this plan did not even have the word 'science' in its title (Wong, 2001). In 1996, the NTP was succeeded by the National Science & Technology Plan (NSTP), which committed \$4 billion to further the work of the NTP, and to leverage manpower development to support growing R&D capabilities of Singapore. This set the base for the 2000s when Singapore redirected focus on innovation and enterprise.

2001 and 2006 saw the commission of the Science and Technology Plan (STP) 2005 and the Science and Technology Plan (STP) 2010 respectively. STP 2005 had a budget of \$6 billion dollars. Building on the previous plans, it aimed to enhance manpower development, intellectual capital development, and industrial capital development (Ministry of Trade and Industry Singapore, 2010). STP 2010 increased the budget to \$ 13.5 billion dollars and continued developing the nation in the same vein.

In 2011, the STPs underwent a rebranding leading to the launch of a new Research Innovation and Enterprise (RIE) Plan 2015 with a budget of \$ 16.1 billion. The RIE 2015 plan reaffirmed Singapore's goals to convert Singapore to a "research-intensive, innovative and entrepreneurial economy like Sweden, Finland, or Israel" (MTI, 2011).

The latest installment is the RIE 2020 with the highest budget yet for developing R&D (Fig. 1.1). With almost 1% of the nation's GDP, the RIE 2020 has committed \$ 19 billion towards innovation and enterprise development. It also focuses on four technology domains that cuts across academic research, manpower development, and innovation and enterprise (Fig. 1.2).

Some indicators for Singapore's development trajectory follows below (Fig. 1.3, Fig. 1.4, Table 1.1).

### **1.3.2 Academic Research Enterprise**

The major public research performers in Singapore are the Institutes of Higher Learning (IHLs), the various institutions under Agency for Science Technology and Research (A\*STAR) and other public research institutions. The university ecosystem of Singapore

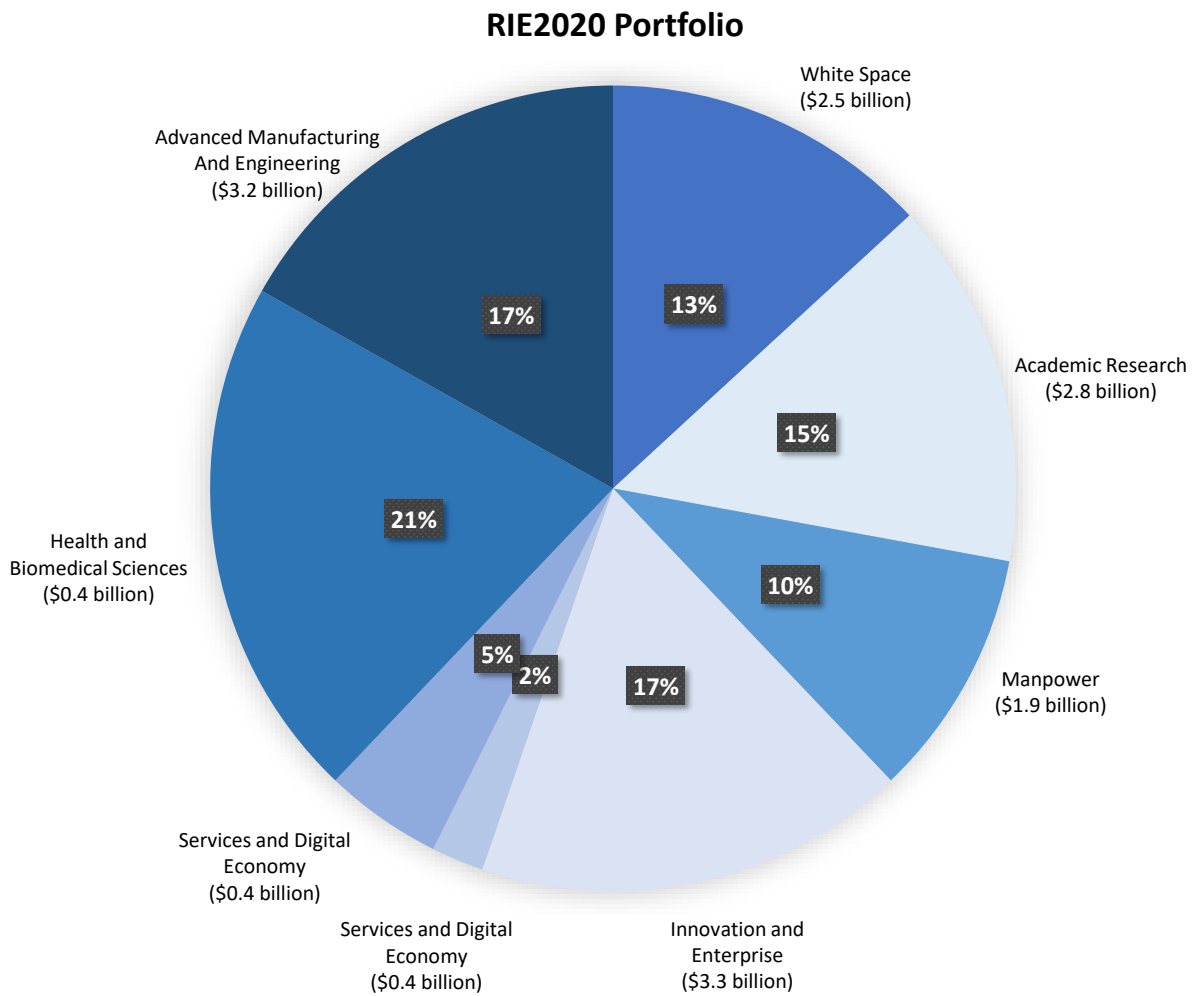


Figure 1.1: Budget for Research Innovation Enterprise Plan 2020 (NRF, 2016)

has six autonomous universities, five polytechnics providing vocational training programs, and numerous other overseas university campuses.

- The National University of Singapore (NUS) was founded in 1905 and has evolved into a fully-fledged comprehensive university with definite entrepreneurial dimensions. It has more than seventeen faculties and schools spanning from the arts to social sciences to engineering with 28,630 undergraduate students and 9966 graduate students in 2016 (more than 33,000 students overall) (2016). NUS is the top ranked university in Asia in the QS ranking and the twelfth in the world. Spanning three campuses in Singapore, NUS has 2.4k full-time faculty and 3.5k research

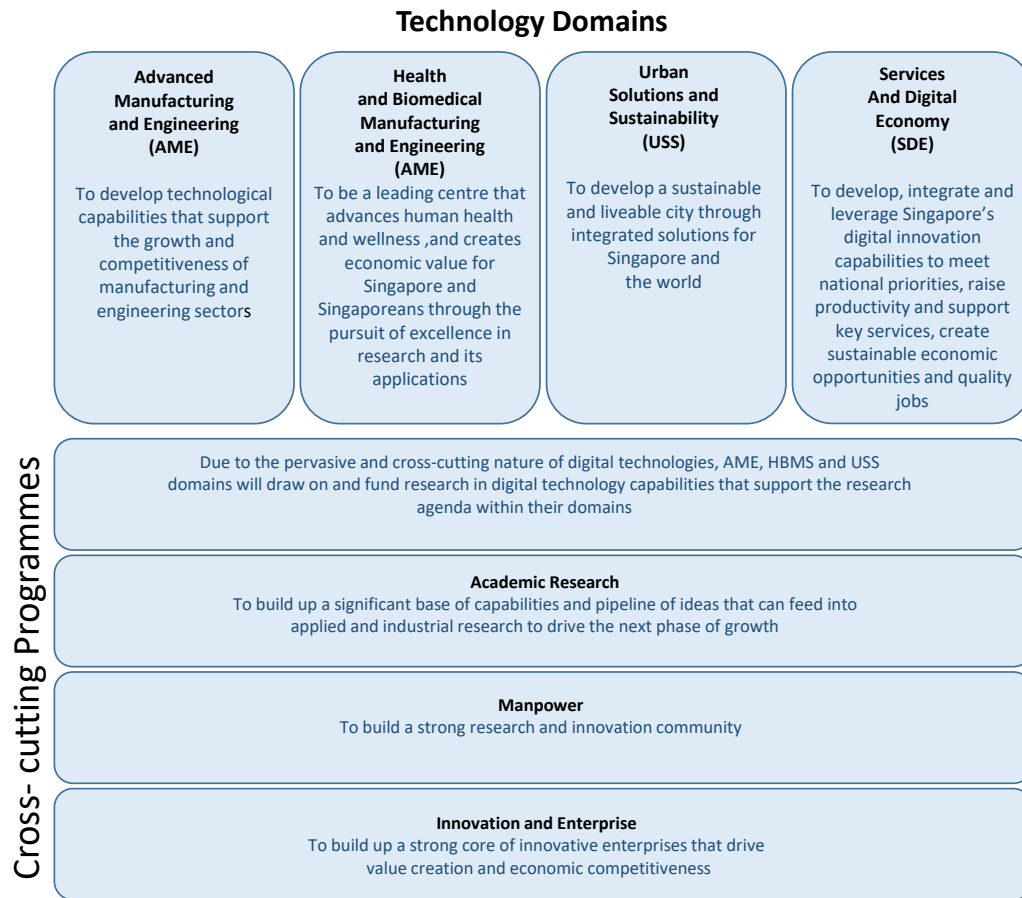


Figure 1.2: Technology Domains & Cross-cutting Programmes of RIE 2020 (NRF, 2016)

Public Investment in Research and Innovation

Plan	National Technology Plan 1995	National Science & Technology Plan 2000	Science and Technology 2005 Plan	Science and Technology 2010 Plan	Research, Innovation and Enterprise 2015 Plan	Research, Innovation and Enterprise 2020 Plan
Budget	\$2 billion	\$4 billion	\$6 billion	\$13.5 billion	\$16 billion	\$19 billion

Figure 1.3: Public investment in research and innovation (NRF, 2016)

staff. NUS also has 30 university-level research centers of which three have been chosen by the Singapore government as Research Centers of Excellence (RCEs). More than 5000 patents were filed by NUS by 2015 along with 3000 invention disclosures, 350 technology license disclosures, and 250 companies set-up by alumni.

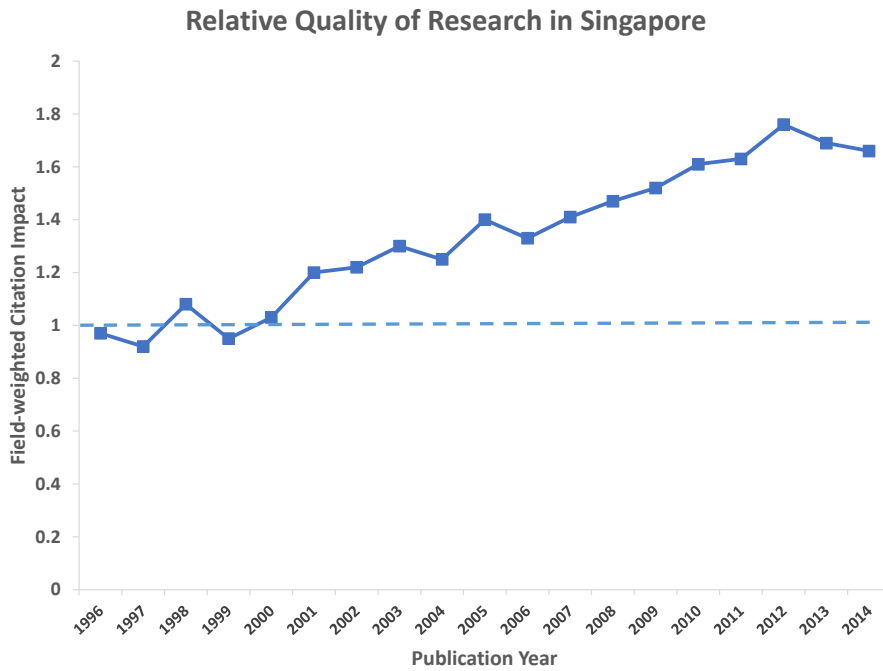


Figure 1.4: Quality of research (NRF, 2016)

8341 research papers were published in top international journals by NUS faculty in 2015.

- Nanyang Technological University (NTU) was established in 1991 and has evolved rapidly and matches-up to NUS in terms of research potential. NTU has seven schools across engineering, sciences, social sciences and humanities with twenty four joint PhD programmes with overseas universities. With 24,300 undergraduates and 9000 graduate students, NTU has been ranked 13th best university in the world and 2nd in Asia by QS world rankings. Located in the West end of Singapore, NTU has 4550 full-time faculty and 2887 research staff today. REsearch at NTU is extensive with 8 university-level research institutes, 2 National Research Foundation (NRF) corporate labs, 2 RCEs, 60 research centers under various schools and 24 joint centers with external organizations. 177 patents were filed by NTU in 2016 and it is the 6th most cited university for engineering research output globally. NTU faculty won S\$503.5 million in FY2015/2016 in competitive research grants.
- Singapore Management University (SMU) was established in 2000 and offers degrees

in management, business, and accounting studies.

- The Singapore University of Social Sciences (SSS) was set-up in 2005 and offers degrees in business studies, arts, social sciences, and law.
- Singapore University of Technology and Design (SUTD) was set-up in 2012 with collaborations with Massachusetts Institute of Technology (MIT) and Zhejiang University. It trains students to develop and design solutions for complex problems with degrees in architecture, engineering and information systems.

Table 1.1: Key Indicators of Singapore, Adapted from (Degelsegger and Sukprasertchai, 2014)

<b>Indicator</b>	<b>Value</b>	<b>Year</b>
R & D intensity: Gross domestic expenditure on R & D (GERD) as a percentage of GDP	2.2%	2014
Full-time equivalent (FTE) personnel (man-year)	47,902	2014
Total labour force	3.61 million	2015
Number of patent applications	10,814	2015
Flow of inward foreign direct investment	\$1255.5 billion	2015
Flow of outward foreign direct investment	\$665.4 billion	2015
Number of research universities	4	2015

### 1.3.3 Socio-economic Framework of Singapore

Until late 1980s, R&D investments were low in Singapore, but has steadily increased since then as a direct result of innovation policies favoring it. The stable political climate of Singapore coupled with intense focus on transforming Singapore into a knowledge-based smart nation has made it a major global player today in competitive R&D. With a committed government, conducive university ecosystem and around 700 national companies (Degelsegger and Sukprasertchai, 2014) and MNCs like Hewlett-Packard, Texas Instruments, Microsoft, Motorola, Dell, Cisco, Seagate, Hitachi, Asustek, Lite-On, Wistron,

Rolls Royce, Trina Solar, Siemens, GlaxoSmithKline, Novartis, Takeda, Roche, Pfizer, Bayer, 3M, BASF, Nestle, Kellogg, Procter & Gamble, LucasFilm etc. reporting research, Singapore is poised to do well in this transition.

### **1.3.4 Singapore's Institutional Framework for STI Policy Formulation**

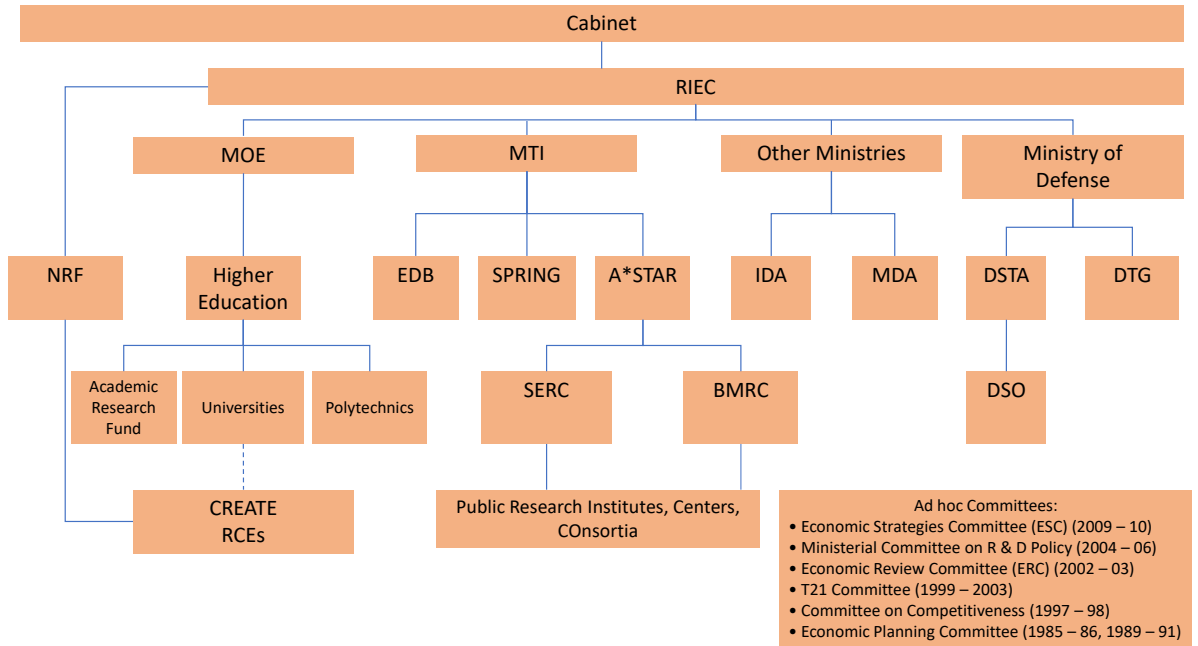
Singapore's government takes a cluster based approach to governance of science, technology, and innovation (STI) policies with multiple institutions and agencies. Figure 1.5 details Singapore's institutional framework for STI policy design and implementation.

In tune with the policies of 2000s, Singapore established the Research, Innovation, and Enterprise Council (RIEC) in 2006 to oversee the national strategy for R&D. The RIEC advises the Singapore Cabinet on STI policy design and implementation, with the objective of transferring Singapore into a knowledge-based economy. RIEC is chaired by the Prime Minister, Lee Hsien Loong, and comprises of ministers from core ministries, deputy ministers, local university chairmen, key academics from world class universities, as well as industry players like Huawei, Volkswagen etc.

The main ministries in the Cabinet that are responsible for STI policy implementation are Ministry of Education (MOE), Ministry of Trade and Industry (MTI), Ministry of Defence (MinDEF), Ministry of Communication and Information (MCI), Ministry of National Development (MND), and Ministry of Environment and Water Resources (MEWR).

The universities and other public research centers fall under the MOE. MinDEF and Ministry of Health via the National Medical Research Council (NMRC) funds specific projects under their purview in public research institutions including universities.

The National Research Foundation (NRF) was established around the same time as the RIEC and its main purpose is to co-ordinate all innovation activities in the nation. NRF exists as a special agency under the Prime Minister's office and develops sectoral R&D activity based on the five-year RIE plans of Singapore combining both top-down and bottom-up approaches.



RIEC - Research Innovation and Enterprise Council EDB - Economic Development Board SPRING - Standards, Productivity and Innovation Board A\*STAR - Agency for Science, Technology & Research IDA - Infocomm Development Authority MDA - Media Development Authority DSTA - Defence Science & Technology Administration DTG - Defence Technology Group DSO - Defence Science Organization

Figure 1.5: Singapore’s institutional framework for STI policy (Degelsegger and Sukprasertchai, 2014).

## 1.4 Research Design and Method of Analysis

### 1.4.1 Theoretical Framework

#### 1.4.1.1 National Systems of Innovation

Since the introduction of the term, a growing body of literature has attempted to study multiple aspects of National Systems of Innovation (NSI) in advanced industrialized nations initially, and more recently, in newly industrializing economies (NIEs). To demonstrate this, I will add a list of commonly used definitions from some of the prominent proponents of the concept of NSI in Table 1.2 below.

The theoretical approach of National Systems of Innovation (NSI) developed as a major stream of research from the broader field of innovation studies which stresses the economic importance of innovation. Innovation studies emerged from the 'Renaissance Canon' of economic theory which argues that human development and evolution is only

Table 1.2: Definitions of NSI

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“ .. the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies.”	Freeman, 1989
“ .. the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state.”	Lundvall, 1992
“... a set of institutions whose interactions determine the innovative performance ... of national firms.”	Nelson, 1993
“ .. the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country.”	Patel and Pavitt, 1994
“.. that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies.”	Metcalf, 1995

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possible through knowledge production (Reinert, 1999). Modern innovation studies arises from the works of Joseph A. Schumpeter whose focus on capital as an engine of growth leading to a need, to explain technological change in economies (Nelson and Sidney, 2005). It soon grew into a multidisciplinary field with interests ranging between technological, economic, organizational, sociological, and institutional change (Sharif, 2006).

In essence, the NSI concept takes into account all elements that influences the process of innovation, where innovation is defined as an original product/process/idea with economic significance produced through “an interactive process in which science, technology, learning, production, policy, and demand interplay through complicated feedback mechanisms” (Edquist, 1997). This model assumes the firm to be the driver of innovation in a nation, having interactions with universities, research institutes, government agencies and so forth. In addition to these actors in NSI, cultural factors, institutional norms, social rules also impact innovation outputs (Edquist, 1997). In fact, Edquist says, “Interaction between various organizations operating in different institutional contexts is

important for the process of innovation. The actors as well as these contextual factors are all elements of systems for the creation and use of knowledge for economic purposes. Innovations emerge in such systems” (1997).

Freidrich List came up with the concept of “national systems of production” in 1856 to account for all national institutions and infrastructure that are involved in transportation, education, and training (List and Colwell, 1856). The “innovation systems” concept was later introduced by Lundvall, and Christopher Freeman used “National Innovation System” in his seminal work on the industrial systems in Japan (1989). Bengt-Ake Lundvall theorized this concept with a study on Denmark’s institutions and other innovation actors (2010). Richard Nelson gave a diverse disciplinary perspective on NIS in an edited book with studies spanning thirteen developed countries (1993). National systems of innovation have specialized approaches for different sectors or technological systems (Carlsson and Jacobsson, 1997). That said, the overall national innovation structure impacts specific sector as well as technological systems (Archibugi et al., 1999). Innovation systems can also be conceptualized at regional, national, or supranational levels. For example, Silicon Valley in California is an example of a regional innovation system and EU is a supranational innovation system. In line with this study’s main objectives, I use the innovation systems approach at the national level to analyze Singapore.

The NSI concept is a commonly used tool for policy formulation and the stress is not on the individual actors of the system, but on how they interact with each other, enabling the flow of ideas and information (Lundvall, 2010). The features of NSI is usually country-specific and this falls on a number of factors like its demography, institutional setting, industrial profile, natural resources etc. Technological trajectories are also shaped by historical contexts (Rosenberg, 1982).

Miettinen (2002) studied the emergence and use of NSI concept in Finland and it is a very influential study of NSI in STS literature. He studied the rhetoric of policymaking in Finland and analyzed the relationship between innovation and the language used in policy making. He concludes that the NSI concept, on its own, was insufficient for successful implementation of policy in Finland. Albert and Laberge (2007) did an ethnographic study on how international organizations (OECD) and regional public administrative offices (in Quebec, Canada) employ the NSI concept. Their discovery was that the success of its application is linked to its perceived scientific validity.

### 1.4.1.2 Entrepreneurial University

Universities are the cornerstones of innovation systems and are traditionally the most important source of fundamental knowledge. University evolution happened in the last two to three decades and now they are sources of industry-relevant innovations especially in knowledge-based economies. This is the result of direct interventions from many governments since the 1970s to make universities important players to spur economic growth (Sampat and Mowery, 2004).

In most OECD economies, universities perform much of the R&D especially basic research (Mowery, 2004). Innovations are known to draw from this rich repository of basic research, in fact many of the modern innovations would not have been possible for lack of this knowledge-base. Universities are also important sources of manpower in the form of trained scientists and engineers and thus, ensures flow of knowledge between university and industry. By now, it has been established that universities are engines of economic growth and policymakers are harnessing this potential by creating policies aimed at commercializing university research (Feller, 1990). The famous example is the 1980 Bayh-Dole Act in the US (Mowery and Sampat, 2005). Similar legislation has been followed by many other OECD countries (Valentin and Jensen, 2005). Creation of science parks and university-industry labs and clusters have been other popular policies for encouraging personnel exchange and thereby facilitate flow of ideas and knowledge (Adams et al., 2001; Hall et al., 2003; Siegel et al., 2002). Recruitment and training of technology transfer staff is the third strategy followed to build a knowledge base in universities (Kirby, 2006; Woolgar, 2007). While these policies have seen some success, they are still not the end all for effectiveness (Mowery et al., 2015).

Universities world over have responded to this with enthusiasm and there is a growing trend towards technology development (Nelson, 2001). From the university side, there has been a greater drive towards patenting (Stiglitz and Wallsten, 1999), to increase revenues by technology licensing (Thursby et al., 2001), and to increase academic entrepreneurship (Shane, 2004).

Thus, the entrepreneurial university was born amidst debates on the changing nature of universities (McKelvey and Holmén, 2010). Advocates of the NSI approach and the Triple Helix model argues that universities have added a third mission of economic and

social growth to the traditional diad of teaching and research (Etzkowitz, 1998). Organically, universities joined the system of organizations including state and industry that predicates innovation and economic growth (Etzkowitz and Leydesdorff, 2000).

Universities are now producing scientific knowledge as well as technological products (Ambos et al., 2008). Academics are taking on multiple roles as university professors and entrepreneurs (Zucker and Darby, 1996). Owen-Smith (2003) shows how a hybrid system is created where universities excel at all its three missions.

### **1.4.2 Entrepreneurial University Evolution in South East Asia**

As early as in the 1990s, OECD identified the importance of promoting higher education for enhanced innovation and technological catch-up and there-by economic growth for the NIEs (OECD, 2013; Stewart, 2011). Governments and economies in East Asian NIEs have been promoting the structural formation of entrepreneurial universities (Fetters et al., 2010) within which “academic entrepreneurship” can thrive (Lee et al., 2011), to ensure sustainable growth and competitiveness in the region.

Higher education has been crucial to the development of East Asia and it has played a major role in nation building which has resulted in more political legitimacy for most of the governments in the region (Bray and Lee, 2001; Gopinathan, 1996). With states moving into competition strategies with the introduction of private sector players into most arenas of the economy, higher education universities are given autonomy and flexibility to develop their business while ensuring that research and development is aligned with national agendas (Mok, 2013). This is done via competition-based grants and resource allocation for top-performers in global and regional ranking lists.

There has been diversification of higher education funding sources in the Asian Tigers viz. Taiwan, Hong Kong, Singapore, and South Korea with some private sector players along with government. Most of the entrepreneurial universities in Singapore and Hong Kong are heavily state-financed while in South Korea and Taiwan there is a higher share of private run institutions (Mok, 2013). There is a greater drive, in recent years, in Hong Kong towards privatization of higher education (Mok, 2013).

As a regional hub for higher education, Hong Kong has limited resources and universities and academics are under immense pressure to match up to global rankings and to

commit to international standards of research and teaching (CHAN, 2007; Mok, 2005). The government has a research performance-led funding style in which only the top performers get resources (Kwiek, 2008). All the universities in Hong Kong undergoes reviews periodically and strengths as well as weaknesses are identified.

The Ministry of Education and the National Science Council of Taiwan jointly launched the “Program for Promoting Academic Excellence of Universities”, to improve the infrastructure and quality of research and teaching at Taiwanese institutes of higher learning (MOE, Taiwan, 2000), and scholars argue that this was a response to the pressures of globalization and a need to excel in global university rankings (Mok, 2013). Following this, there was a national agenda to ensure at least one Taiwanese university broke into top 100 university rankings in the world and to develop 15 schools/departments as the best in the region (Mok, 2013).

Chinese universities have always been key players in contributing to national innovative capabilities as early as from the 1950s (Nezu, 2007). In the Communist regime, the Chinese economy was considered to be in a state of “shortage” and in the 1980s key policy changes were initiated to mobilize academics to increase productivity. China has implemented policy schemes called “211 Project” and “985 Scheme” to develop 100 key Chinese universities/departments and to transform Beijing University and Tsinghua University into world class destinations for research. There are identified national centers for specific disciplines in sciences as well as humanities with key research centers for advancing science and technology (Jen Huang and Ju Liu, 2005).

Japan started developing university-industry linkages (UILs), as a means of increasing innovativeness, only in the late 1990s. This was the direct result of losing out on competitiveness to United States in the global North and to South Korea and Taiwan within the region. Japanese firms started to look towards universities as a source of knowledge. In this context, the Japanese government initiated the “Flagship Universities” program that develops universities in the country into globally competent ones. There has been strong national policy impetus on developing a strong higher education ecosystem in Japan since the late 19th century (Yonezawa, 2007). Academics and students are encouraged by the government to engage with industry as well as international researchers (Yonezawa, 2007).

South Korea, due to intense competition from Japan, intensified the role of universities very early on in its development trajectory. Classified as belonging to an innovation system based on the catch-up model (OECD, 2013), South Korea places value on long-term basic research and fosters a close relationship between universities and firms (Nezu, 2007).

### **1.4.3 Relevance of Social Construction of Technology (SCOT) to the Study**

This research attempts to apply social construction of technology in studying innovation in Singapore. This theoretical approach was chosen to understand the nature of academic innovation, the different pathways academics take to innovate, and the role of innovation policy in driving this process. It has been outlined in previous research that there are 'black boxes' in the process by which basic science leads to applied research and creation of spin-offs (Tait & Williams, 1999). The aim was to understand the perspective of a major innovation player in the NSI of Singapore i.e. the academic beyond public documents. Hence, by conducting an empirical study at the level of university, this study broadens the vision of NSI and qualitative research reveals the formal and informal social and cultural aspects of innovation at universities. This study combines a top-down study of policy implementation and a bottom-up study of these initiatives through the academics's perspective. My purpose is to understand the development of innovation system of Singapore and given the social nature of the phenomenon, it can be assumed that innovation happens in multiple and fragmented contexts and hence, in multiple locations (Czarniawska, 1998). Thus, this research highlights to need to map out the various social groups involved in the innovation system of Singapore and to understand their perceptions. It was also designed to be exploratory in nature as is required to understand a necessarily dynamic process. Prior to beginning my fieldwork, after considerable literature review, it was decided to not apply any pre-existing theories or hypothesis so that diverse data sets and new perspectives can be generated on a well-studied phenomenon i.e the NIS. This reflects the broader conceptual framework of social construction of technology which has an exploratory design towards data collection as well as research design. As pointed out, SCOT should be used "as a collection of sensitising concepts that aims to provide

the researcher with a set of heuristics with which to study technological development” (Bijker 1995: 49). An inductive approach was used and the research began with a round of interviews with some academics in NTU and using this the final research as well as interview questions were determined. This was to understand facts that are socially and historically mediated and its bearing on the phenomenon under study (Dunbar et al, 2002). To understand the social context better, semi-structured interview method was followed.

#### **1.4.3.1 Limitations**

In keeping with the overall objective of this study which was to study the perspectives and roles of academics in the NSI of Singapore, SCOT offered the theoretical lens to study this. To achieve necessary depth, key themes and issues were prioritized over others while still offering a new perspective on the NSI. As a matter of methodological limitation, only those issues the social group under study focused on has been elaborated in the thesis. Another limitation is in the form of the market under study i.e. Singapore. Due to being located in Singapore and as a student of a public university in Singapore, it was relatively easy to gain access to the relevant actors and data. The theoretical and methodological approach provide very context-dependent knowledge and all results should be treated as such.

#### **1.4.4 Methodological Approach**

This dissertation uses a mixed-methods approach to study the role of universities in the National System of Innovation of Singapore. The rationale for this choice was to combine the best of two research cultures i.e. qualitative and quantitative. The qualitative part offers “deep, rich observational data” and quantitative elements offers “hard, generalizable data” (Sieber, 1973). It is an attempt to illuminate with depth, definition, and diversity how academics negotiate with, understand, and make sense of the environment around them and thereby offer a critique of the narrative of innovation and innovation policies in Singapore.

The three essays in this paper all uses multiple sources of data. Triangulation was necessary to view the phenomenon under study from multiple vantage points (Johnson

and Onwuegbuzie, 2004). It also ensured reliability of the data collected. Both primary and secondary sources of information were used; the sources are clearly identified in each section. Broadly the sources include:

1. Interviews with faculty from NTU and NUS
2. Interviews with policymakers from NRF and EDB
3. Public talks or lectures given by members of Singapore government
4. Singapore global talent research survey 2016 (Chou et al., 2017)
5. Singapore government publications from the National Research Foundation (NRF), Ministry of Trade and Industry (MTI), Ministry of Education (MOE), Economic Development Board (EDB) and Agency for Science, Technology and Research (A\*STAR).
6. Academic journals, books, unpublished theses, review papers, newspaper articles (cited as and when used)

Most of the primary data that informed this research was generated through interviews. This proved valuable for generating testimonies of key actors involved in producing and policing innovation in Singapore which otherwise would not have been possible with quantitative research (Schoenberger, 1991).

There is no authoritative answer as to how large a sample for a research study should be nor is there a formulaic sampling strategy, instead the sample size and sampling technique should tally with the objectives of the study (Alreck and Settle, 1995; Fowler Jr, 2002; Hoinville and Jowell, 1978). For the purposes of my study, I identified the National Research Foundation (NRF) and Economic Development Board (EDB) to be the most relevant governmental agencies. The respondents were chosen based on ease of access and on their relevance to the investigation. A non-probabilistic sampling strategy was used and over 100 members of the NRF and EDB of Singapore were emailed requesting interviews. I conducted semi-structured interviews with 4 members from the NRF and 1 from the EDB (coded as 'PM'). A similar strategy was employed, and more than 300

tenure-track academics from the two largest and most established universities of Singapore, the National University of Singapore (NUS) and Nanyang technological University (NTU), were emailed with interview requests. Thirty seven academics were interviewed in total (coded as 'A'). Of this, 27 interviews were conducted with academic faculty from NTU and 4 from NUS. The rest 6 has concurrent appointments at both NTU and NUS.

Data collection involved qualitative, semi-structured, and open-ended interviewing of study subjects. The interviews were kept informal and conversational to favor an easy environment where the interviewees could be vocal about the issues and perceptions about the topic under study. All the interviews lasted approximately between thirty minutes and an hour based on conversation dynamics. Two of the policymakers (PM3, PM4) were interviewed in person at their offices and PM2 over the telephone. PM1 and PM5 corresponded with me via email. All the academics were interviewed in person at their respective university campuses except A12 who was contacted via telephone; A9 and A25 who corresponded via email. Even though doing telephone/email interviews prevented the possibility of observing gestural cues and other subtle non-verbal communication methods, it was necessary to do so to gain access to the study participants.

The interviews were digitally recorded with the permission of the respondents. A denaturalized method of transcription was done (Oliver et al., 2005). The questions mainly centered around the researchers' views on what innovation is, what its indicators are, how they approach it in their everyday professional studies, and on general trends in Singapore. The questions were altered for academics and policymakers to understand the subjectivity of their views on innovation in Singapore. The interview questionnaires are provided in Annex I and II.

### **1.4.5 Main Sites of Study**

Of the six universities in Singapore, two were chosen for this study: National University of Singapore (NUS) and Nanyang Technological University (NTU). The rationale was to choose the oldest and most established universities in the nation as they have evolved through the different policy cycles of Singapore. NUS and NTU are both research-intensive universities with an entrepreneurial dimension. The other universities, as described in the previous section, have not been around long enough to have witnessed the development of Singapore.

## 1.5 Structure of the Thesis

Using Singapore as a case, this dissertation expounds the role of universities in National Systems of Innovation (NSI). This dissertation has three empirical chapters addressing important and related aspects on the evolving role of universities in knowledge economies. A brief abstract of each chapter follows.

In chapter 2, I study how the concept of 'innovation for economic growth' came about in the early 1990S, and how it is embodied institutionally in Singapore. The origin of the concept of innovation in STI policy design in Singapore, its development, and current status (1965-2015) is traced by drawing on the social construction of technology approach (Pinch and Bijker, 1987). Andrew Barry showed us how the arbiter of innovation has expanded from technical machines to include political machines (2001) with the state and citizens holding contrasting positions in this political machinery (Asdal, 2008). While the state sets the direction for innovation, academia produces it, within a political sphere constructed by technical/technological machines. Using interviews with academics from NTU and NUS and key policymakers from the EDB and NRF, I explore tensions that exist between these two groups of actors. In doing so, I aim to contextualize the state of innovation in Singapore and expose gaps that need to be addressed for efficient innovation system planning.

Chapter 3 addresses university-industry linkages (UILs) which are an important strategy for innovation for universities, industries, as well as governments. Extant literature identifies the various barriers to such collaborations and suggests ways to improve them, but does not sufficiently describe how academics, the key decision-makers who drive the formation of UILs, perceives these barriers and how it affects their realities and daily practices. A mixed-methods approach is used to provide a rich description of barriers to UILs in Singapore from the academics' perspective. By providing a comprehensive analysis of the nature of and barriers to UILs across Singapore from the academic's (from NTU and NUS) perspective, this paper aims to fill this gap in literature. Based on the results, policy recommendations are made that Singapore can adopt to address specific gaps in university-industry collaborations in the nation.

Chapter 4 looks at the academic experience of funding in Singapore's knowledge race. Funding systems have changed drastically globally and how universities adapt to

such changes is of topical interest. Numerous studies address this in the knowledge-economy context in the UK, EU and USA. The global south has been largely ignored so far. This paper attempts to study this- i.e. how a specific group of institutions viz. public universities in Singapore (NTU and NUS) respond to the particular funding systems that exists in Singapore and how Singaporean academics experience and perceive them. Singapore is an interesting case study as it has a highly market-oriented university system and there is an evident push towards the more utilitarian or applied research on the part of the government which funds almost 90% of academic research. With mission-oriented innovation policies, Singapore has firmly situated itself as a leader in most global innovation indices. The university eco-system of Singapore also has rigorous expectations placed on them to help drive Singapore towards a knowledge-based economy. Using interviews and archival research, I describe how academics in Singapore perceive and deal with current funding systems thereby opening up debate and discussion on the evolution of universities in the South East Asian region.

# Chapter 2

## Narratives of Innovation in Singapore

### 2.1 Introduction

This chapter aims to take a closer look at the concept of innovation, specifically in light of debates on National Systems of Innovation (NSI) and the role of entrepreneurial universities in knowledge-economies. Innovations are icons of social and economic development and mastery of innovation is closely associated with global superiority. To demonstrate the relationality and hybridity of this concept, I will situate the notion of innovation in Singapore and seek to understand it through the eyes of the state and public university academics.

Andrew Barry showed us how the arbiter of innovation has expanded from technical machines to include political machines Barry (2001). The state and the citizen (academia in this study) hold the two contrasting positions in this political machinery (Asdal, 2008). I will introduce how this complex relationship between the actors of the political machinery of Singapore impacts academic research.

Year after year, Singapore consistently ranks high up in the indices of most innovative countries in the world (Index, 2015). In fact, Singapore is one of the few Asian countries to be in the top 10 list of the most innovative countries in the world. And, it is the most innovative country in Asia according to 2016 Global Innovation Index ranking (Index, 2016). The word innovation is a popular buzzword in the policy circles of Singapore. There is a strong sense, drilled in by the government, that innovation is the way for

Singapore to be successful, to be innovative is the way for anyone to be successful in Singapore. Since gaining independence from the British in 1965, Singapore has achieved rapid industrial and technological catch up by evolving a very distinct national innovation system mandated by dominant state ideologies. It is an impressive growth and Singapore enjoys a unique position on the world economic map despite its small size and total lack of natural resources.

While technical and technological machines are fundamental to the idea of innovation, extant literature often overlooks the machinery of the state with its numerous structures, processes, and its various actors in contributing to and shaping innovation in a nation. The institutional framework for science, technology, and innovation (STI) policy in Singapore is a complex machine with several administrative and functional bodies with independent cultures, materialities, and agencies that function together to oversee the production of innovation in the nation. This machinery has succeeded in transforming a fledgling state into a booming economy in less than 50 years with focused Science Technology and Innovation (STI) policies.

I study how the concept of 'innovation for development and economic growth' came about and how it is embodied institutionally in the National System of Innovation (NSI) of Singapore. The origin of the concept of innovation in STI policy design in Singapore, its development, and current status (1965-2015) will be traced by literary analysis. In addition, I explore how the dominant narrative of innovation produced by the state has impacted academic research in Singapore. I am interested in the multiplicity of perceptions on innovation that exists among the policy makers and academic researchers.

I will demonstrate that the notion of innovation is highly subjective in Singapore. The academics in public universities have to innovate within strict mandates set by the Singaporean state. The two dominant actors of the NSI: academics and the state both define and approach the idea of innovation differently. This paper explains what these different opinions and perceptions are and what this means for the future of innovation policy making in Singapore.

## 2.2 Theoretical Background

### 2.2.1 Innovation

Before the term innovation entered our lexicon, most activities concerned with economic growth and technological change were considered to be important (Lorenzi et al., 1990; Veblen, 1899). Since then, scholars and practitioners alike have attempted to define 'innovation' in multiple ways and in different contexts. Due to proliferation of literature in this area, there is a certain level of ambiguity in understanding it (Garcia and Calantone, 2002).

Schumpeter gave the simplest and most widely used definition by calling innovation as commercialized invention (Schumpeter and Backhaus, 2003). Zahra and Covin (1994) suggested that "innovation is widely considered as the life blood of corporate survival and growth". Bessant et al. (2005) on the role of innovation in renewal and sustaining competitive edge emphasize that "innovation represents the core renewal process in any organization. Unless it changes what it offers the world and the way in which it creates and delivers those offerings it risks its survival and growth prospects". Acknowledging the significance of innovation, the United States has a Department for Innovation since 2008 (Massa and Testa, 2008). In 2003, the Department of Trade and Industry (DTI), UK commented: "If UK-based companies fail to innovate, jobs and profits will suffer, and our standard of living will fall compared with other countries" (DTI, 2003).

Massa and Testa (2008) identified the various labels used for innovation namely radical or incremental (Dewar and Dutton, 1986; Ettlie et al., 1984; Koberg et al., 2003); discontinuous or continuous (Bower and Christensen, 1995; Lynn et al., 1996; Walsh et al., 2002); revolutionary or evolutionary (Patrakosol and Olson, 2007; Utterback, 1994); major or minor (Downs Jr and Mohr, 1976; Katz and Shapiro, 1987) etc. An extended review of as many as sixty definitions of innovation is given by Baregheh et al. (2009). The most popular definitions of innovation used in literature and policy circles are given in Table 2.1.

In between this range of definitions, some researchers emphasize the importance to understand more about the status of innovation and what it means to societies at large (Danneels and Kleinschmidt, 2001; Kahn et al., 2003; Rosenø, 2005). The argument

Table 2.1: Definitions of Innovation

<p>“Innovation is conceived as a means of changing an organization, either as a response to changes in the external environment or as a pre-emptive action to influence the environment. Hence, innovation is here broadly defined to encompass a range of types, including new product or service, new process technology, new organization structure or administrative systems, or new plans or program pertaining to organization members”</p>	<p>Damanpour, 1991</p>
<p>“Innovation as the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market driven products and services. Innovation encompasses both radical and incremental innovation”</p>	<p>Du Plessis, 2007</p>
<p>“... a set of institutions whose interactions determine the innovative performance ... of national firms. As long as the idea is perceived as new to the people involved, it is an 'innovation' even though it may appear to others to be an 'imitation' of something that exists elsewhere”</p>	<p>Van de Ven, 1986</p>
<p>“Innovation can be defined as the effective application of processes and products new to the organization and designed to benefit it and its stakeholders”</p>	<p>Wong, 1995</p>
<p>“There are three stages of innovation: innovation as a process, innovation as a discrete item including, products, programs or services and innovation as an attribute of organizations.”</p>	<p>Nystrom and Starbuck, 1984</p>

is that 'who' and 'where' these definitions stem from matter. In this context, introducing the various individuals or groups involved in innovation and their perspectives is important. Zaltman et al.(1973) contends that “the distinguishing characteristic of an innovation is that, instead of being an external object, it is the perception of a social unit that decides its newness.”

Measures of innovation are based on innovation inputs and outputs as demonstrated by the Global Innovation Index (Index, 2015). The indicators of innovation inputs include political stability, government efficiency, regulatory environment, business environment, human capital, research & development (R&D) budget, tertiary education, infrastructure, market sophistication. The commonly measured innovation outputs are publications, patents, citation index, new business density, intellectual property rights (IPR) receipts,

trademark applications, creative goods exported, number of start-ups etc.

For investigating innovation, while there are multi-scale questionnaires available, much of it relies on perceptual, and self-reported data (Hoffman et al., 1998). In statistical research, innovation performance is an entity that has been difficult to quantify (Romijn and Albaladejo, 2002). A strong correlation has been found between perceptual and objective measures of innovation (Khan and Manopichetwattana, 1989) while some other studies have highlighted that innovators tend to over assess their achievements (Coombs and Tomlinson, 1998; Flor and Oltra, 2004).

It is important to clarify what innovation means to different groups of actors as literature highlights that perspectives can influence behaviors (Massa and Testa, 2008). This chapter is an attempt to unravel the different perspectives that academics and policymakers have on innovation in Singapore and it also highlights how these differences impacts academic research. While it is not the objective of this research to say who or what is right, the researcher hopes that a deeper understand of the subjectivity of innovation can inform innovation policy design and existing gaps can be addressed. This will lead to a more coherent innovation ecosystem in Singapore.

### **2.2.2 Social Construction of Innovation**

Social construction is a sociological theory which postulates that all human development cannot be separated from the social and all knowledge produced, that is purported to be universal and objective, is the result of interactions between humans and institutions and situated in the social and cultural (Bijker et al., 2012).

The social construction of technology (SCOT) from which stems the paradigm of social construction of innovation can be traced back to Wiebe Bijker and Trevor Pinch's seminal work on how technological artifacts are the result of intergroup negotiations and sense making of the scientific observations produced from experimentation 1987 .

Interpretive flexibility is the first principle of this approach which proposes that while trying to explain the origins of all scientific theories and assumptions, successes and failures should be equally examined. It is not just technological reasoning but all social, cultural, political, economic reasonings should be given due importance.

Social construction of innovation takes root in this theoretical framework. It is not technology that shapes innovation rather it is human action or combined interactions between humans and institutions that drives innovations.

Conventional wisdom suggests outlining objectives to all innovation proposals to circumvent any ambiguity of innovation definition, but emphasis on the social and cultural aspects of innovation is now considered to be more or as important as the technical and economic aspects. Weick (1995) uses the term 'sense making' to explain the social construction of innovation. Sense making is explained as follows: "what the situation means is defined by who I become while dealing with it or what and who I represent" (Weick et al., 2005).

It is important to clarify what innovation means to different groups of actors as literature highlights that perspectives can influence behaviors (Massa&Testa, 2008). As early as in 1928, sociologists William I. and Dorothy Swaine Thomas demonstrated how when things are perceived to be real, then it has real consequences.

Social construction of innovation argues that the source of innovation perception is social (Burns and Stalker, 1981). How creators or innovators conceive of and perceive their innovations are impacted by social and cultural factors (Zaltman et al., 1973). Innovation management and other social science literature describes in detail how such perceptions impact entrepreneur behaviors and ultimately firm performances. Cooper et al (Cooper et al., 1988), with data collected from 2994 entrepreneurs, argue that the continuous appraisals that they make of their own success influences any changes or plans to discontinue their businesses regardless of how close it is to reality. Risk-taking propensities of entrepreneurs and managers vary, especially with goals like venture growth or generation of more income, based on such perceptions too (Stewart Jr and Roth, 2001). Lerner and Almor demonstrate how female lifestyle business owners rate their skills, that correlate positively with business performance, lower and how this implicates innovation negatively in such ventures (2002). In a Fortune 500 company study of managers, Smith-Doerr et al argues that social networks of R&D project managers shapes their perspectives of the outcome of innovative projects (2004). Massa and Testa studied the various perceptions of innovation amongst three stakeholder groups in Italy namely policymakers, academics, and entrepreneurs from manufacturing industries (2008). They find that vastly different

perspectives exist for these three groups and this has serious implications for effective policy implementation (Massa and Testa, 2008).

Building on Massa and Testa's qualitative study, this study generates empirical data on the state of perception of innovation among academics in Singapore. It also compares and contrasts this narrative with the Singaporean state's construction of innovation in the country. With the understanding that perspectives impact behaviors (Massa and Testa, 2008), this paper attempts to bring to light the state of innovation in universities in Singapore. This has important considerations for national level innovation policy design.

Theoretically, it explores an understudied group of actors viz. academics in National Systems of Innovation (NSI) literature.

### **2.2.3 National Systems of Innovation in STS Literature**

Technology and technological innovations are a classic feature of modern societies and yet, the sociological analysis of such systems from within is still quite nascent. It had indeed been reawakened with vigor in the last century and this is important because as Lewis Mumford said: "When one examines [technology] freshly, however, many of these [traditional ideas] are upset. We find that there are human values in machinery we did not suspect" (1930). That there is some inherent logic to all technology is an outdated argument and how social and human values shape technological development is a question of topical interest.

While the scholarship on economic, policy- and management-related aspects of National Systems of Innovation (NSI; used interchangeably with Innovation Systems and Systems of Innovation) is growing fast, there is as yet very little from a constructivist standpoint (Sharif, 2006). In this chapter, I adopt a Science and Technology Studies (STS) framework to study rhetoric and controversies in the development of the NSI of Singapore and subsequently the changing role of university in the nation.

Miettinen (2002) studied the emergence and use of NSI concept in Finland and it is a very influential study of NSI in STS literature. He studied the rhetoric of policymaking in Finland and analyzed the relationship between innovation and the language used in policy making. He concludes that the NSI concept was on its own insufficient for successful implementation of policy in Finland.

Albert and Laberge (2007) did an ethnographic study on how international organizations (OECD) and regional public administrative offices (in Quebec, Canada) employ the NSI concept. Their discovery was that the success of its application is linked to its perceived scientific validity (2007).

## 2.3 History of the Concept of Innovation

Since time immemorial, human beings have been innovative. As a result of that, there are innovations everywhere. It is important to note that innovation is not just technological or technical. It is also in words, in politics, in society, in organization. Innovation is all pervasive in popular imaginations and in public policy. Thus, the definitions of innovation have also changed across time. While notions of discovery, invention, research etc. have been easier to conceptualize, the idea of innovation remains a puzzle. In this section, I will attempt to bring some clarity on how the definition of innovation has changed in global history with time and why this matters.

“Innovations....at first are ill-shapen....[They] are like strangers....what is settled by custom ... is fit ... whereas new things piece not so well ... They trouble by their inconformity. [Yet,] he that will not apply new remedies, must expect new evils.....A forward retention of custom, is as turbulent a thing as an innovation....It were good, therefore, that men in their innovations would follow the example of time itself; which indeed innovateth greatly [time is the greatest innovator], but quietly, by degrees scarce to be perceived....It is good also, not to try experiments in states, except the necessity be urgent, or the utility evident; and well to beware, that it be the reformation that draweth on the change, and not the desire of change, that pretendeth the reformation. And lastly, that the novelty, though it be not rejected, yet be held for a suspect.” (Bacon, 1881)

Today, innovation is irrevocably welded to economic development. Contemporary theorists and practitioners ignore innovation’s testy history because of its much lauded benefits to economy and abilities to retain competitiveness to nations. The popular imagination of contemporary innovation was captured succinctly by John Lyons who said, “innovation is popularly considered to be a great endowment. People, and even

institutions, are criticized for [not being innovative enough]" (Lyons et al., 2007). Innovation did not always have this status in society and its history is mired in myths and confusions and contradictions. Before the twentieth century, innovation was a pejorative, forbidden by the law. According to Pierre Rosanvallon, innovation had a "negative history" (Rosanvallon, 2003, 43-45). It was a vice and had no linkages with creativity.

In ancient Greece, *kainon* (novelty) in the arts and science was acceptable as long as it did not change the societal order but *kainotomia* (innovation) was unacceptable (Godin, 2015, 19). Xenophon, the Greek historian and philosopher, in fifth century BCE, made a literal reference to innovation as the panacea to improve war-torn Athens' financial situation. Xenophon's idea of innovation had three important characters. To him, innovation was "making new cuttings" or "opening new veins" (Godin, 2008) which simply meant to open new ways. The second was that innovation was a "scheme" or "project" for the state to improve. Finally Xenophon, understanding the times, suggests that the state does so "gradually" (Godin, 2008).

This conceptualization of innovation became the groundwork for theorists of the succeeding centuries and innovation continued to be associated with political change which essentially meant revolution. Plato discusses *kainotomia* in *The Republic* and suggests that the onus of innovation lies on accidents and not on men (Godin, 2008) and it is in times of calamities that men fall on their skills to seize the opportunity to make new laws. He also rejects innovation in education as this leads to a new generation of scholars who will demand new institutions and new laws causing social instability (Godin, 2008). Interestingly, Plato accedes that innovation is a popular concept in society especially with children even though it causes political instability. And this is why innovation should be contained. Hence, in Plato's republic music, dance, games, and foreign customs were strictly controlled.

In modern and pre-modern eras, economists have been writing about machines and inventions even before this, and systematic studies about what we now understand as technological innovations were called technological change in industrial production (Johnson, 1931; Macleod, 2008). The origins of these inventions or innovation were never probed and it was merely adoption of this in society that was scrutinized (Godin, 2008). Neoclassical economics studied technological change in a predominantly quantitative tradition

and this became an established field in econometrics with foci on factors of production, market structure, economies of scale, etc. Technological innovation started to appear in writings in the early 1900s and since then, economists, anthropologists, historians, and sociologists have attempted to theorize it (Godin, 2011). Christopher Freeman was one of the earliest economists to define it as, “an essential condition of economic progress and a critical element in the competitive struggle of enterprises and of nation-states. It is also important for improving the quality of life” (Freeman, 1982, 15).

Soon after, in the 1940s, the focus came to be on commercialization of technological innovations and this became the de-facto definition of innovation (Maclaurin and Harman, 1949). Josef Schumpeter sealed this when he defined it as “an idea, a sketch or a model for a new or improved device, product, process or system. An innovation in the economic sense is accomplished only with the first commercial transaction” (Freeman, 1982, 22).

It is in this tradition, Benoit Godin states, that modern innovation studies took birth (2008). Modern innovation studies is both descriptive as well as empirical, with institutions as the unit of analysis, major policy focus where process and product innovations are emphasized. International organizations and governments embraced it as a solution to societies most pressing problems and as a means to sustain competitiveness (Godin, 2012; Manual, 2002). This led to design of national innovation policies and all governments began to launch some version of this (Pavitt and Walker, 1976).

## **2.4 History of Innovation Policy in Singapore**

Singapore attained independence from the British on 9th August 1965 and began the industrialization of its economy soon after. The state of development Singapore has achieved can be traced to its changing innovation policies. The trajectory of Singapore’s innovation policies (as described in detail in Chapter 1) can be traced over five distinct phases (Wong, 1995):

1. “Labor-intensive industrialization of the 1960s
2. Export-oriented industrialization of the 1970s
3. Cost-competitive industrialization of the 1980s

4. Enterprise development industrialization of the 1990s
5. Bolstering of innovation of the 2000s”

Today, there are a number of public bodies in Singapore that are responsible for driving the innovation of Singapore forward. A short description of each one follows.

### **2.4.1 National Research Foundation**

The primary body that is responsible for setting the direction for innovation in Singapore is the National Research Foundation (NRF). It was founded on January 1 2006 and exists as a special department in the Prime Minister’s office. The NRF reviews and charters all the policies and strategies for the national direction for research, innovation, and enterprise. The main strategic thrust of the NRF’s innovation policies have been in four major areas (NRF, 2016):

- “Strengthening foundational capabilities;
- Developing talent;
- Driving research excellence through competition; and
- Ensuring impact through public-private collaborations, industry-oriented R&D, and commercialization”

### **2.4.2 Research, Enterprise and Innovation Council (RIEC)**

The Research, Enterprise and Innovation Council (RIEC) was set-up in 2006 to provide direction for the research and development endeavors in Singapore. Chaired by the Prime Minister, Lee Hsien Loong, the RIEC is responsible for national research and innovation policies that are geared towards driving Singapore into a knowledge-based economy. It tries to uncover and catalyze novel areas of economic growth while encouraging initiatives for knowledge creation in science and technology.

It is a political body that underscores the importance of R&D in transforming Singapore. The NRF was formed in conjunction with the RIEC and they coordinate with each other to grow Singapore’s research capabilities.

### 2.4.3 Economic Development Board (EDB)

The Singapore Economic Development Board (EDB) was set-up in 1961, as mentioned before, with the objective of enhancing foreign-direct investments (FDI) in the nation. The goals and objectives of the EDB have changed with every passing decade to reflect the changing innovation policies of Singapore. Today, the EDB is the primary strategic business development body of the nation.

To increase its investments, the EDB set-up three offices in China (Shanghai, Beijing, and Guangzhou) in 2002, 2004, and 2006 respectively. The EDB also founded an office in Mumbai, India in 2004. This has resulted in enhanced economic relations with both China and India. More recently, the EDB has persuaded MNCs like Hewlett Packard (HP), Johnson & Johnson, Procter & Gamble (P&G), and Hyflux to found their innovation and leadership centers in Singapore.

## 2.5 National Construction of Innovation, Today

The Organization for Economic Cooperation and Development (OECD) argues that, “in the long run, knowledge, especially technological knowledge, is the main source of economic growth and improvements in quality of life” (OECD, 1996, pg. 13).

The Research, Innovation, Enterprise 2020 (RIE 2020) plan is the latest installment from the Singapore government in its series of innovation policy proposals that began in early 1990s (Fig. 1.1, Fig. 1.2). The RIE 2020 reinforces the nation’s commitment to research, innovation, and enterprise with a fund of \$19 billion for the next five years from 2015-2020. This follows the trajectory of other policy proposals viz. RIE 2015, Science & Technology 2010 plan, Science & Technology 2005 plan, National Science & Technology Plan 2000, and National Technology Plan 1995.

The RIE 2020 identifies four key thrusts: to encourage multi-disciplinary research in the four identified strategic technology domains namely Advanced Manufacturing and Engineering (AME), Health and Biomedical Sciences (HBMS), Urban Solutions and Sustainability (USS), and Services and Digital Economy (SDE); continue to distribute public funds for research (40%) competitively; focus on value creation through sustained public-private partnerships; and to retain research, innovation, and enterprise talent.

In fact, in the words of Teo Chee Hean<sup>1</sup>, the nation's Deputy Prime Minister who used to serve as Singapore's Minister of Education:

*“R&D is an investment in our own future. It's an expression of belief in Singapore and Singapore's future. If we want to be a knowledge-based economy, which thrives on innovation and enterprise, we must build this knowledge base on which we can build the future of Singapore-then R&D is where we have to invest”* (NRF, 2016).

In an otherwise technology oriented policy brief, this quote which precludes the report, stands out. Here there is a brief allusion to something besides science, maybe culture in the phrase “expression of belief in Singapore and Singapore's future”. The report makes no other reference to the relationship between culture, creativity, and innovation (Gibson and Anderson, 2008). A similar criticism was levied against Australia's 2001 innovation policy plan titled 'Backing Australia's Ability -Building our Future through Science and Innovation' by Dr.Margaret Seares who contrasts it with the Uk government's Green Paper on Culture and Creativity, which states that it looks:

“...forward to a future in which individual creative talent is given the support it needs from childhood to flourish; in which artists and cultural institutions are freed from bureaucratic controls; and in which freedom to explore and enjoy creativity and culture is available to all.” (DCMS, 2001).

Innovation is clearly identified as a nation building activity and the Singaporean state has determined what innovation is and what kinds of innovations are desirable.

## 2.6 Methods

### 2.6.1 Research Design

The present investigation was designed to be a qualitative research study to understand the impact of innovation policymaking on university research in Singapore. The first step was to trace the history of innovation policymaking in the nation and this was done mainly by literary analysis of secondary sources of data like journal articles, policy documents, and newspaper articles.

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<sup>1</sup><https://www.nrf.gov.sg/rie2020/>

The next step was to understand the multiplicity of perceptions on innovation that exists between university academics and policymakers in Singapore. This was achieved through semi-structured interviewing of the study subjects. Literature review was done, prior to the interviews, to study the inception of NSI to its current status in Singapore.

This revealed a lack of empirical data about the perceptions and opinions of academics on how they define innovation and what their role is in an NSI. The present study aims at filling this gap in literature.

### **2.6.2 Study Sample & Data Collection**

There is no authoritative answer as to how large a sample for a research study should be nor is there a formulaic sampling strategy, instead the sample size and sampling technique should tally with the objectives of the study (Alreck and Settle, 1995; Fowler Jr, 2002; Hoinville and Jowell, 1978). For the purposes of my study, I identified the NRF (National Research Foundation) and Economic Development Board (EDB) to be the most relevant governmental agencies involved in design and implementation of innovation policies in the nation. The respondents were chosen based on ease of access and on their relevance to the investigation. A non-probabilistic sampling strategy was used and over 100 members of the National Research Foundation (NRF) and Economic Development Board (EDB) of Singapore were emailed with requests for interviews. I've conducted semi-structured interviews with 4 members from the NRF and 1 from the EDB (both coded as 'PM'). A similar strategy was employed and more than 300 tenure-track academics from the two largest and most established universities of Singapore, the National University of Singapore (NUS) and Nanyang technological University (NTU), were identified from the various schools' websites. They were mailed with interview requests. I've conducted 27 interviews with academics from NTU, 4 from NUS, and 6 with concurrent positions in NTU and NUS (all coded as 'A').

Data collection involved qualitative, semi-structured, and open-ended interviewing of study subjects. The interviews were kept informal and conversational to favor an easy environment where the interviewees could be vocal about the issues and perceptions about the topic under study. All the interviews lasted approximately between 30 minutes and an hour depending on conversation dynamics.

Two of the policymakers (PM3, PM4) were interviewed in person at their offices and PM2 over the telephone. PM1 and PM5 corresponded with me via email. All the academics were interviewed in person at their respective university campuses except A12 who was contacted via telephone; A9 and A25 who corresponded via email. Even though doing telephone/email interviews prevented the possibility of observing gestural cues and other subtle non-verbal communication methods, it was necessary to do so to gain access to the study participants.

The interviews were digitally recorded with the permission of the respondents. A denaturalized method of transcription was done (Oliver et al., 2005). The questions mainly centered around the researchers' views on what innovation is, what its indicators are, how they approach it in their everyday professional studies, and on general trends in Singapore. The questionnaires are provided in Annex I & II.

### **2.6.3 Data Analysis**

The collected data were organized and interpreted using the qualitative method of thematic analysis as described by Braun and Clarke (2006) and Charmaz (1995; 2003). This process aided in identifying the complex themes, in the form of perceptions and views of the researchers, which were embedded in the narratives. The identified themes from each of the transcripts were compared and it was put together to study the everyday realities and experiences of the policymakers and academics of Singapore. A summary of the interviews is provided in Table 2.2.

## **2.7 Empirical Findings**

### **2.7.1 Innovation and its indicators in Singapore**

For the policymakers in Singapore, innovation is an economic necessity. As PM3 said:

*“Innovation can be broadly defined as the creation of new ideas, products, services, solutions. To take that definition further, we should be looking at innovation that creates economic impact since the creation of a new idea which is not applicable by itself has*

Table 2.2: Summary of Interviews

Innovation	Academics	Policymakers
<b>Definition</b>	<ul style="list-style-type: none"> <li>○ Making either fundamental advances or understanding of/or fundamental translations of scientific principles</li> <li>○ New methods of doing things</li> <li>○ both theoretical innovations and practical innovations</li> </ul>	<ul style="list-style-type: none"> <li>○ Creation of new ideas, products, services, solutions</li> <li>○ Stresses economic benefits</li> <li>○ Mostly practical with theoretical advances seen as necessary to advance knowledge</li> </ul>
<b>Indicators</b>	<ul style="list-style-type: none"> <li>○ H-index is too instrumental and ignores nuances and complexities in research</li> <li>○ Peer-review is a valuable indicator</li> </ul>	<ul style="list-style-type: none"> <li>○ Tangible measures are necessary like citation index, patents, spin-offs etc.</li> </ul>
<b>Environment</b>	<ul style="list-style-type: none"> <li>○ Less bureaucratic</li> <li>○ Innovation is difficult to engineer; must have a culture that supports risk-taking</li> </ul>	<ul style="list-style-type: none"> <li>○ Focus on sectoral strategies and outcomes by providing infrastructure and funds</li> </ul>
<b>Approaches</b>	<ul style="list-style-type: none"> <li>○ Complete autonomy is a must to do bottom-up research</li> </ul>	<ul style="list-style-type: none"> <li>○ Build Singapore's economy with focused top-down policies</li> </ul>
<b>Five-year plans</b>	<ul style="list-style-type: none"> <li>○ Encourages interdisciplinary research</li> <li>○ Promotes superficial results due to too narrow funding calls</li> </ul>	<ul style="list-style-type: none"> <li>○ Provides jobs for Singaporeans</li> <li>○ Targeted research to address areas of national concerns</li> </ul>

*limited impact.”*

Time and again I heard different variations of the same answer from the policymakers I interviewed and at public speeches/events by the various government agencies (like EDB, A\*STAR, NRF, PUB) that innovation equals money. The implication is that only those innovations that have the potential to make money are desired, and others are not worthwhile pursuits.

Interestingly, university academics define innovation differently. In the words of A12 who summed it up:

*“the term innovation in Science and technology is inherently paired up with the concept of making either fundamental advances or understanding of/or fundamental translations....it doesn't have to be the necessary cutting edge results. It's either doing something very different in terms of knowledge generation or understanding of existing knowledge.”*

Another academics, A11, had a broader definition of innovation:

*“Innovation is basically coming up with new tricks, right? New methods of doing things in a very broad sense of the word. So 'innovation' for a mathematician could be coming up with a new proof of a theorem, or coming up with a new algorithm for performing a certain calculation. For engineering, 'innovation' could be coming up with a particular design or principle or technique for....I don't know, for mixing cement or coming up with a new type of solar cell. Those are fairly concrete, practical innovations. So there are both theoretical innovations and practical innovations. But it all basically boils down to new ways of doing things of whatever sort that you have never thought of, or anybody has ever thought of before.”*

For most, if not all, academics that I interviewed, money making is not a goal. In fact, any money that is generated out of any of their innovations or research is just a happy side-effect of what they do. And, university faculty have a problem-solving mindset while

approaching innovation. A4 said:

*“There is really no metrics to tell us this is a good innovation and this is a bad innovation. Basically, I don’t actually ask that question to myself because whether it is a good innovation or a bad innovation, as long as it is helping to solve something, I’m fine with it. Even if it is not an innovation, let’s say something you are doing which has been done before also, then it’s no longer innovation. But the same concept-if it can solve your problem, it’s good. So I’m not worried if it is a good innovation or a bad innovation. What I am concerned is, can it solve something?”*

This subjectivity in defining innovation assumes importance in light of the national conversation on innovation in Singapore. As described previously, the state has specific innovation policy agendas and academics have to act within these mandates placed on the university ecosystem.

To understand how this becomes problematic, it is necessary to take a look at how innovations are measured. How are they gauged as potential moneymakers today or in the future? Literature analysis (Denti, 2013) reveals three main standards of measure: product or technology measures, financial or market measures, and subjective measures. Product or technology measures include generation of new products or product improvements (Elenkov and Manev, 2009), patents or patent applications (Sonn and Storper, 2008), patent citations (Makri and Scandura, 2010), invention disclosures or suggestions (Axtell et al., 2000) and process innovations (West and Altink, 1996). Financial or market measures study ratio of sales of new products to total sales (Czarnitzki and Kraft, 2004), ratio of sales of new products to R&D expenditures (Gumusluoglu and Ilsev, 2009), total R&D spending (García-Morales et al., 2008), number of employees in R&D (García-Morales et al., 2008), and new markets entered (Elenkov and Manev, 2009). Subjective measures of innovation include innovative work behavior (IWB) (De Jong and Den Hartog, 2010), team innovativeness (Hurley and Hult, 1998), and organizational innovation (Chen et al., 2009). My interview data and analysis of secondary data reveals that the various ministries and statutory boards of Singapore like the EDB, NRF, PUB etc. do use most of these quantitative measures of innovation.

Clearly, the two actors in this narrative i.e. the policymakers and academics have different perspectives on what innovation is. Hence, it becomes pertinent to note that academics and departments and universities are still evaluated on the basis of scientific production. Traditionally evaluation and comparison of academics are done via peer-review and bibliometric indicators (Van Raan, 2000). In fact, bibliometric indicators are the practical instrument that is used by most governmental organizations and research/higher secondary institutions to gauge the performance of its employees (Orr, 2004). Bibliometric indicators include research output (number of publications per unit), research profile (publications per field), scientific impact or citations, and evidence of research collaborations in the form of co-authorship (Aksnes and Taxt, 2004).

But how do the academics feel about this system of evaluation? A10 mused about bibliometric indices:

*“Hirsch came up with a very novel, simple, single number to give some measure of academic success (h-index). It is like trying to put one single number to something as complex as human beings. For me the true measure of innovation would be whether I have started a new branch of research, whether I have started a new frontier of research.”*

A6 offered another point of view:

*“The standard public policy measures of innovation are not bad. Things like citation index, impact factor, h-index etc. People complain about them all the time. Not always unfairly. But, as a first pass they do capture this idea of how much stuff that’s new is actually being generated. If you publish something that’s already known then your citation count will be low. Incremental research will also not give you high citations. So, I think if what you mean is something like how to measure innovation that is percolating out to broader society? Then there are existing measures for this like number of patents, tie-ups with companies...there are problems with all this but these are not fundamentally flawed. Again, just because somebody cites your paper, it doesn’t mean that your paper is good. Maybe the community is critiquing your results or methods. So knowing that these measures are flawed is important.”*

The point that comes across is that quantitative measures of innovation is not enough to capture the complete picture. Unless it's coupled with other qualitative measures, its not possible to capture the complexity of innovation. A6 continues to say:

*“If you want really to look at a person’s quality....it’s hard to have one system for all disciplines. It is hard to come up with a matrix that is accurate and easy to calculate. There is a way to measure the quality of innovation by a researcher. In established tenure processes, they go around asking different experts in the field for a detailed evaluation of a candidate. The experts should be able to gauge the quality of a person’s work because they are aware of the status of the field. They give a long comprehensive report detailing how the researcher has advanced the field. This happens once or twice in a person’s career. It’s not easy as clicking a button to generate the h-index. So there is no magic bullet. So the most accurate way would be peer-review. Not to make it sound too ivory tower. There are many innovations outside academia. Public perception of science will be very different from an academic’s judgment of what good science is. But I strongly think the general principle would be to go by the opinions of experts.”*

*“Once you start measuring people’s success by a number, then in that system all people would care about is to increase that number. Then the result would be that I would publish in nonsense journals, colleagues would start citing each other because then they will get a bonus. Academic incentives come into play when doing research. The incentives are skewed towards doing things that are as different from what is usually done.”*

There is also the question of how to compare academics from different disciplines and respectively their productivity. A1 discusses what is problematic about using publication number and citations to evaluate innovativeness.

*“If you are working in physics or you are working in material chemistry for instance, then if you look at the impact factor of journals you are publishing in, they are really very high. You start at 3 or 5, and then go beyond that. But if you take traditional fields like polymers, polymer engineering, you are looking at 1. And most of the reputed journals are like 1.5-2. So how do we compare these journals? So if you are publishing in this*

*journal, which many of the readers will read, and if you publish an engineering paper in a journal with a high impact factor, but no one will read because that journal only covers some of the aspects of polymer engineering.”*

It is evident from this that academics define innovation very differently from the policymakers of Singapore and this impacts its measures as well. They continue to innovate (perform research) within a system and under mandates set by a government that is largely unrepresentative of their true interests.

### **2.7.2 Environment for Innovation**

Academics and policymakers have very different conceptions of an environment that is instrumental to innovation. I refer to A30 here:

*“Innovation is very difficult to engineer. You’d have to have the climate for rather than something that you can specifically target. I think all academics try to be innovative in their research activities. But the job of an academic is not to go out and start companies. If I wanted to start a company or to make the next best laser or even become a billionaire, I would not be here. The reason I came to academia is because I wanted the freedom to pursue whatever intellectual pursuits I wanted to and at the same time train students to be smart in the field generally, so that if they wanted to they could go out and start companies.”*

Even in the knowledge economy context, academics do not consider it their jobs to start companies. Academics, in general, valorizes temporal and spatial autonomy and academic freedom. For them, creative pursuits like research and innovation should happen in an organic manner.

Policymakers emphasized the need for central planning. PM4 said:

*“We (government) have invested in building up the research capacity over the last few years. The focus as depicted in the latest RIE 2020 plan is to focus more on sectoral*

*strategies and outcomes as well as on innovation/commercialization efforts.”*

In fact, the official position of the Singaporean state, as stated by PM4, is that:

*“if we are to move towards a knowledge and innovation economy, we have to find ways to the create new innovation that has economic impact.”*

In the words of A4:

*“Once you start directing research, that is steering an economy in one direction, that is only going to work if you have a long term view. Researchers are the experts. They should be given complete freedom to do the kind of research that they want to do. Once you take that power of decision-making away from that, you are cutting down creativity and innovation.”*

### **2.7.3 Top-down and Bottom-up Approaches**

The government of Singapore has a clear sense of what it wants to achieve. In terms of innovation, it is the cornerstone on which the nation has to continue to build itself in order to retain competitiveness in the coming decades. As has been described before, this is evident by the five year plans of Singapore that first started in 1991 and the latest one that was released in January 2016 called the 'RIE2020'. The state has a top-down approach to innovation where-by it preselects areas of interest every five years and pours in funds and concentrated efforts into developing them. In the words of PM4:

*“(the state’s) goal is to build Singapore’s economy. Whether we do this internally with our public sector partners or encourage companies to setup activities in Singapore, the eventual goal is to build the economy and provide good jobs for Singaporeans. For this you need to understand that our government understands the gaps in our economy best and this is why our five-year plans are important.”*

This is in clear contrast with the ethos of academia. For most academics, innovation is a by-product of research. They are involved in research because of personal interest and are solely motivated by internal factors. A1 succinctly put it by reminding me that:

*“nobody joins this profession (academia) to earn money. I am in this because it allows me to pursue my curiosities”.*

Universities have a bottom-up approach to innovation and the academics enjoy that. In fact A22, upon being questioned on what kind of innovation support is required, said:

*“for me, if we mean innovation purely as something new, its autonomy. Academic labor is meant to be a certain kind of toil that is unique. If you read what Newton or Descartes wrote or Marie Curie they worked out in their backyard, hacking away at their craft for hours. That’s the ideal space for innovation, in my mind. It’s not fancy lighting or beautiful office spaces, those are all nice things. But autonomy, both temporal and spatial is key.”*

These are completely contrasting points of view. Another perspective on this was offered by an academic, A16. In Singapore, government is the main source of academic research funding and the changing policy systems dictate which areas of research gets funded.

*“[in Singapore] the government is the main source of funding. In US they have private sources of funding. Since many things in Singapore are done by top-down, the administration focuses on certain areas based on consulting that they receive and it filters down. Certain areas get funded, others don’t. As academics, we cannot constantly change our area of research to suit what the administration wants. The things the civil servants want to fund is based on projections. They are based on things that they know about. Research is based on trying to develop new things. I am not sure if the NRF or MOE knows what is going to be the next big thing in the next 10 years. For example, if Apple was funded by the Singapore government or Hello Kitty...they may not exist. Coz,*

*they will say who cares about cats? Or who wants to buy computers named after a fruit?"*

The implication here is that narrow policy focus might miss true innovations that can have a huge impact.

#### **2.7.4 The Five-Year Plans**

Since the implementation of the first five-year plan in 1991 to the latest in 2016, the state has sought to create value and exploit new economic opportunities. For the RIE2020 (Research, Innovation, and Enterprise 2020) that is to be implemented between 2016 and 2020, the government has set aside SGD 19 billion for research and development in four vertical domains viz. advanced manufacturing and engineering, health and biomedical sciences, services and digital economy, and urban solutions and sustainability. To achieve the set key performance indicators (KPI) in all these four domains, three key areas will be given highest priority: academic research, manpower, and innovation and enterprise.

The main issues that are plaguing Singapore today are an ageing and declining population, lack of diverse and sustainable sources of energy, and the need for more space for future development. The RIE2020 has been specifically created to tackle these problems.

There is increased focus on enhancing public-private partnership through existing infrastructure in the form of R&D labs and corporate labs at universities, research institutes, hospitals etc. There is also a call for more intensified inter-disciplinary research from university scientists to solve the complex problems that exist in society today. The government hopes to achieve this by over-funding research areas of national concern like the ones mentioned above and by setting up multi-disciplinary research centers at the public universities of Singapore like the Singapore Center on Environmental Life Science Engineering (SCELSE), the Mechanobiology Institute, Earth Observatory of Singapore (EOS), Centre for Quantum Technologies (CQT), Cancer Institute of Singapore (CSI), Centre for Ageing Research and Education (CARE), and the latest Ageing Research Institute for Society and Education (ARISE) and the Centre for Population Health Sciences (CePHaS).

As a result of such policies, not at all areas of research are equally funded. In the words of A11:

*“It is not all bad when my area of research is not one of Singapore’s peaks of excellence, as they call it. It encourages me to do interdisciplinary research actually. I don’t move to a completely new research. I may want to apply some of my research expertise to solve some new problems. Like I said, I have been in the research community of distributive stimulation and high performance computing system for a long time. This was in high demand when I moved to Singapore a few years ago, but not anymore. So I decided to do some collaborative projects from medical scientists on medical simulation etc. which have been ongoing since 2015.”*

And a contrasting point of view was given by A16:

*“I think also a breadth of funding calls. We need targeted funding calls. Today it’s too targeted. Write a proposal on water research. That’s fine. You are going to get a lot of proposals on water research. But you are also getting researchers who are not experts on water research competing with experts from overseas and you are going to end up with mediocre research results and a lot of money wasted. Rather ask an academic community, propose what you think is best. Then you will get students who are trained in areas of expertise that we already have.”*

This is an example of how national policies can backfire to produce unintended consequences.

## **2.8 Discussion**

This paper finds relevance in the innovation discourse that permeates Singapore today. The question of what innovation is, in Singapore is especially important. Mr. Ong Ye Kung, the Minister of Education, at the Lee Kuan Yew Centre for Innovative Cities International Roundtable on the Future of the Economy in January 24, 2017 said that:

*“We need to protect our sense of belonging that we are Singaporeans, and develop our unique Singapore identity. We are on an irreversible journey to pursue growth based on*

*productivity and innovation.*"<sup>2</sup>

The government sees innovation as an identity building and nation building activity in Singapore. In this context, it becomes essential that we know what the individuals who are engaged in this process perceives and understands what innovation is. In devising policies to foster and encourage innovation, there is some element of rationalizing and standardizing human activity and creativity into an administrable format. The danger is that only what is interesting to the policymaker is represented without an understanding of the true purpose or capacity of the people (Scott, 1998).

That there are different positions regarding innovation is clearly depicted. And the definition of innovation is closely tied to perceptions on how it should be evaluated too. This has important implications in policy design.

For academics, innovation is not a necessity at universities. Most of them do not consider their work to be innovative in the entrepreneurial sense of the term. So here innovation takes on a slightly narrow definition which is distinct from state/entrepreneur conceptualizations. The scientific or technical content of innovations are more important to academics. They accept that market/profit oriented notions of innovation can exist but that in the role of a university academic, knowledge production takes precedence. In spite of modern innovation literature considering this far too linear and R&D based (Massa and Testa, 2008), it is still a reality in academic circles. To be respected in academia, or to be peer-reviewed positively, theory-building is as important as practical applications. This is especially true for non-tenured, early-career academics as they are more prone to taking risks later in their careers.

It is interesting to note how academics draw a distinction between knowledge production and market-oriented innovations. The strong sense that knowledge cannot always be marketed or that what is being marketed is not necessarily knowledge is reflected upon by many academics throughout my fieldwork. That for an academic, there is a distinction between these two is to be noted.

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<sup>2</sup><https://www.moe.gov.sg/news/speeches/opening-address-by-mr-ong-ye-kung-minister-for-education-higher-education-and-skills-at-the-lee-kuan-yew-centre-for-innovative-cities-international-roundtable-on-the-future-of-the-economy>

In Singapore, the position of policymakers differ markedly from that of academics. The state of Singapore, for whom the policymakers speak, clearly identify the economic importance of innovations. The market orientation of innovations is well outlined in literature (Nelson and Rosenberg, 1993). They also ascribe important nation building and competition retaining responsibilities to it. Singapore is a self-proclaimed survivor and this tendency continues to be featured in the innovation policies as well. The nation has always focused its policies according to changes in global financial markets in a bid to stay competitive and Singapore attempts to transition into a knowledge-based economy with its policies enhancing innovation.

How does this compare to other national constructions of innovation? The Australian construction of innovation (Minister, 2004) prioritizes technoscience over arts and culture, and uses a similar narrative to that of Singapore in determining innovation to be the future of Australia. Italian policymakers conceptualizes innovation in narratives of dream and risk where the innovator is motivated to achieve his/her dreams by taking risks (Massa and Testa, 2008). The British governments 10-year national innovation plan released in 2001 also specifies the importance of individual creativity and culture:

*“forward to a future in which individual creative talent is given the support it needs from childhood to flourish; in which artists and cultural institutions are freed from bureaucratic controls; and in which freedom to explore and enjoy creativity and culture is available to all”* (Smith, 2001).

Singapore tends to avoid such “romantic” notions of innovation (Massa and Testa, 2008) even though extant literature exhorts the importance of psychological and motivational factors over economic ones as a reason for entrepreneurship and innovation (Baron, 1998; Volery et al., 1998).

While discussing the model of innovation they pursue, academics made a distinction between what is available and what is ideal. Ideally, academics want complete autonomy and the capacity to go where their research takes them. For academic research to be funded, there is a need to clearly identify the goals as well as potential outcomes of research. For some researchers, this counteracts the true purpose of innovation. At this

point, it is to be noted that the RIE2020 does assign 2.5 billion dollars (more than what the RIE2015 offered) for blue sky research aside from the 2.8 billion dollars promised for academic research. But the funding structures does not fully permit university faculty to take advantage of this. A common criticism leveled by the faculty are that the funding calls are too specific and it does not reflect the expertise of all researchers (Chapter 4).

So in reality, the academics pursue a “closed innovation” model where a formal ,linear process of innovation is pursued in research institutions or university labs without many opportunities for interactions with other members in the supply chain (Chesbrough, 2006). Today, open innovation models are preferred and disorder is inherent to this model with multiple actors. Increasingly, this is found to be more conducive for ground-breaking innovations (Chesbrough, 2006). To encourage such models, there should be integrated funding programs for multiple players in the network (Desbarats, 1999; Ragatz et al., 1997).

The policymakers maintain the necessity to fund research that are crucial to national needs and they have identified areas of concern that needs cutting-edge and innovative solutions. Singapore has always identified specific areas of national concern in its five-year Science & Technology (S&T) plans. It cannot be denied that Singapore has seen much success and development with central planning and strategy. In fact, Singapore ranks as the 6th most innovative country in the world according to the Global Innovation Index 2016 (Index, 2016). A closer inspection reveals that Singapore ranks number 1 in innovation input sub-index that shows aspects of national economy that enable innovation in the nation. And, yet Singapore is only ranked at number 20 in innovation outputs: both knowledge and creative. So clearly, the policy initiatives have not been completely successful. As revealed in this study, there are some definite areas of disconnect that needs to be dealt with.

## 2.9 Conclusion

This study highlights issues that arise in matters pertaining to innovation development when there are different stakeholders present. This is a contribution to a more refined conceptual understanding of how different social groups understand innovation. Without

making any judgments on who is right and wrong, the purpose of this study is to highlight the similarities and differences which can help in designing better innovation policies.

Traditional innovation indicators are strongly criticized by academics. With an increased role for universities to perform socially relevant research, it is important that academics' views are considered in developing new frameworks for innovation. Expectations from academics have evolved rapidly while evaluation measures remains that same. Policymakers have difficulty in adapting to new and emerging technologies and ideas.

Policymakers insist, and some academics agree, that innovation is a necessity. But there are still academics who believe that it is not necessary to be innovative to be a good educator. Reconciling both these missions of the university: education and research, is not easy in this scenario.

Pushing this analogy to innovation in Singapore, it does seem like the state is rationalizing and standardizing human creativity into an administrable format. Such social simplifications, ranging from the basics of statecraft like public health, political surveillance, welfare etc. to innovation today, represents what is interesting to the power wielding official. It doesn't necessarily depict the true purpose or capacity of its people (Scott, 1998).

Innovation is complex and as yet there is no grand theory to explain it. What this study reveals is that the complexity of innovation exists in the social space as well. This is important because perceptions shape behaviors and resolving differences is necessary towards achieving a theory to innovation. Long and stable relationships are mandatory between the various actors and institutions in any National System of Innovation (NSI) with shared visions and goals.



## Chapter 3

# Barriers to University-Industry Collaborations in Singapore

### 3.1 Introduction and Theoretical background: University Industry Linkages

Innovation in any national context is generally termed as a 'collective achievement' (Sharif and Tang, 2014) and this collective achievement requires the seamless participation of the triple-helix of innovation namely government, industry, and university (Hughes, 1993; Malerba, 2005). The triple-helix model of innovation (Etkowitz and Leydesdorff, 1997) outlines an increasingly important role for the university in the national innovation system (NIS). Governments are increasingly looking towards universities to play more important roles in the economy to retain competitiveness and to transform to knowledge-economies (Hatakenaka, 2004). Generation of high-quality research and teaching are the primary mission of universities but commercialization of said research is also contributing to their eminence in recent decades (Etkowitz and Leydesdorff, 1997). Thus, to stay relevant in national systems of innovation universities have developed a 'third mission' with a strong focus on technology transfer and by partnering with knowledge-users (Etkowitz et al., 2000; Florida and WM, 1999; Gulbrandsen and Slipersaeter, 2007).

Academic partnerships with industry have a long standing documented history with examples from German pharmaceutical industry and fertilizer industries in the 17th century (Etkowitz, 1983). But university industry linkages (UILs), as they are understood today, started around the late 1800s in Europe and around the same time in Harvard

University and Massachusetts Institute of Technology (MIT) in the United States of America (USA) (Shimshoni, 1970). Today, such research partnerships are accepted to be critical sources of competition in advanced economies like the US and in most of EU (Hagedoorn et al., 2000). Thus, in the last few decades UILs have increased in number tremendously and policymakers at national, regional, and international levels are trying to develop specific policy instruments to close gaps between academia and industry (O'Shea et al., 2008; Phan et al., 2006; Rothaermel et al., 2007; Valentín, 2000). In this paper, UILs refer to all aspects of engagement between universities and industries including and not limited to commercialization of academic knowledge involving patenting and licensing of inventions; academic entrepreneurship including creation of spin-offs; as well as research partnerships and collaborations with the profit sector mediated by the university or otherwise (Etzkowitz et al., 2000; Florida and WM, 1999).

The growing importance of UILs, rising demand for innovation and innovative products globally, evolution of university-industry collaborations into complex multi-organizational linkages in many countries, and UILs as a manifestation of national innovation or science and technology policies have led to massive amounts of research on this phenomenon and there is no scarcity of literature on UILs (Valentín, 2000). Specifically, the literature on UILs have a two-pronged focus: to study the motivations and benefits of UILs and to study the barriers to UILs. University-industry collaborations have been extensively studied in advanced industrialized economies in a number of studies (Bell, 1993; Matkin, 1990; Salisbury, 1993). In literature concerning barriers to UILs, there are two kinds of studies: qualitative or quantitative studies that outline barriers to UILs (Bonaccorsi and Piccaluga, 1994; Bowie, 1994; Boyle, 1986; Brannock and Denny, 1998; Burnham, 1997; Chiesa and Manzini, 1998; Gluck et al., 1987; Ingham and Mothe, 1998; Liyanage and Mitchell, 1994; Meyer-Krahmer and Schmoch, 1998; Nimtz et al., 1995; Oliver and Liebeskind, 1997; Samsom and Gurdon, 1993; Schmoch, 1997; Van Dierdonck et al., 1990; Wigand and Frankwick, 1989) as well as studies that propose ways to overcome them (Bonaccorsi and Piccaluga, 1994; Brannock and Denny, 1998; Liyanage and Mitchell, 1994; López-Martínez et al., 1994; Webster and Etzkowitz, 1991). In addition, Hounshell et al. (1996) and Rosenberg and Nelson (1994) extensively describes the historical contexts and evolution of UILs in advanced economies. A summary of the above research studies can be found in Table 3.1.

Table 3.1: Summary of Research on UILs

<b>STUDIES THAT OUTLINE BARRIERS TO UILS</b>	
Bonaccorsi and Piccaluga, 1994	Proposes a taxonomy of UILs
Bowie, 1994	Explores close linkages as a strategy to enable UILs
Burnham, 1997	Provides a checklist for successful partner selection in UILs
Chiesa and Manzini, 1998	Conceptualizes the organizational form of UILs
Gluck et al., 1987	UIL experience on graduate students are studied
Ingham and Mothe, 1998	Observes organizational learning processes in UILS
Meyer-Krahmer and Schmoch, 1998	Explores culture and cooperation in UILs in different technical fields
Oliver and Liebeskind, 1997	Explores implications of UILS in biotechnology
Samson and Gurdon, 1993	Studies spin-off companies in the UK and describes advantages and disadvantages to universities
<b>STUDIES THAT PROPOSE WAYS TO OVERCOME BARRIERS</b>	
Brannock and Denny, 1998	Provides basic guidelines to overcome common barriers
Liyanage and Mitchell, 1994	Outlines cultural and organizational issues in UILs
López-Martínez et al., 1994	Reconceptualizes motivations and barriers to UILs in Latin America
Webster and Etzkowitz, 1991	Explores barriers in the triple-helix in knowledge-based societies

All these studies have proven beyond doubt that university research is a major source of ideas and technology for industry in advanced countries (Wong et al., 1999). It is suggested that research on UILs in NIEs (newly industrialized economies) are still in its nascent stages (Wong et al., 1999). While the NIEs have seen impressive industrial growth in the last three decades, the linkages between tertiary educational institutions and industry have also grown. The socio-economic contexts of the newly developed Asian countries are different from the more developed Western counter-parts and thus there is

a need to extensively study such developments to address important gaps that exist and thereby improve systems. Technology management journals occasionally publish studies offering statistical evidence of university industry collaborations in East Asia. The Academic Corporate Nexus published a bibliography of such linkages in 250 countries over the world which has some references to NIEs in Asia (1996). An Asia Pacific Economic Corporation (APEC) study published in 1996 shows why such collaborations are important.

Chen (1994) provides a conceptual framework to understand the evolution of university-industry collaborations in Hong Kong. Lim and Hang (2003) conducted a similar study in Singapore that outlines the various research collaborations that exist here. Wong et al. (1999) and Chou (1993) have done studies that offer some statistical evidence on the role of the National University of Singapore in promoting university-industry collaborations in Singapore. Most of these studies are done from the perspective of the industry or from that of university administrators.

The aim of this chapter is to build on the existing literature and add to it with a study using mixed-sources of data on the barriers to university-industry collaborations in Singapore from the perspective of the academic faculty in public universities in Singapore. This study uses survey data as well as interviews to understand how academics in Singapore perceive barriers to UILs and how specific barriers play out in their everyday research. It also addresses disciplinary differences between academics and how this changes their perception of barriers. To the best of my knowledge, there are not yet published studies on NIEs or Singapore specifically, that discusses the how different academic faculty perceive barriers to UILs. This paper will address this gap in literature and offer key recommendations to public policy challenges that should be addressed for Singapore to achieve more university-industry linkages.

In spite of this proliferation of research, UILs still face significant challenges. It is generally well-established that university and industry have completely different institutional settings and norms (Tartari et al., 2012). There have been accounts of science as being ex-territorial to society (Polanyi, 2000) and Merton's (1973) description of institutional differences between the academia and industry still informs much of extant literature on barriers to UILs (Partha and David, 1994). Literature on UILs gives considerable

attention to how universities are increasingly taking charge of and driving these collaborations as well as the measurement and management of UILs. Academic perceptions of barriers to UILS and how they experience these barriers is less studied (Hall et al., 2001). Supporting UILs is central to innovation policy, and this lack of understanding of the academics, who are essentially the decision-makers of initiating UILs, is a serious obstacle to creation of effective policies.

This study considers the academic as the unit of analysis and takes two important aspects into consideration: the attitudes of academics on how they perceive UILs and barriers to it and the specific organizational context of the academic namely the university and school/department characteristics. Much attention has been paid to the differences between universities and industries and yet the attitudes of different academics' and how they perceive and experience barriers is still under-studied. While it is generally accepted that scientists and engineers in universities have different kinds of collaborations with industry, what is less explored is how such barriers impact their collaborations differently or similarly in their perception. So this paper addresses an additional question of how disciplinary and departmental differences figure in barriers to UILs.

## **3.2 Why Singapore?**

The level of economic development in Asian countries vary greatly and so does the focus of UILs with the most developed ones like Japan and Korea involved in creation of spin-offs, patenting to the least developed like Thailand and Laos involved in entrepreneurship education and business incubation services (Guimon, 2013). Singapore is one of the newly industrializing economies (NIEs) with the highest GDP growth in the period since 1940 to 2000 (Wong, 2006). Singapore is unique in this as it has been open to international competition since the 1960s and reached a high degree of industrial sophistication and became an anomaly in Asia that doesn't offer cheap labor. Hence, it was necessary for Singapore to transition into an innovation-driven model earlier than others in the region to stay competitive. This move to transforming to a knowledge-based economy happened started in the late-1990s and Singapore revamped its innovation policies to reflect this change (Wong and Singh, 2008). The trend has continued since 2000, with

Singapore achieving more growth and development. This success is due to Singapore identifying the need to shift to a knowledge-driven pattern of growth since its initial decades of development was driven by foreign-direct investments (FDI). This move to transforming to a knowledge-based economy happened started in the late-1990s and Singapore revamped its innovation policies to reflect this change (Wong and Singh, 2008).

The new course in Singapore's development focuses heavily on intellectual capital and commercialization to advance the economy. The university system in the nation is being paid special attention and is expected to play a huge role in value creation. Increasing prominence is laid on doing utilitarian research that is industry-driven, commercialization of technologies, creation of high-tech spin-offs, attraction of foreign talent and to build generations of entrepreneurial graduates (Wong et al., 2011, p. 165). Creation of an ecosystem where universities and industries collaborate to achieve these goals is an important aim for the Singaporean state. The two most established universities in the nation, Nanyang Technological University (NTU) and National University of Singapore (NUS), have industry liaison offices that were set-up to facilitate this process.

Singh and Wong identified four challenges that Singapore needs to overcome to be a truly knowledge-driven economy (2008). Singapore has been adept at using technologies but does not have the capabilities to be a technology creator. This is the result of high reliance on MNCs to boost the economy in Singapore's developing decades through 1970s and 1980s. Due to its small size and population, Singapore lacks sufficient talent to achieve critical mass in high-tech creation. Singapore is a stable and growing economy with less than 2% unemployment and this has created a non-entrepreneurship mindset in the citizenry and they are risk-averse (Wong et al., 2005). Finally, technology commercialization is still at its nascency and so is venture capitalization which were crucial reasons for the success of entrepreneurial cultures like those in Silicon Valley (Lee et al., 2000). Thus, the innovation policies since the 2000s were created specifically created to address these concerns.

While some other NIEs have followed suit, Singapore is interesting because of the huge proportion of foreign researchers who bring with them different research cultures. Within the social construction paradigm, this has serious implications for innovation capability of Singapore. I want to highlight this in my thesis.

This paper is timely in that it takes a closer look at the status of UILs in this context from an oft-overlooked perspective i.e. of the academic.

### **3.3 Research Questions**

The aim of this study was to gain a clear understanding of the barriers to university-industry linkages in Singapore from the perspective of academics. The following research questions are addressed:

1. What are the barriers to university-industry linkages in Singapore, from the academics' perspective?
2. How do basic scientists and engineers perceive these barriers differently?

### **3.4 Context of the Study**

#### **3.4.1 National Policy Framework for University-Industry Collaborations in Singapore**

Singapore's vision, since the early 2000s, is to transform its economy into a knowledge-based one. The state has set-up a dynamic and supportive infrastructure to enable this in the best possible way. Singapore has a vibrant academic landscape with public and private universities. The Ministry of Education (MOE), Ministry of Manpower (MOM) and Ministry of Trade and Industry (MTI) work closely with these institutions to enhance employability and livelihood. One of the arenas that the government is paying attention to is collaborations between universities and industries.

For this to be effective, intellectual property (IP) creation and its protection must be enhanced. Singapore follows the World Trade Organization's (WTO) Trade-Related Aspects of Intellectual Property Rights Agreement (TRIPS). The TRIPS is the most comprehensive multilateral agreement on IP and grants ownership and protection of IP created by anyone in a member country. Singapore is also a member of World Intellectual Property Organization (WIPO), the Paris Convention, the Berne Convention, the Madrid Protocol, the Budapest Treaty and the Patent Co-operation Treaty. Due to the nation's due diligence in matters related to IP, Singapore has been awarded 'Best IPR Protection

in Asia' by the Political and Economic Risk Consultancy (PERC) since 1997. Singapore is also the 'Top Country in Asia for IP protection' awarded by both the World Economic Forum and the Institute of Management Development.

There is an Intellectual Property Office (IPOS), under the Ministry of Law in Singapore that provides the infrastructure for creation and protection of IP. IPOS is involved in creating IP laws and implementing them, and it ensures a safe and secure IP environment in Singapore.

The Ministry of Trade and Industry (MTI) works towards economic development of Singapore and has two agencies: the Economic Development Board (EDB) and the Agency for Science Technology and Research (A\*STAR). While the EDB works holistically on national economic projects, the A\*STAR is responsible for nurturing talent at universities and supporting scientific research.

For National System of Innovation (NSI) development, Singapore's strategy has changed from developing operational capabilities in 1960s-1980s to a focus on process adaptive capability after the 1980s which led to innovative capability development in the 1990s (Wong 2011: 1661). To enable companies to pursue R&D in collaboration with universities, the government introduced a Research and Development Assistance Scheme (RDAS) in 1981. This scheme also allows for the training of skilled manpower for the R&D industry.

It is important to note that the government does not own the IP; instead the universities are given autonomy on deciding policies, strategies, and best practices. Thus, universities can decide how to handle the technology.

Singapore government devised the Research, Innovation and Enterprise 2015 (RIE2015) Plan to further boost R&D and to support the nation to become an innovative and entrepreneurial economy. One of the key themes of the RIE2015 is to foster greater synergies between researchers in the public and private sectors. An Industry Alignment Fund was also set up as a part of this to encourage these collaborations.

A scheme called Corp Lab@University was launched in 2013 by the National Research Foundation (NRF) which allows the establishment of corporate laboratories in universities. As a result, Rolls-Royce set up a lab in NTU and Keppel in NUS, in 2013, to enable the faculty and students to closely work with their respective R&Ds. The

autonomous universities are also given AU Technology Transfer Office Fund (AU TTO Fund) to facilitate strategic tie-ups with industry.

### **3.4.2 Autonomous Universities (AU) of Singapore**

The publicly funded higher education institutions of Singapore are autonomous universities (AU) that are corporatized under a board of trustees. They are free to make policy, strategy, and best-practices related to all aspects of its running. The AUs of Singapore are:

- Comprehensive Universities
  - a. National University of Singapore (NUS);
  - b. Nanyang Technological University (NTU);
- Business and Management Universities
  - c. Singapore Management University (SMU);
- Architecture, Engineering, Design & Technology
  - d. Singapore University of Technology and Design (SUTD);
- Practice-Oriented Degrees
  - e. Singapore Institute of Technology (SIT).

### **3.4.3 Industry Links of AUs**

#### **NUS**

NUS have set up laboratory collaborations on campus with companies like GE water, Keppel, Carl Zeiss; and established strong working relationships through Lean Launchpad@Singapore, an experiential learning programme which aims to foster entrepreneurial interests in researchers by educating them on the fundamentals of technology commercialization and start-up development. NUS's TechLaunch also aims to help students develop start-ups based on NUS technologies.

## **NTU**

NTU has set up Research Institutes for translational research, such as Nanyang Environment and Water Research Institute (NEWRI) and Energy Research Institute @ NTU (ERI@N) to forge links and draw industry partners and public bodies both locally and overseas. NTU has been successful in attracting technologically sophisticated MNCs to the campus, including industry leaders such as Rolls-Royce, BMW Group, Lockheed Martin, Johnson Matthey and ST Engineering.

## **SMU**

The DHL-SMU Green Transformation Lab (GTL) aims to enhance the advancement of sustainable logistics across the Asia-Pacific region and develop interdisciplinary solutions by bringing in technology know-how and innovative solutions to real-world challenges in logistics and supply chains.

## **SUTD**

SUTD runs several research centers and labs for research and industry collaborations such as the SUTD-MIT International Design Centre, and the Lee Kuan Yew Centre for Innovative Cities. In addition, SUTD and Jurong Town Corporation Cooperation for the Industrial Infrastructure and Innovation Centre aims to carry out research, development and demonstration projects to support Singapore's dynamic industrial landscape.

## **SIT**

SIT is active in the consortium for joint research, especially for new platform technology. SIT is leading and working with the five polytechnics and the InfoComm Development Authority of Singapore (IDA) for the sponsored Free App Development for Small and Medium Enterprises (SME AppStore). SIT also engages industry leaders through each phase in the programme development life cycle. Industry Advisory Committees are formed for each programme and the committee provides inputs on curriculum development to meet industry needs. An Enterprise and Innovation Hub is currently being established with the aim of promoting close industry ties between SIT and the Industry.

## 3.5 Methodology

This study combines both qualitative and quantitative research methods to provide a comprehensive picture of university-industry linkages in Singapore, from the academics' perspective. Tenured or tenure track STEM (Science, Technology, Engineering, and Mathematics) academics from two higher education institutions of Singapore, NTU and NUS, were targeted for the study. The key criteria for selecting the participants was direct knowledge of the university ecosystem of Singapore by having been members and subsequently university-industry linkages in Singapore. This paper brings together information from the Singapore Global Talent Research (SGTR) survey (Chou et al., 2017) as well as in-depth qualitative data providing a rich account of the informants' experiences which corroborates with country-wide survey results.

### 3.5.1 Singapore Global Talent Research Survey, 2016

The Singapore Global Talent Research (SGTR) survey , 2016 was conducted by Dr.Wang Jue and her research team from Nanyang Tehcnological University, Singapore (Chou et al., 2017). This study uses the data collected by this survey to fill the gaps in our understanding of university-industry linkages in Singapore (Chou et al., 2017).

2691 academics from NTU, NUS, and SMU were emailed to take part in the Singapore Global Talent Research survey (SGTR) and 707 responses were recorded. Of the 623 tenured/tenure-track respondents, 289 were STEM faculty from NTU and NUS (Fig. 3.1). All the surveyed STEM faculty did their PhD in the following disciplines and continue to work in similar or related areas: Engineering, Life Sciences, Medicine and Health Sciences, and Physical Sciences and Mathematics. Further, the respondents were divided into two groups: basic scientists(hereafter referred to simply as 'scientists') and engineers. The number of scientists surveyed in this study is 152 (52.59%) and they belong to the broad disciplinary areas of Life Sciences (38), Medicine and Health Sciences (29) and Physical Sciences and Mathematics (85). The number of respondents who identified as engineers are 137 (47.40%).

The SGTR survey has 10 sections in total with questions probing the views of researchers on their motivations to come and work in Singapore. Section 7 of the survey

looks at the researchers’ research activities in Singapore. Questions 7.4 and 7.6 are of relevance to this study. These questions ask the researchers to rate their level of activity in areas outside the university as well as perceived barriers to external collaborations on a five-point Likert scale (Fig. 3.2).

### 3.5.2 Interviews

The qualitative portion is the result of interviews conducted with 30 tenured or tenure-track academics from NTU and NUS, the two largest and established public universities in Singapore. Academics from Science, Technology, Engineering, and Mathematics (STEM) faculties were targeted for this study. The focus of the interviews was on collecting unique insights from academics that can clearly identify and clarify the phenomenon under study.

Non-probability sampling techniques were used, specifically convenience and snowball methods to identify the informants throughout the study. To establish initial contact, the informants were contacted via email. Over 200 academics from NTU and NUS

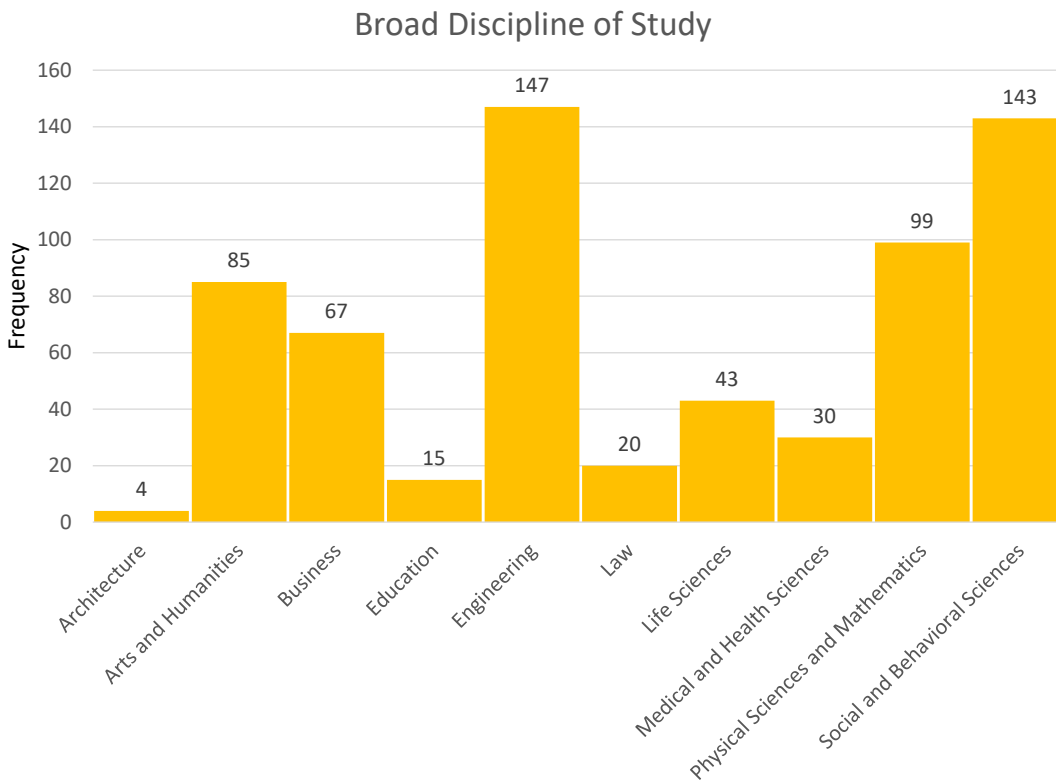


Figure 3.1: Broad discipline of study

7.4 During you stay in Singapore, how did you **perceive your level of activity** in terms of the following:

	Not active	Less active	Active	More active	Very active	Not Applicable
Consultancy - Paid (Government, NGOs, INGOs, companies)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Expert subject advice (media/government /NGOs/INGOs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Community outreach	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Serving on advisory boards	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Patent licensed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Setup companies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7.5 When working in Singapore, how important were the following reasons for your **potential collaboration** with businesses, government or non-profit organizations?

	Not at all important	Not very important	Somewhat important	Important	Crucial	Not Applicable
Learning about problems that are relevant for practical use	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Influencing policy, business practices	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Getting inspiration for research projects	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Access to resources (e.g. data, materials, or equipment)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Additional source of research income	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Additional source of personal income	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Increasing networks for future research grants	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recognition of my expertise outside of academia	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is part of my performance evaluation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 3.2: Singapore in the Global Talent Race Survey Questionnaire

were contacted and barring many replies expressing inability to take part in the study, 30 interviews were scheduled and conducted by the researcher. 4 of the interviewees belonged to NUS, 20 belonged to NTU and 6 of the faculty have concurrent appointments

at NTU and NUS. The interviews were conducted over a period of three months (March, April, and May) in 2016. The interviews were conducted in person and typically lasted anywhere between 30 minutes and 1 hour. The interview questionnaire is provided in Annex II.

Qualitative data analysis techniques were employed to organize as well as analyze the collected data (Miles and Huberman, 1994). The recorded interviews were transcribed by the researcher. And the transcripts were thematically analyzed to obtain unique and embedded perspectives of the academics (Braun and Clarke, 2006). As the first step, open coding of the transcripts was done to generate an initial list of themes. This was followed with axial coding to merge the themes together to create a smaller list of categories. Selective coding was finally done to interpret the data. The results reflect unique themes in the narratives of public university academics in Singapore on what motivates them to collaborate with industry and their perceived barriers to successful university-industry collaborations in the nation.

## **3.6 Analysis of Survey**

### **3.6.1 Characteristics of respondents**

The STEM faculty who took part in the survey had 152 basic scientists and 137 engineers. Their number of years of working in Singaporean universities ranged from less than 1 to maximum 9.

### **3.6.2 Level of Activity**

The level of activity of all STEM academics in Singapore is outlined in Table 3.2.

Around 48.96%, on average, of all surveyed STEM academics in Singapore reported to be in some kind of external collaboration. 45.36% of STEM academics are reportedly engaged in paid consultancy roles with governments, companies, or NGOs and INGOs. Around 3.93% indicated that they are 'very active' in consulting. 30.94% of all surveyed academics are involved in setting-up companies. Of this, 2.52% are 'very actively' involved. 61.37% of academics indicated they are serving on advisory boards of various organizations. 7.22% is actively engaged in this role. Only 39.5% of surveyed faculty

Table 3.2: Level of Activity

Activity	% Less Active to Very Active	% Very Active
Consultancy-Paid (Government, NGOs, INGOs, companies)	45.36	3.93
Setup companies	30.94	2.52
Serving on advisory boards	61.37	7.22
Patent licensed	39.50	2.90
Expert subject advice (media/government/NGOs/INGOs)	48.74	4.69
Community outreach	67.86	7.86

have licensed patents in NTU and NUS. 2.90% reported to be very active in patenting activities. 48.74% of surveyed faculty are actively giving expert subject advice to institutions. 4.69% are 'very active' in this role. 67.86%, the highest, are engaged in community outreach programs. 7.86% of faculty are 'very active' in community outreach.

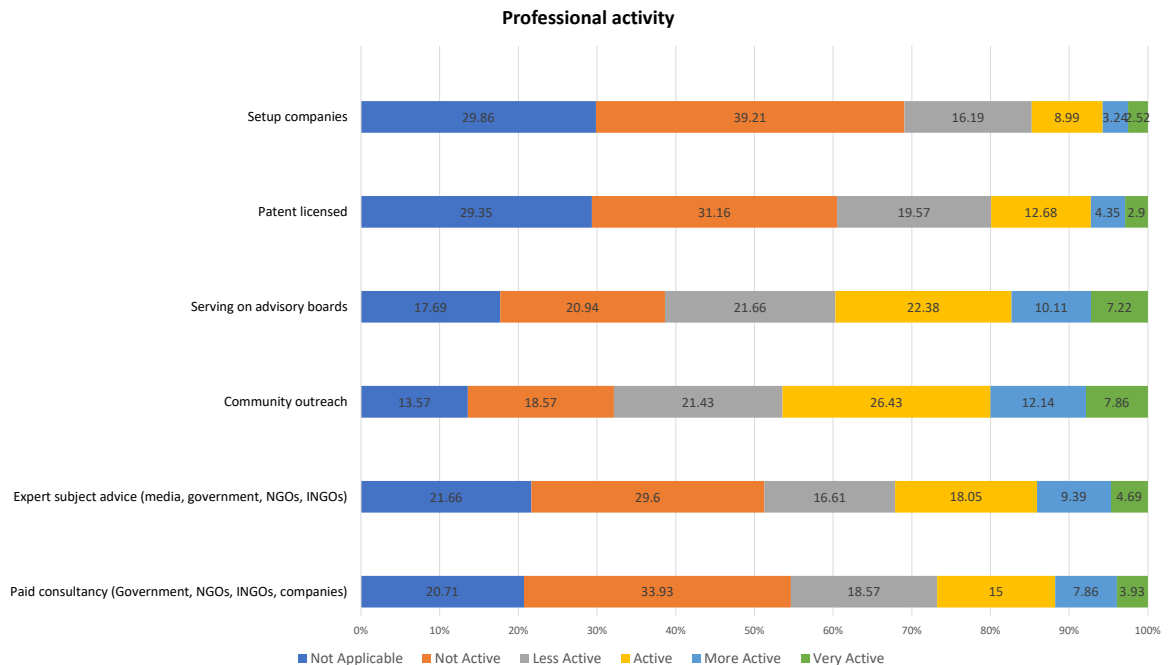


Figure 3.3: Level of professional activity of scientists and engineers

### 3.6.2.1 Activity Level of Scientists vs. Engineers

Figures 3.4 and 3.5 shows the frequency of level of activity as indicated by scientists and engineers in setting-up companies, licensing patents, serving on advisory boards, community outreach, giving expert subject advice and in consultancy roles.

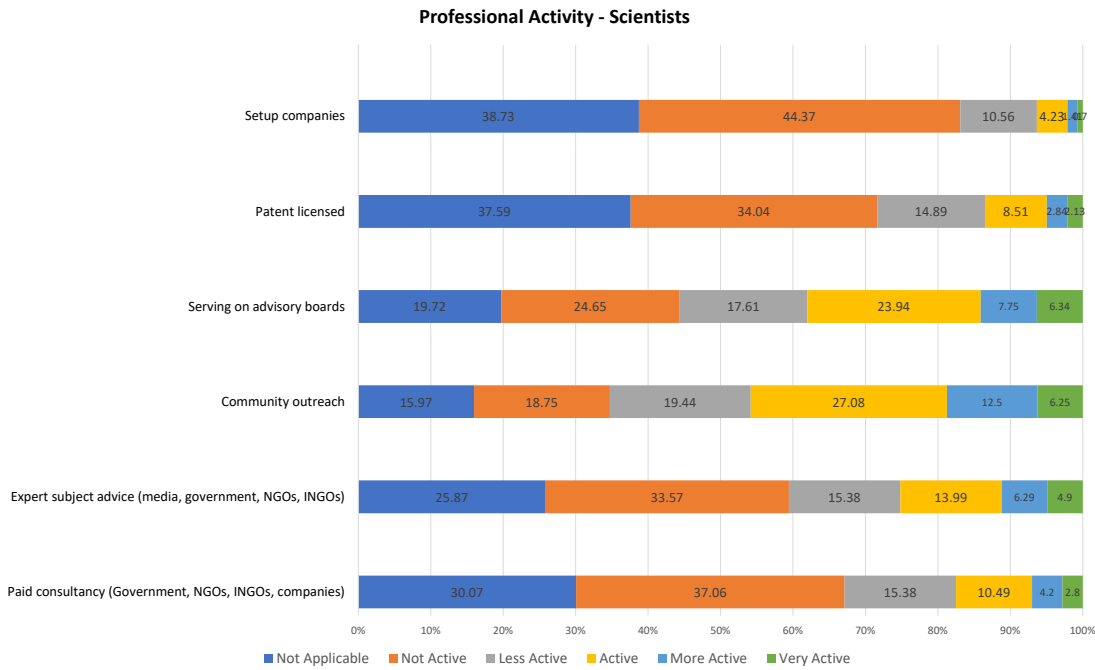


Figure 3.4: Level of professional activity of scientists

Table 3.3 shows the difference in level of activity for scientists and engineers. Engineers are more active than scientists in setting-up companies ( $p_i.001$ ), in licensing patents ( $p_i.001$ ) in paid consultant roles ( $p_i.001$ ) and in giving expert subject advice ( $p_i.05$ ). No significant differences were found between the groups for their level of activity in community outreach and service on advisory boards. When considered together, more than 60% of all respondents had some kind of relationship with external organizations.

### 3.6.3 Barriers to External Collaborations in Singapore

Eight common barriers to university-industry collaborations were identified from literature (Chou et al., 2017). On average 67.19% of all surveyed faculty indicated that the

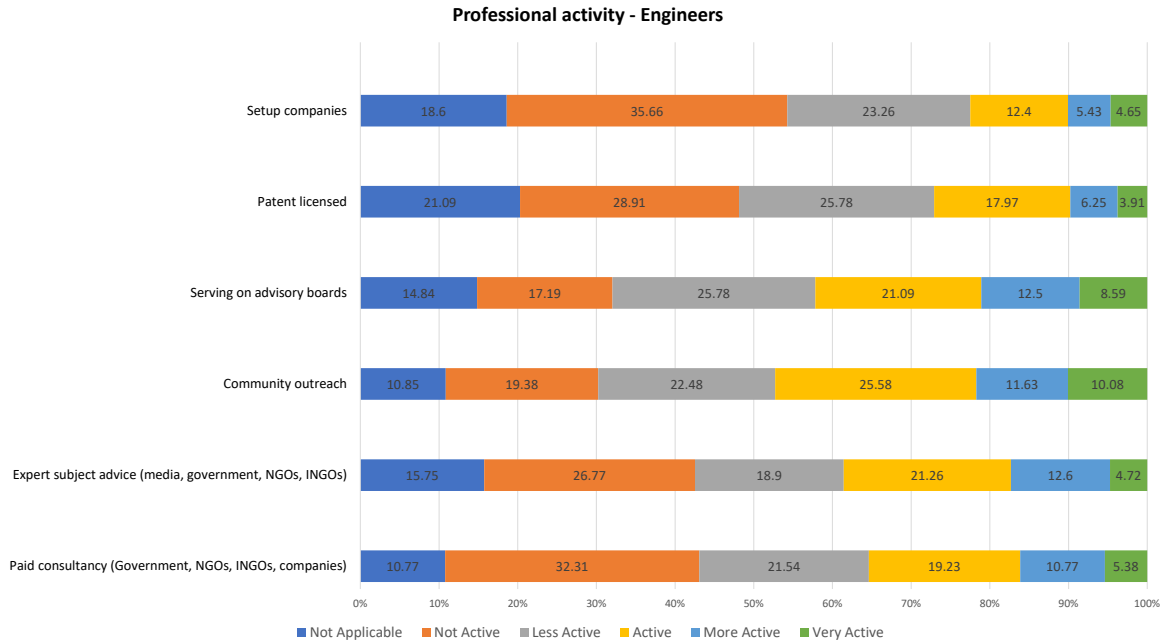


Figure 3.5: Level of professional activity of engineers

Table 3.3: Test of Significance for Professional Activity between Scientists and Engineers

Professional Activity	Mean score for scientists	Mean score for engineers	Difference	p-value
Set-up companies ( $N_s=142$ , $N_e=129$ )	0.87	1.64	0.77	0.00
Patents licensed ( $N_s=141$ , $N_e=128$ )	1.11	1.78	0.68	0.00
Serving on advisory boards ( $N_s=142$ , $N_e=128$ )	1.94	2.25	0.31	0.09
Community outreach ( $N_s=144$ , $N_e=129$ )	2.30	2.38	0.18	0.31
Expert subject advice ( $N_s=143$ , $N_e=127$ )	1.56	2.02	0.46	0.01
Consultancy-paid ( $N_s=143$ , $N_e=130$ )	1.30	2.03	0.73	0.00

$N_s$  = Number of scientists;  $N_e$  = Number of engineers

eight identified barriers had some role to play in their external collaborations. The responses of all STEM academics on how pertinent each of these eight barriers are is given in Fig. 3.6 below. Table. 3.4 gives a breakup of the same.

76.49% of surveyed faculty indicated that 'lack of university support' is a barrier to

Table 3.4: Barriers to University Industry Linkages in Singapore

<b>Barrier</b>	<b>% indicating Rarely to Always pertinent</b>	<b>% indicating Always pertinent</b>
Lack of university support for research with partners (e.g., admin support, procedures)	76.49	6.32
Lack of government support for research with partners (e.g. funding, regulations)	77.74	5.42
Difficulty in identifying suitable partners	84.65	6.36
Potential conflicts with partners regarding Intellectual Property Rights	72.55	2.50
Partners imposing delays in or restricting the dissemination of research results	68.05	4.43
Partners interested only in short term-oriented research	82.46	9.42
Lack of continuity in partners' research strategies and priorities	78.28	6.17
My area of research does not easily translate into partner interests or needs	78.28	5.19

their collaborations rarely to always. 13.81% found it not applicable and 9.70% identified it as not a barrier.

77.74% of surveyed faculty indicated that 'lack of government support' is a barrier to their collaborations rarely to always. 13.58% found it not applicable and 8.68% identified it as not a barrier.

84.65% of surveyed faculty indicated that 'difficulty in identifying suitable partners' is a barrier to their collaborations rarely to always. 11.99% found it not applicable and 3.37% identified it as not a barrier.

72.55% of surveyed faculty indicated that 'potential conflicts with partners regarding Intellectual Property Rights' is a barrier to their collaborations rarely to always. 18.42%

found it not applicable and 9.02% identified it as not a barrier.

68.05% of surveyed faculty indicated that 'partners imposing delays in or restricting the dissemination of research results' is a barrier to their collaborations rarely to always. 19.92% found it not applicable and 12.03% identified it as not a barrier.

82.46% of surveyed faculty indicated that 'partners interested only in short term-oriented research' is a barrier to their collaborations rarely to always. 21.73% found it not applicable and 10.38% identified it as not a barrier.

78.28% of surveyed faculty indicated that 'lack of continuity in partners' research strategies and priorities' is a barrier to their collaborations rarely to always. 11.94% found it not applicable and 5.60% identified it as not a barrier.

78.28% of surveyed faculty indicated that 'mismatch of research area' is a barrier to their collaborations rarely to always. 16.48% found it not applicable and 5.24% identified it as not a barrier.

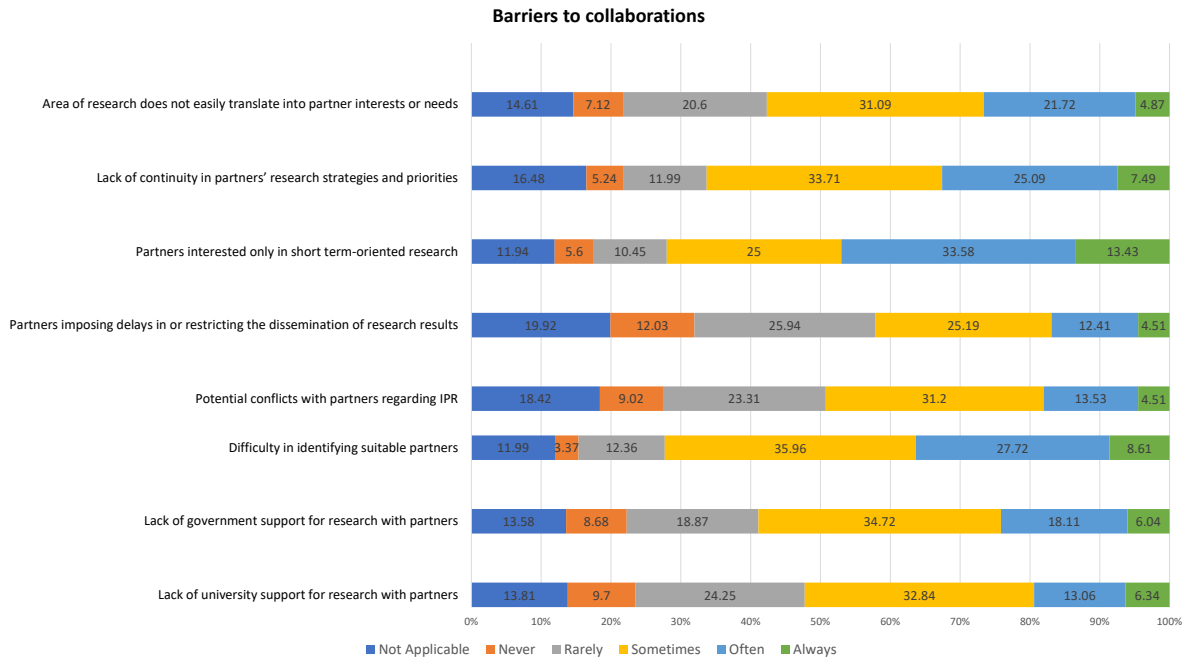


Figure 3.6: Barriers to collaborations in Singapore - Scientists and Engineers

### 3.6.3.1 Barriers as Perceived by Scientists vs. Engineers

Scientists and engineers varied in their responses to the perceived barriers. The following figures (Fig. 3.7, Fig. 3.8) show their responses.

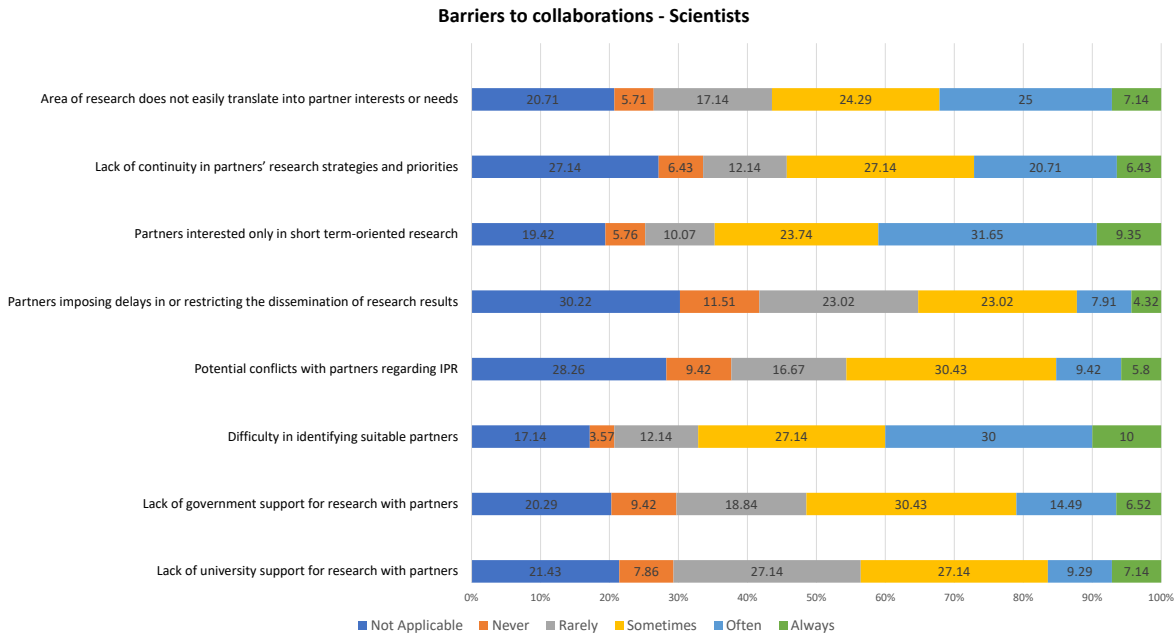


Figure 3.7: Barriers to collaborations in Singapore - Scientists

Table 3.5 shows how the two groups perceive barriers to UILs in Singapore. There are significant differences between how scientists and engineers perceive six of the eight barriers.

Engineers were significantly more likely than scientists to express lack of university support ( $p_i.05$ ); lack of government support ( $p_i.05$ ); IPR conflicts ( $p_i0.001$ ); partners interested only in short-term orientation of research ( $p_i.001$ ); and lack of continuity in partners' research strategies and priorities ( $p_i.001$ ) as barriers sometimes, often, or always in their collaborations.

There was no significant difference between scientists and engineers on two barriers: inability to translate area of research into partner interests and needs and difficulty in identifying suitable partners.

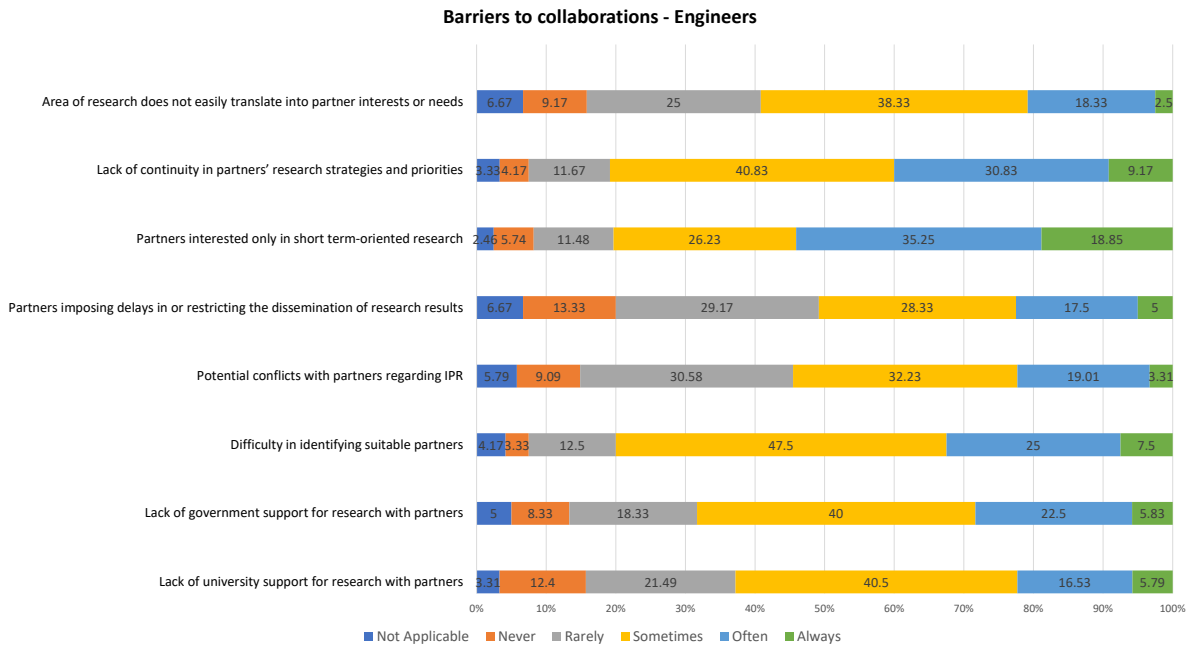


Figure 3.8: Barriers to collaborations in Singapore - Engineers

### 3.7 Analysis of Interviews

The aim of interviews with STEM academics from NTU and NUS were to provide in-depth description of how some of the barriers to university-industry linkages, as perceived by the academics', affect their daily lives. While the survey results showed how scientists and engineers in Singapore perceive the various barriers and its impact on their collaborations, the focus of the interviews were to unravel how these barriers play out in their academic realms. Using direct quotes and examples from professors in Singapore, this section gives a rich analysis of their collective lived realities.

Academia and industry are two classes of organizations with vastly different cultures. Direct transfer of knowledge between these two organizations is not easy to institutionalize (Foray, 2007). The following section reveal how academics perceive these differences and how it impacts their collaborations with industry in Singapore.

Lopez et al. identified and classified barriers to UILs into three: structural, institutional and individual (1994). While this paper follows this classification system to identify some of the barriers discussed by academics, overall I stay away from classifying

Table 3.5: Test of Significance for Barriers to UILs between Scientists &amp; Engineers

Barrier (no)	Mean Score for Scientists	Mean Score for Engineers	Difference	p-value
Lack of university support for research with partners ( $N_s=140$ , $N_e=121$ )	2.16	2.72	0.55	0.00
Lack of government support for research with partners ( $N_s=138$ , $N_e=120$ )	2.29	2.84	0.55	0.00
Difficulty in identifying suitable partners ( $N_s=140$ , $N_e=120$ )	2.79	3.08	0.29	0.09
Potential conflicts with partners regarding IPR ( $N_s=138$ , $N_e=121$ )	2.01	2.59	0.59	0.00
Partners imposing delays in or restricting the dissemination of research results ( $N_s=139$ , $N_e=120$ )	1.80	2.52	0.72	0.00
Partners interested only in short term-oriented research ( $N_s=139$ , $N_e=122$ )	2.71	3.43	0.72	0.00
Lack of continuity in partners' research strategies and priorities ( $N_s=140$ , $N_e=120$ )	2.27	3.19	0.92	0.00
Area of research does not easily translate into partner interests or needs ( $N_s=140$ , $N_e=120$ )	2.49	2.6	0.11	0.51

$N_s$  = number of scientists;  $N_e$  = number of engineers

them into groups. Most of these barriers have interconnected dimensions and sometimes they overlap in intricate patterns. Hence, the following section outlines unique perspectives on specific barriers faced by Singaporean academics and does not try to classify them.

### 3.7.1 Misaligned Goals of Academia and Industry

There is an inherent assumption amongst academics that monetary motivations matter while collaborating with industry. Academia is traditionally not a for-profit organization and it is revealed that this is an important factor for academics.

*"I am not a business man. I do not do research to make money. If I wanted to make money, then I would take up an industry job. Why would I stay in academia then? I came here to do exciting research. I like the flexibility the university system gives me to pursue research that is interesting to me. Whatever collaborations I do have with the*

*industry, is solely to increase the impact of my research. But the industry is a for-profit system. I cannot work along those objectives. So I am very careful about choosing who I partner with and what I get out of such partnerships.”* (Scientist, A6)

This sentiment also reveals that many academics continue to believe that making money is a primary reason to collaborate with industry.

Hardy et al. (1983) called universities ‘professional bureaucracies’ in that they are organizations where its members have a lot of flexibility in their professional activities if it benefits the university overall. Academic freedom and curiosity-driven research are major draws for researchers at universities (Lee, 1996). Preserving the fundamental mission of research and teaching while ensuring that knowledge produced can be translated to economic gains is not simple. Universities are traditionally not-for-profit and academic motivations are varied; usually not geared towards making money.

It is interesting to note here that the faculty (Scientist, A6) who provided the quote above is from a physical and mathematical science school. A study by Owen-Smith and Powell (2001) found that disciplinary differences contribute to this puzzle. Patents are high value generating in life-sciences as opposed to the physical sciences where they have generally low pay-offs and thus, researchers in life-sciences are more prone to patenting than others. Patenting is but just one form of UIL and this doesn’t sufficiently explain other related concerns that academics have.

Another academic (Engineer, A2) noted that:

*“Everyone forgets about students. Teaching is a very important part of my life. I want my graduate students to be involved in my projects. Whatever possible tie-up has come my way so far is so confidential that I’ve to separate it from the rest of my work. At this stage in my career, I want my whole lab to be involved in all the projects that I have”.*

Industry funded projects have clearly outlined scopes that doesn’t allow graduate students to get involved. Even if they do get involved, the projects are of short-term and confidentiality agreements does not allow publishing their work. This hinders faulty labs to work cohesively and many academics stay away from industry collaborations due to this.

This view was captured by a scientist (A13):

*“As an academic my research is long-term. I am not trying to find quick and easy solutions. My goal is to do ground-breaking research that can push frontiers. This takes a long time. Industry is usually focused on short-term projects. This doesn’t interest me. It also doesn’t allow me to involve my students in such projects. A PhD student typically needs 4-5 years to complete his work. Industry linkage does not work in such scenarios”.*

Clearly, the objectives of industry and university are different. One is to make money and the other is to produce knowledge. Unless a balance is struck between these two sectors, it will be hard to nurture collaborations.

### **3.7.2 Research Orientation**

Industry research is aimed at solving immediate problems or improving products (Chia, 1999). This is in contrast with university research where knowledge production takes precedence and this can take many years depending on the scope of the project. Since training students is an integral part of an academics’ job, it adds to the problem.

A life-sciences professor (A14) explained a related issue:

*“Much of what I do is blue-sky research. I cannot always guarantee that it will work. But if it works then it can have tremendous market applications. Sometimes I want to collaborate with industry but here (in Singapore) I find it very hard to form collaborations with this flexibility. I have previous experience in the US where it was possible but the industry sector in Singapore doesn’t really allow me to do it.”*

This also alludes to the difference in orientation of both institutions generally and specifically to Singapore. The constitution of industry sector in Singapore contributes to this. This is discussed elaborately in the following sections.

### **3.7.3 Discriminate Reward System**

Academic 16 (engineer) said:

*“We are not a profit or perish model which is how the industry works. We are a publish and perish model. Sometimes, due to tech transfer agreements or patents, we cannot publish the research that we do in collaboration with industry. So, this is a deterrent*

*to me at this stage in my career. To get tenure, I am evaluated based on peer-reviewed publications. Perhaps, once I am tenured I would be more prone to such collaborations”.*

This is complicit with lifecycle theories in academia which postulates that junior researchers are more keen on building their reputation in academia before branching out for external collaborations (Stephan and Levin, 1992; Zuckerman and Merton, 1972). In Singapore, both NUS and NTU has clearly outlined policies regarding Intellectual Property Rights (IPR)<sup>1</sup>. Royalty sharing and monetary rewards are used to incentivize researchers to commercialize their research. Such policies presuppose that researchers are motivated solely by money. This is an impediment as academic entrepreneurship is still not a primary criterion for tenure-ship awards. For many young academics, this is a barrier to forming UIIs.

### **3.7.4 Nature and Size of Industries**

In 1965, when Singapore broke away from the Malaya Federation it was as Mr. Lee Kuan Yew put it “an economical, geographical, and political absurdity” without any natural resource, industry, or hinterland. The government made a strategic decision to attract global multinational companies to invest in Singapore and thereby achieved impressive economic growth in a short fifty years. Bringing in foreign direct investments (FDI) was a major thrust of the industrial policies of Singapore. It was only around the 2000s that the Singaporean government started to turn focus to knowledge outputs and this is reflected in the innovation policies of this period. This is strongly reflected in the nature and size of industries in the nation. The Singaporean economy is made-up of services and ownership of dwellings (73.9%) and industry (26.4%) accounts for the rest.

One academic (Engineer, A25) noted:

*“Most of the MNCs in Singapore are branch offices that deal with marketing and sales. They don’t have big R&D facilities here. That is a problem to us because small firms don’t have enough resources to set-up meaningful collaborations.”*

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<sup>1</sup>IP guidelines for academic entrepreneurship is provided by NUS Enterprise (<http://enterprise.nus.edu.sg/technology-commercialisation/for-researchers/faq-and-policies-for-pis>) and NTUitive (<http://www.ntuitive.sg/policy-on-intellectual-property>)

The overwhelming majority of the industry sector, aside from the service sector, is constituted of manufacturing companies followed by construction and then utilities. Most of the top MNCs in Singapore focus on developing marketing and sales and see Singapore as a hub for expanding across the South-East Asia region. What this means is that they do not have a focused R&D division set-up in Singapore. This is a serious obstacle to sustained research collaborations with the universities here.

#### 3.7.4.1 Industry Profile of Singapore

Singapore's emphasis on MNCs and government-linked companies (GLCs) to kick start its economic growth and industrialization meant that the domestic small and medium sized enterprises (SME) did not develop in the same pace. After five decades of growth, the SME sector remains largely underdeveloped. This is in direct contrast with other NIEs in the region like Hong Kong, South Korea, and Taiwan. So how does this impact academic research?

One professor (Engineer, A19) noted:

*“When we try to innovate, for example, new instrument or new techniques...we need a lot of help. Basically, the economy of Singapore has been developing by asking foreign companies to come here, but these companies will never move their headquarters or R&D to Singapore. So certain skills are not sufficient in Singapore and in the case of US or Japan or Europe, and the reason why there are many new instruments or many new techniques coming out of these countries is very clear. These countries have a lot of small family owned factories...We must ask the small factory to make 1 or 2 small stuff for these things and then when there's trouble, and then we have to ask them to update it. And we must keep repeating that and it's very difficult to find that kind of price in Singapore. And so that's the difficult part and another part is that if we try to commercialize instrument, its actually very difficult. So if I really want to develop instrument and sell it I don't think I'm going to work in Singapore.”*

Another engineering faculty, A4 said:

*“I am working in medical-imaging devices. So, (some MNCs that I could collaborate with) could be GE, Philips, Siemens, and none of these companies have research facility*

STRUCTURE OF ECONOMY	Nominal Value Added (% Share)	Real Growth (%)
<b>TOTAL</b>	<b>100.0</b>	<b>2.0</b>
<b>Goods Producing Industries</b>	<b>26.4</b>	<b>-3.4</b>
Manufacturing	19.8	-5.2
Construction	5.2	2.5
Utilities	1.4	1.2
Other Goods Industries	0.0	-3.6
<b>Services Producing Industries</b>	<b>69.2</b>	<b>3.4</b>
Wholesale & Retail Trade	15.6	6.1
Transportation & Storage	7.4	0.0
Accommodation & Food Services	2.1	0.2
Information & Communications	4.2	4.2
Finance & Insurance	12.6	5.3
Business Services	15.5	1.5
Other Services Industries	11.7	1.6
<b>Ownership of Dwellings</b>	<b>4.3</b>	<b>5.0</b>

Figure 3.9: Industry profile of Singapore (MTI, 2016)

*in Singapore. So there is no natural attraction happening. So if they come and they are in Singapore, I think it could help to collaborate and build things together.”*

*“The medical-imaging devices’ entry barrier is very high. So it’s very difficult or I generally haven’t seen many start-up companies come in because you need a huge investment in the beginning to start a company. Unlike maybe software companies, chemical companies, they need much smaller scale of investment to start with. So that’s another in the entry-level area from the industry point of view. It’s not easy to find a start-up company working in these areas.”*

It was only in 1988 that the state came up with the SME Master Plan to revitalize the fledgling sector and by 2003 it was concluded by the Ministerial Committee on Research and Development (MCRD) that more sustained efforts will be required to develop the SME sector (Chia, 1999). Some of these efforts have paid off with the contribution of the SME to total enterprise value increasing from 30% in the 1990s to 58% in 2010 (OECD, 2013). In 2010, a committee appointed by the government to set strategies for driving the economy called the Economic Strategies Committee (ESC) identified the SME sector as a key player to promote innovative productivity. Singapore is set to double the number of local SMEs by 2020 (OECD, 2013). But so far, the academics are not reaping the benefits of it.

A related issue of industry maturity was brought up by a professor (A13) in an engineering school:

*“Industries in Singapore are not at the level where they value academic research. I mean, companies in the US clearly see value in collaborating with academics. They have mature R&D departments’ set-up within these companies and they see value in investing in R&D. Companies in Singapore are just not there yet. In fact, companies that are doing it here are pretty much multi nationals whose headquarters are based in US or Europe. They just have an Asia branch that does this. But if you look at an intrinsically Singaporean company, an SME, they rarely come up with a research agenda. They have small problems that need solutions but this is just a consulting gig for people like us (academics). I keep getting emails asking for somebody who can solve plumbing problems in an underwater sewage system. This can be done in six months. It’s not a new problem that academics that use their expertise to solve. There is no building of new knowledge here.”*

Industry maturity is another major factor that decides how extensively they want to focus on research and what kinds of research and development. The MNC focus on sales and marketing and the still growing SME sector doesn’t provide for a lot of opportunities for the university academics that are at the same time interesting as well as advances their research.

It is established that longer term collaborations in the form of joint projects or public-private partnerships with periodical re-contracts lead to stronger innovative capacities

(Koschatzky and Stahlecker, 2010). SMEs are less visible from universities and have more difficulty optimizing their research and collaboration needs (Foyer, 2007). Hence, specific policy instruments need to be put in place to help SMEs overcome their absorptive capacity problems.

### **3.8 Discussion**

The surveys clearly indicate that different academics experience the barriers differently. Scientists and engineers have significant variation in which barriers impact UILs more. Hence, it is imperative to understand that single policy formulations will not work across all disciplines.

The results also comply with much of what is known about barriers to UILs globally. The individual and institutional factors apply to academics in Singapore still. While there has been indication of boundary blurring between academia and industry in certain geographic locations or sectors (Shapin, 1996), it still exists in Singapore.

It is already well established that senior academics are more likely to engage with industry than junior faculty (Boardman, 2008; Boardman and Corley, 2008; Bozeman and Gaughan, 2007). The current study confirms this in the Singapore context. It would be desirable to get young academics to engage more with industry. The perks of more money through royalties or consulting fees is not motivating them to engage more. Job security is of utmost importance and young academics want tenure before making risky moves. The way forward is to change evaluation structures for tenure and to add an extra parameter of external engagement. It is a simplistic solution, that poses dangers of generalizing academics over all disciplines and thus changing the face of the university. So further analysis needs to be made on how this can be resolved.

To be specific to Singapore, the nature and size of industries here poses a rather big obstacle to UILs. Targeted policy instruments should be in place to develop the SME sector and to attract more MNCs to do R&D in Singapore.

### **3.9 Conclusion**

*“Academics, what we do is come up with ideas. We can do prototyping. But at the end if something has to go to the product level, the industry has to come in. Because we don’t*

*have infrastructure to do what the industry is doing. Otherwise we will basically become an industry. So in the entire innovation process, industry has a role, academia has a role. And it is the best interest that everybody come together.”*

Borrowing from A4, this quote succinctly clarifies the different roles of academia and industry and why these two entities need to come together for true innovation.

This study contributes to a more succinct understanding of the micro-foundations of the entrepreneurial university (Jain et al., 2009). Understanding how individual academics perceive barriers to university-industry collaborations is crucial to develop clarity on organizational as well as societal aspects of the entrepreneurial university. While interactions between the two realms continue to be beneficial, undue emphasis on enhancing collaborations often overlook the issues that academics face in setting-up such collaborations.

This paper contributes to the emerging literature on informal aspects of university-industry collaborations (D’este and Perkmann, 2011; Grimpe and Fier, 2010; Link et al., 2007). Most of the published studies on UILs tend to focus on the measurable aspects of it like extent of patenting, licensing, entrepreneurship and how barriers affect academic productivity in these terms (D’este and Perkmann, 2011). There have been some notable exceptions that have explored academic attitudes towards UILs (Martinelli et al., 2008; Meyer-Krahmer and Schmoch, 1998; Perkmann and Walsh, 2008; Ponomariov, 2008) and this paper adds to it exposes the soft side of barriers to UILs by exploring academic beliefs and perceptions.

The results show that the conception of the entrepreneurial university in Singapore has not addressed all the complex issues in UILs. This paper, in illuminating some of the gaps that exist, will be resourceful for streamlining policies for enhancing UILs.

# Chapter 4

## University Funding and Innovation in Singapore

### 4.1 Introduction and Theoretical Framework

This paper focuses on the recent developments in academic research funding in Singapore. The post-World War II rationale for supporting university research was simple. University research was treated as a public good and academic quality was expected to increase with increased funding. This led to an increase in the number of universities and number of faculty and enrolled students. The linear model of innovation was topical in the succeeding decades which stated that basic research leads to applied research to development and finally innovation. Hence, governments were justified in investing in future welfare by funding university research. Since 1945, university systems have underwent massive changes all over the world due to budget constraints as well as debates regarding their true purpose in modern societies (Geuna, 1999, p.88). While teaching remains to be a primary mission, universities as public institutions are slowly transforming into specific service providers. University services are bought by governments, corporations, research institutions, development organizations etc. (Geuna, 1999). As a result, there are wide-ranging debates on the issue of public resource-allocation for university research.

Funding systems have also changed drastically globally and how universities adapt to such changes is of topical interest. This has been studied in the context of the UK, EU and the USA. The global south has been largely ignored so far. In this context, this paper

attempts to study this- i.e. how a specific group of institutions viz public universities in Singapore respond to the specific funding systems that exists in Singapore and how Singaporean academics perceive them. Singapore is an interesting case-study as it has a highly market-oriented university systems and there is an evident push towards the more utilitarian or applied research on the part of the government which funds almost 90% of academic research in the state. With mission-oriented innovation policies, Singapore has firmly situated itself as a leader in most global innovation indices. The university eco-system of Singapore also has rigorous expectations placed on them to help drive Singapore towards a knowledge-based economy. Gaining a better understanding of how academics in Singapore perceive and deal with the present funding systems will open up debate and discussion on the evolution of universities in the South East Asian region.

This chapter is organized as follows. The first section will give an overview of the changing university funding in Singapore. This is followed by an analysis of qualitative interview data with academics in public universities in Singapore on what their perceived gaps in the funding systems are, and how this impacts academic research.

## **4.2 The Singapore Context**

### **4.2.1 Funding Landscape of Singapore**

The publicly-funded universities of Singapore are considered to be vital players in the national systems of innovation and the Singaporean government is committed to the continued development of the two missions of these universities, i.e., generation of knowledge and creation of skilled manpower.

A Steering Committee was established in April, 1999 to oversee the governance and funding of the two largest publicly-funded universities of Singapore viz. National University of Singapore (NUS) and Nanyang Technological University (NTU). The committee did a University Governance and Funding (UGF) review to ensure that university governance policies, funding structures, and staff management was aligned with the universities' mission and vision. Following this, the goal to become world-class universities was born and it was suggested that both NUS and NTU should be given more autonomy, but with greater accountability. The Ministry of Education (MOE) continued to

set the policy parameters for higher education and an external review process was set up every three years to complement the universities' internal review process, which is covered under the Quality Assurance Framework for Universities (QAFU). The plan to diversify funding sources from the MOE to industry, alumni, and other wider sources was also set in motion. A new remuneration system was also introduced for the faculty with basic and variable components to reflect performance, market relativities, and other responsibilities. The basic pay of Assistant Professors was increased by 20% and staff development and leadership trainings were made mandatory.

By 2003, it was proposed to have a new higher education landscape in Singapore by the Committee to Review the University Sector and Graduate Manpower Planning. NUS was recommended to expand into a multi-campus set-up, and it was decided to develop NTU from a technological university into a more comprehensive one with different schools dedicated to various engineering disciplines. The Singapore Management University (SMU), which was established in 2000, continued its expansion. In 2003, 21% of the primary one cohort entered into tertiary education in a publicly-funded university and these expansion efforts were aimed at increasing that to 25% (MOE, 2016).

In 2002, the Economic Development Board (EDB) of Singapore started the 'Global Schoolhouse Initiative' as a means to attract global brand universities to establish their campuses in Singapore. The primary goal with this initiative was to attract 150,000 foreign students to Singapore by 2015 who will continue to live in and contribute foreign revenue to the Singaporean economy as employees and entrepreneurs and thereby, raise the education sector contribution to GDP from 1.9% to 5% (MTI, 2015). In 2006, the Research, Innovation, and Enterprise Council (RIEC) approved the Campus for Research Excellence and Technological Enterprise (CREATE)-an international collaboration of universities for research on four peaks of excellence viz. human systems, energy systems, environmental systems and urban systems (CREATE, 2015). The universities that are currently a part of this alliance include Swiss Federal Institute of Technology (ETH), Massachusetts Institute of Technology, Technical University of Munich, Hebrew University of Jerusalem, Ben-Gurion University, University of California, Berkeley, Peking University, Shanghai Jiao Tong University, and Cambridge University.

Building on the 2000 UGF review, a review of the University Autonomy, Governance and Funding (UAGF) was done in 2004 by a Steering Committee chaired by the then

2nd Permanent Secretary to Education. The goal was to grant more autonomy to the public universities in Singapore so that they can respond to the growing needs to attract the best international students and faculty. As a part of this, the Deputy Prime Minister and Coordinating Minister for Security and Defence visited three universities in the USA with a delegation to study their internal and external administration and the issue of university autonomy. The universities that were chosen were Massachusetts Institute of Technology (private), the University of Virginia (UVA) and the University of Michigan at Ann Arbor (UM) (both public). The primary purpose was to understand how autonomy is practiced by universities in the US, and how accountability works given the level of autonomy.

Private universities in the US, like MIT, have total autonomy on matters of admission standards, student enrollment, tuition fees, financial and human resource policies. They work independently of state and federal governments and the only overlap is for competitively-won research grants, federal loans, state scholarships and affirmative action groups. On the other hand, for public universities, state control is exerted in varying degrees. UVA follows state policies on student allotment, procurement, personnel, tuition fee structure, etc. On the other end of the spectrum is UM with autonomy on all aspects of governance. The passing of the “Restructured Higher Education Financial and Administrative Operations Act” in 2005 allowed UVA to move towards a ‘Chartered University’ model with support from the state but with more autonomy on internal policies.

The internal governance of all universities is maintained by a Board of Trustees, key administrative staff, and an involved faculty. MIT has a 79 member board called the MIT Corporation; UVA has a 16 member Board of Visitors; and UM has the 9 membered Regents. The Singaporean delegation was particularly impressed and would later implement this home-side. As stewards to university development, the board of trustees is actively involved in fund-raising. Other hallmark features were clear delegation of responsibilities and open lines of communication between trustees, university faculty and leadership. They saw a merging of top-down and bottom-up approaches with clear directions set at the top with open ears for ideas at the bottom. Outreach to alumni, industry, and larger society are also key features.

The main sources of funding for all three universities are tuition fees and private money from endowments and gifts. State funding constitutes less than half of their

resources and this grants them valuable internal autonomy. Financial autonomy also allows them to issue bonds for projects, and to hire top faculty from across the world. The financial aid system is very effective and every student is individually assessed for her needs, while the admissions are needs-blind.

### 4.2.2 Funding Agencies of Singapore

The research funding landscape in Singapore is competitive with the Ministry of Education (MOE) administering foundational-research funding for research at the four research-intensive autonomous universities (AUs) viz. Nanyang Technological University (NTU), National University of Singapore (NUS), Singapore Management University (SMU), and Singapore University of Technology and Design (SUTD). There are other competitive research grants available for translational research from agencies like National Research Foundation (NRF), A\*Star (Agency for Science and Technology Research) and the National University Hospital (NUH).

The main funding agencies of Singapore are:

- Ministry of Education (MOE)
- National Research Foundation (NRF)
- Agency for Science, Technology, and Research (A\*STAR)
- Ministry of Defence/Defence Science Organization (MINDEF/DSO)

#### **Ministry of Education (MOE)**

The MOE in Singapore oversees all education-related institutions from primary schools, Institute of Technical Education, polytechnics and universities in the nation and develops education policies, curriculum, pedagogy, and assessment.

The Academic Research Funding (AcRF) administered competitively by the MOE aims to advance knowledge-based research in the four autonomous universities in Singapore. It comprises of three tiers.

- AcRF Tier 1 provides core institutional funding for research projects under two authorities: University Research Committee (URC) and Faculty Research Committee (FRC). Under the FRC, research projects budgeted below S\$180,000 for Sciences and Engineering clusters, and S\$150,000 for Humanities cluster are funded. Under the URC, research projects valued between S\$180,000 to S\$250,000 is funded in both Science and Engineering as well as Pure Mathematics and Statistics. It is administered competitively to full-time faculty of the AUs.
- AcRF Tier 2 is also a competitively administered grant for research projects with a total project value between S\$500,000 to S\$ 1 million over a three-year duration, for all disciplines including Sciences and Engineering, Humanities, Pure Mathematics and Statistics .
- AcRF Tier 3 is the largest research grant from the MOE and it funds high-impact and multi-disciplinary research and has two schemes. Type A has a funding cap of S\$ 10 million and Type B has a funding cap of S\$ 25 million, both spread over five years.
- The MOE Tertiary Education Research Fund (TRF) was set up to promote research in education and pedagogy and encourages innovative teaching and learning programs.

### **National Research Foundation (NRF)**

The NRF was founded on January 1, 2006 as a special division in the Prime Minister's office. It is the NRF that is responsible for overseeing all policies and projects for developing the nation's research and development. The NRF also acts as the secretariat to the Research, Innovation, and Enterprise Council (RIEC) which advises the Singapore Cabinet on research and innovation policy design. The NRF mission as outlined by the organization follows (NRF, 2016):

- “Developing policies, plans and strategies for research, innovation and enterprise;
- Funding initiatives that strengthen research and scientific capabilities, and achieve economic and national impact;

- Building up R&D capabilities and capacities through nurturing our people and attracting foreign researchers and scientists; and
- Coordinating the research agenda of different agencies to transform Singapore into a knowledge-intensive, innovative and entrepreneurial economy.”

The National Research Foundation (NRF) is the other major funder in Singapore and the Research Innovation Enterprise Plan (RIE) 2015 allocated S\$ 5 billion to achieve its missions. It has been upped to S\$ 10 million by the RIE 2020 and public researchers in Singapore have to compete for that in the next four years. NRF has four main schemes for public research funding in Singapore.

- The Singapore NRF Fellowship is for early-career, researchers of all nationalities to carry out independent research for up to S\$ 3 million in Singapore over a period of five years. The awardees will also be offered tenure-track faculty positions at NTU, NUS, A\*STAR, SMU, SUTD, Temasek Life-sciences Laboratory (TLL), or Duke-NUS Medical School.
- The NRF Investigatorship is for mid-career researchers with a proven track record in Singapore to perform high-risk research. The funds can go up to S\$ 3 million for a period of three years.
- The NRF Competitive Research Programme (CRP) encourages multi-disciplinary research based on use-inspired basic research with an impact on Singapore’s areas of concerns. It aims to enhance collaborations between complementary research teams in the nation. Eighty projects have been awarded the CRP since its inception in 2007 and the funds are available in different packages up to a period of five years.
- The Science of Research, Innovation and Enterprise Programme supports Singaporean faculty to in performing evidence-based policy oriented research in the areas of innovation and enterprise. It was launched recently in 2014 and six projects have been awarded so far to tenure-track faculty from NTU and NUS.
- The Science of Learning grant supports short-term, small sized awards, with the aim of developing full proposals. Launched in 2015, the grant is tenable for 3-5 years.

- The Central Gap Fund is open to faculty from the IHLs, as well as scientists from local hospitals and labs, and business developers. It is aimed at funding translational research and creation of products. The award is up to S\$ 750k, for a period of two years.
- The Returning Singaporean Scientists Scheme is for Singaporean scientists established overseas to return to the home land and to pursue their research here.

### **Agency for Science, Technology, and Research (A\*STAR)**

A\*STAR's key mission is to drive economic growth and create jobs by advancing scientific discovery and technological innovation. By partnering with the public and private sectors, A\*STAR endeavors to (A\*STAR, 2017) :

- “integrating our capabilities to create impact with Multi-National Corporations and Globally Competitive Companies;
- partnering Local Enterprises for productivity and gearing them for growth; and
- nurturing R&D-driven Start-ups by seeding for surprises and shaping for success.”

A\*STAR provides competitive grants for scientists and engineers in various research institutes, hospitals as well as universities in Singapore. The major funding programs are: Bilateral Joint Research Grant Calls (International), Translational Clinical Research Partnership (TCRP) Grant Call for Duke-NUS/Singhealth Academic Local Programme (ACP), A\*STAR Joint Council Visiting Investigatorship Programme Grant, and Funding for A\*STAR Joint Council Workshops.

In addition to these, the RIE202 has entrusted A\*STAR to implement for important national funding programs namely AME Individual Research Grants (AME IRG), AME Programmatic Funds, IAF-PP and IAF-Industry Collaboration Projects (IAF-ICP). There are also other funding programs under the Biomedical Research Council (BMRC), and the Science and Engineering Research Council (SEC).

### **Ministry of Defence/Defence Science Organization (DSO)**

DSO is Singapore's national organization for defence R&D. The DSO works to develop technologies to ensure national security. DSO funds a post-doctoral fellowship program with NTU called Nanyang-DSO Postdoctoral Fellowship. MINDEF has a larger funding program of up to S\$ 600,000 called the Defence Innovative Research Program which is available to investigators from NTU and NUS.

### **4.2.3 Changing Rationale for Funding and RIE2020**

The MOE convened a Committee on University Education Pathways Beyond 2015 (CUEP) after the 2012 review of universities. The purpose of this committee was to diversify the university landscape and to provide new opportunities for faculty and students. Three policy thrusts were suggested and all future policy frameworks are to be analyzed in terms of economic relevance, quality education and cost-effectiveness.

All education provided by the universities in Singapore should be economically relevant, as well as sustainable. In other words, while there is a need to increase publicly-funded cohort participation rate (CPR), doing so without providing jobs for all graduates will be a burden on Singapore. So this policy thrust emphasizes the need to be prudent in increasing CPR as a result of learning from countries like Denmark and Finland, whose high CPRs can only be sustained by higher taxation of citizens. In addition, Singapore is also careful to align intake in various disciplines according to the manpower requirements of the economy. While bio-medical sciences remain a priority, social sciences or humanities is relegated down the list as job opportunities are relatively lesser for graduates from such disciplines. Ensuring good employment outcomes takes precedence here.

Provision of high quality higher education is the second policy thrust. National University of Singapore (NUS), the Nanyang Technological University (NTU) and the Singapore Management University (SMU) are internationally recognized universities whose ranks rise every year in the world ranking indices for universities. The newer institutions are being groomed to rise to the same standards and international partners are being chosen for Singapore university of Technology and Design (SUTD), Singapore Institute of Technology (SIT) etc.

Providing cost-effective higher education remains as an important policy consideration. The Singaporean government is consciously increasing CPR while ensuring that the Singaporean economy will get return investments.

#### 4.2.4 The Universities, Today

*“3.13 Both NUS and NTU welcome corporatisation and see it as a necessary step to accelerate the mindset change among the faculty, staff, students and alumni. As corporate entities, the universities will have a greater impetus to be self-reliant and catalyse a profound change in culture.”* (MOE, 2005)

NTU and NUS were established as statutory boards under the NTU Act and NUS Act respectively. As statutory boards, they were under the Ministry of Education (MOE) and followed Civil Service rules for all governance aspects. SMU was established as a private company under the Companies Act and enjoys more autonomy than the other universities but still held accountable to the Private Institutions Management Framework (PRIMF).

After the 2005 review, NTU and NUS were transformed into corporatized autonomous universities under the Companies Act. With this move, all the regulations imposed by the MOE on them were removed and as corporate entities, like SMU, greater autonomy and flexibility in matters of internal and external governance were allowed. This move was expected to engender a culture change in the running of the universities, with all responsibility to be shouldered by the stakeholders, and not the government of Singapore.

A new relationship was born between the state and the universities. The scope of autonomy to be enjoyed by NTU and NUS were outlined under five clauses in the Steering Committee report. University governance will be in the hands of the university Councils (board of trustees) and leadership. The government of Singapore will be the primary source of funding for NTU, NUS, and SMU and the universities should seek industry funding and other private endowments. NUS and NTU were given leeway to choose 10% of their student intake according to independent criteria, with the rest to be according to MOE regulations. The National Manpower Council (NMC) will set targets for manpower in specific areas of focus but increasing flexibility will be granted to the universities to admit foreign talent. NUS and NTU have complete autonomy

in matters regarding human resource hiring, remuneration, and benefits. The MOE also set up the Quality Assurance Framework for Universities (QAFU) according to which the universities conducts internal reviews which are then assessed by an external committee under the MOE. It also outlines the funding parameters and deliverables that the universities must follow.

### 4.3 Research Question and Methodology

The goal of this study is to understand how academics in Singapore experience and produce outputs from the various funding programs that are available to them. This is closely tied to the question of innovation and enterprise in the nation, as this has been expressly identified as the goal for universities, by the Singaporean state in its various 5-year plans. On a tangential line, it explores notions of academic autonomy and how this plays in producing innovations.

The data for this study comes mainly from archival research and interviews. The national archives of Singapore were scoured to yield various policy documents, government papers, and government statistics published by various agencies of the Singaporean government, mainly the MOE, A\*STAR, EDB, and NRF. Literary analysis of these documents were done to provide a comprehensive picture of the funding programs of Singapore, the main agencies of funding, and the rationale for university funding in the city-state.

In the next stage, interviews were done with tenured and tenure-track professors from the two autonomous universities of Singapore: NTU and NUS. A non-probabilistic sampling method was used and the professors were invited to take part in the interview via email. They were chosen from the engineering, science and social science and humanities schools to get the perception of all kinds of academics.

30 interviews were conducted in total, with 22 interviewees belonging to NTU and 8 to NUS. Of the 22 interviewees from NTU, 5 identified themselves as social scientists, and the rest belonged to various science and engineering schools. The 8 interviewees from NUS all belonged to science and engineering fields. The interviews were semi-structured with open-ended questions and they lasted anywhere between 30 minutes to 1 hour. The

guide to the interview questionnaire is provided in Annex II. All the interviews, except two, were conducted in person, on the respective university campuses and mostly inside the faculty offices. One interview with a faculty from NTU was telephonic and another one from NUS was via email.

## 4.4 Academics as Actors in the NSI of Singapore

This section analyses how academics in Singapore understand and perceive the funding systems of Singapore. It details what the positives and negatives are, from the academics' perspective.

### 4.4.1 The Positives of Singapore's Funding System

#### Efficient Systems of Support at NTU and NUS

The universities, NTU and NUS, have emerged to accommodate the varying needs of a multi-disciplinary and international faculty. Both the universities have Research Support Offices (RSO) to cater to the needs of the faculty by giving them administrative support for applying for grants.

The grant calls from the major funding agencies of Singapore viz. MOE, NRF, A\*STAR, MINDEF are advertised via email across all schools and divisions. Timely reminders are sent before each deadline. The offices also collect the application materials from the faculty and submits it to the funding agency after providing their input on it.

Faculty A8 said:

*“So the process (funding application) goes through the university channel. They help us by announcing where the funding is coming from and we can submit the paper (application bundle) to them, and then they go through the paperwork, and then they also go through a pre-selection or pre-screening of the proposal. And then they forward it for us. So in a way, we get total admin support.”*

Faculty A5 added:

*“I write most of the grants myself. So what I get is administrative checking. Effectively just making sure that if the grant call requires five or six components that we satisfy all of them. That is pretty much the administrative help that I get. It's mostly a check process*

*rather than a help process. They are basically making sure that I have all the forms that need to be done.”*

The faculty are appreciative of this support in both universities.

### **Availability of Research Grants**

The Singaporean government began its focus on R&D in Singapore in 1991 and set-up the National Science and Technology Board (NSTB) to fulfill this purpose. The first five-year national technology plan was framed by the NSTB and the government set aside SGD \$2 billion to transform the state into a hub for science and technology in the years leading up to 1995. For the second five-year technology plan from 1996-2000, the R&D investment doubled to SGD \$4 billion and an intense focus was placed on growing the biomedical sector alongside Engineering, Electronics and Chemicals initiatives. The Singaporean economy grew several fold with these plans and SGD \$6 billion was budgeted for 2001 to 2005, and a further SGD \$13.5 billion for the 2006 to 2010 periods.

In the 2010s these five-year plans underwent a re-branding and are now called the Research, Innovation, and Enterprise (RIE) plans. The RIE2015 allocated SGD 16 billion to enhance research, innovation, and enterprise. In the latest RIE2020, the government has allocated SGD 19 billion, an amount that is close to 1% of the national GDP. It’s an 18% jump from the RIE2015 and is the largest budget till date.

This availability of research grants is clearly felt by the foreign as well as local researcher population of Singapore and they often quote it as a reason for choosing Singapore as a desirable location for them.

In the words of A14:

*“The funding situation for science in Singapore is very good compared to say the US. There is a lot of money that is available for not that many people. The success rates for grant funding is very high. I think its between 20-50% and its like 8-10% in the US now for comparable grants. So there is no long term viability as a scientist I feel unless you are very fortunate. The same applies to Europe.”*

And A18 concurred:

*“(One of the) strengths of Singapore is that we have funding. I believe that if you write a good proposal, you can still get funded in practically diverse areas of research.”*

This makes Singapore, together with its infrastructure and global appeal, a very attractive destination for top talent from all over the world.

## 4.4.2 The Negatives of Singapore’s Funding System

### Misaligned Goals

Funding agencies in Singapore have definite goals that are aligned with national level policies. As a result, academic research grants are also available to realize those goals. It is not always easy for all faculty to get their research funded. As academic A33 said:

*“(One type of funding that is required) which is for a researcher who has an idea and wants to make a project. The level of this, the availability of these (white space funds) calls is too small, way too small for the level of people that we have.”*

The academic funds available to public university faculty in Singapore have clearly identified goals. This is slightly problematic in the context of a knowledge-economy driven by innovation.

Academics want a more flexible funding system. A4 explains this in the following manner:

*“One of the things for innovation is that, again, you don’t know the solution. So doing all these things beforehand is a waste of time and may not be productive. Because if I exactly knew I need ‘n’ number of things, ‘y’ number of days, it’s not really research then. Because you know everything. So the Singapore system actually pushes for these things: very much categorized and budgeted exactly. And I don’t think that’s the right approach because it’s too micro-management. It should be more flexible. Don’t put too many administrative barriers. Like if I want to introduce an item ‘x’ or budget an item ‘y’, there are like 5 forms to fill. I think they should just remove this because it is counterproductive.”*

One academic, A11, points out that the approach to innovation is very different for academics and funding agencies. This inherently stems from the fact that these two

groups of actors define innovation differently.

*“I tend to apply for the MOE academic research funds, which tend to be slightly more aligned with basic research. Traditionally, it has been the case. It’s kind of a bit like the NSF grant in the United States and the MOE academic research fund is supposed to be distributed with a very broad mandate of academic quality. I don’t know how much you are aware of this, but it seems like they are trying to push more towards applied, real-world thing and away from this fundamental scientific interest. Usually the way I align my interest is simply that I apply for funding where the grant is aligned with my own kind of value, what I value. What kinds of innovation I personally value. But a little bit of ambiguity in this whole grant proposal exercise. Scientists always try to prompt certain things in the grant proposals and funding agencies like it when you give them a lot of details about what you are going to do. But if you already know what you are going to do, then usually it’s not that innovative. So this is fine for kind of almost venture capital-like scenarios where a professional may already have a very concrete idea in mind and has already planned everything out, and he just needs a very expensive piece of equipment and he applies for the fund. And the innovation lies in actually realizing the idea. That is the innovation. But applying the grant for the original idea itself, is much more of a tricky situation and it does not fit in well with this grant proposal infrastructure that we in Singapore and across the world have developed, where the problem is coming up with the idea in the first place.”*

### **Lack of Engagement with Academics in Singapore**

A main concern for a lot of my interviewees is the lack of engagement of the Ministry of Education or National Research Foundation (the main funding agencies of Singapore) with the local academics. A11 reflects on this by comparing Singapore to the United States of America:

*“If you want to compare how the funding agencies in the United States works, for example the NSF or the DOE, there are actual PHD recipients on their staffs, multiple*

*ones, they have actual teams, they also get work groups or scientists that are drawn from leading universities to sit in their communities. Of course, they recuse themselves when their friends come up for evaluation. But there is actually a deep engagement with the (local) academic community in order to build this expertise for evaluating grants. Basically, in there you have both in-house expertise and de-drawn expertise from the academic committee. Contrast that with Singapore, how does Singapore handle grant applications? We have a crippling reliance on fixed high-level committees or scientists.”*

Peer review is the most important evaluator for most academics. Internal evaluation of their own work, for academics, is done based on how well published their papers are or how much of an interest it garners in the niche areas that they work in.

Whether an application to a research grant gets approved or not, the consensus among faculty is that they do not understand how the funding agency evaluates their project. This stems from their lack of engagement with local academics. The funding agencies of Singapore usually refer to a high level committee of international experts while making such decisions, or so we are made to understand. As one academic, A13, said:

*“The feedback system is lacking. I was rejected for Tier 2 grant for what I thought was a good enough proposal. If I had received proper suggestions then I would’ve resubmitted an improved proposal. But I did not receive any aside from a couple of cursory statements about the KPIs of the grant. I do not find this helpful.”*

On a related note, A16 said:

*“How can a committee of international experts judge the true potential of my work? Even they are not experts on everything. I would be happier if my Dean (of the school) evaluated my proposal. Or even academics from my niche field. The irony is that even Einstein wouldn’t be funded by any agency today.”*

A31 attempts to explain this problem in the Singapore context:

*“...because Singapore is a small community, getting objective reviews, of scientific reviews of the proposals, from the funding agencies are very tied, tied down by the number of reviewers available on certain fields. And without those objective reviewers sometimes the evaluation process might not be the most objective. Because you don't have experts in those areas right? So there are mechanism to involve international panels but there are, you can't keep taping on experts for every types of project calls. That's done in selective cases only. So again this is to do with the size of the country and the number of people here.”*

### **Standards of Evaluation**

Academics and departments and universities are evaluated on the basis of scientific production. Traditionally evaluation and comparison of academics are done via peer-review and bibliometric indicators (Van Raan, 2000). In fact, bibliometric indicators are the practical instrument that is used by most governmental organizations and research/higher secondary institutions to gauge the performance of its employees (Orr, 2004). Bibliometric indicators include research output (number of publications per unit), research profile (publications per field), scientific impact or citations, and evidence of research collaborations in the form of co-authorship (Aksnes and Taxt, 2004).

How does this tally when the goal is innovation and enterprise? In the words of A11:

*“In science, people often are subject to pressures to do things for the sake of doing them. Short term irrelevant innovation is prioritized for long-term risky and more beneficial innovations. There is no easy way to combat this problem. (The work that goes into such innovations) doesn't show up in bibliometric analysis.*

*Top Ivy League schools in the US are also subject to such pressures. But academic departments are willing to push back against this and take risks and support quality innovation over superficial standards. E.g.: a department chairman based on their scientific judgment, extending tenure support for a colleague who is working on something really important but is just not yet showing up on bibliometrics.*

*Classic example: Kenneth Wilson who won the Nobel was not awarded tenure at Cornell University initially but only upon the intervention by department chair. So to*

*encourage deep innovation there is a need to trust departmental leadership and at the same time the leadership should be uncorrupted, impartial and have expertise.”*

So the academics have a feeling that while innovation is expected of them, they are not evaluated for true innovation and creativity but instead on other factors. This needs to be corrected or can be huge impediment to true progress.

Relatedly, all types of academics regardless of the discipline they belong to are evaluated by the same factors mentioned above. This risks the danger of promoting certain disciplines over others. For example, A24 said:

*“As a social scientist, I don’t need millions of dollars to do my research. I just need a few 1000 dollars to complete most projects. So I am really not motivated to apply for the big Tier 1 or 2 grants. But the problem is that, if I don’t acquire these funds then my tenure will be affected. It’s really something that de-motivates me. I wish the school could provide a small fund that can be sustained over many years for researchers like myself. Because these big grants don’t really make sense for me.”*

### **Narrow Scope of Funds and Short-term Orientation**

Since the implementation of the first five-year plan in 1991 to the latest in 2016, the state has sought to create value and exploit new economic opportunities. For the RIE2020 (Research, Innovation, and Enterprise 2020) that is to be implemented between 2016 and 2020, the government has set aside SGD 19 billion for research and development in four vertical domains viz. advanced manufacturing and engineering, health and biomedical sciences, services and digital economy, and urban solutions and sustainability. To achieve the set key performance indicators (KPI) in all these four domains, three key areas will be given highest priority: academic research, manpower, and innovation and enterprise.

The main issues that are plaguing Singapore today are an ageing and declining population, lack of diverse and sustainable sources of energy, and the need for more space for future development. The RIE2020 has been specifically created to tackle these problems.

There is increased focus on enhancing public-private partnership through existing infrastructure in the form of R&D labs and corporate labs at universities, research institutes, hospitals etc. There is also a call for more intensified inter-disciplinary research from university scientists to solve the complex problems that exist in society today. The government hopes to achieve this by over-funding research areas of national concern like the ones mentioned above and by setting up multi-disciplinary research centers at the public universities of Singapore like the Singapore Center on Environmental Life Science Engineering (SCELSE), the Mechanobiology Institute, Earth Observatory of Singapore (EOS), Centre for Quantum Technologies (CQT), Cancer Institute of Singapore (CSI), Centre for Ageing Research and Education (CARE), and the latest Ageing Research Institute for Society and Education (ARISE) and the Centre for Population Health Sciences (CePHaS).

What are some consequences of these policies? An academic (A4) sums up their experience in the quote below.

*“For example, let’s say some funding agency’s interest is cancer. Even though our initial goal was not in cancer, but because there is money available, we think of our work. ‘Okay, can this be useful in cancer?’. So I am actually retrospectively trying to fit my work into that problem, and that happens all the time. Which there are both good and bad things. I mean there is no clear answer whether someone should do that or not do that. But like I said, we need money. So whichever field that there is money, people move to that field.”*

So it definitely gives the impression that Singapore’s innovation policies are encouraging academics to do multi-disciplinary research and initiating new collaborations.

But here is an example of how this is not the case always. A contrasting point of view was given by A7. It is common knowledge that funding calls in Singapore is highly targeted. There is a need for a breadth of funds. Using the example of funding calls for water research, A7 says:

*“...You are going to get a lot of proposals on water research (once the calls are out). But you are also getting researchers who are not experts on water research competing with experts from overseas and you are going to end up with mediocre research results and a lot of money wasted. Rather ask an academic community, propose what you think is best. Then you will get students who are trained in areas of expertise that we already have.”*

This is an example of how national policies can backfire to produce unintended consequences. Narrowing the scope of funds poses the danger of mediocre research and an unsatisfied academia. In the first case, the policy seems to be having its intended consequence i.e. more inter-disciplinary research. But it is evident from the next case that the academics of Singapore are capable of producing higher quality research but not able to reach their full potential.

Another point of view was offered by A34:

*“10 years ago when I started my career in Singapore, I wanted to do inter-disciplinary research with some academics from the humanities and social sciences (A34 belongs to a highly creative engineering field). I proposed a very interesting topic of research and submitted a grant proposal, but it got rejected. Now, 10 years later, I find that it is a very popular area of research in Singapore and there are many grants for it.”*

This exemplifies of how focused policies can miss the mark on what could be truly innovative. When the breadth of focus is too narrow, sometimes the bureaucrats are not able to identify truly exceptional research that is outside their purview.

Another problem that academics voice with these policies is that they are not long-term. Faculty A4 discusses this:

*“One (of the weaknesses of funding) is (that they are) very short-term. To foster innovation, you need to spend some time. So I find the time spent are short, and the goals shift very quickly. It’s like 3 years, you want to do something, 3 years again, you change it. I think for good innovation, you need long-term planning. That is something I feel may be lacking in Singapore. Very short-term goal-oriented.”*

A5 talks about the impact this has on personal academic research:

*“Because in Singapore, things move pretty quickly and they change very rapidly as well. So sometimes you would find that what they would call ‘focus areas’ or ‘hot areas’, five years later, they are not hot anymore. To me, I can’t change. I’m not a chameleon to change my research area because someone deems it good enough or not good enough. To me, what I do is important. People just need to have the maturity to realize that an academic institution or any research institution for that matter, you have faculty doing different kinds of work. Just because nanosciences is a hot field, doesn’t mean every single person in the world should be doing nanoscience. I do my work because I love doing what I do, and that’s basically it. I’m going to send my ideas for funding. Whether you fund it or not, that’s really up to you.”*

Finally another academic A31 explains how improper balance between short-term and long-term funding visions can hamper innovation and how academics navigate this conundrum.

*“Not every innovation leads to the desired outcome in a short run. Short run as within 3 years, within 5 years even. So depending on the nature of the work some will need more nurturing. (For most funds) the granting period are only 3- 5 years. And if it needs more nurturing, how will the funding agencies know it’s going in the right direction or not? Firstly it might not even get funded if it needs long term nurturing. Because a big thing in research funding is to see what will be the outcome or deliverables and not everything has outcomes or deliverables. So how do they do long term strong research? So everybody to be practical, they take long term goals, they split it into short term goals. So now, not all short term goals can be linked up or not all types of long term projects will be broken down into short term things, which might be fundable. But the short term objectives might not be fundable, because the big picture which is the basis for that is not there yet. So that’s the downside.”*

## 4.5 Discussion

The above reveals how academics perceive the changes undergoing to the funding structures and identifies some important gaps between university and state. While these perceptions are interesting on their own, what impact does this have on higher education in Singapore overall? In this section, I will have a broader discussion of some of the implications.

### 4.5.1 Weakening Excellence

Funding systems play an important role in giving a structure to the process of innovation that ensues within it. It is evident from the policies and funding programmes available in Singapore that the state is keen on encouraging excellence in research and innovation. The Singaporean state sees great value in multi-disciplinary research and identifies it as an important source of innovation. And, innovation is the answer to a sustainable, future with greater liveability (Ministry of Trade and Industry Singapore, 2010).

From the interviews we know that the Competitive Research Programme or the Central Gap Fund has encouraged some Singaporean researchers to branch out and seek collaborations in an attempt to utilize the available resources. Researchers, upon their own admission, talks about mediocre results that hits the key performance indicators (KPI) but doesn't truly count as knowledge produced. The faculty agrees that granting performance does not equal excellence and yet, they are trying to enhance grant success. So the focus is not so much on the research itself, rather on securing the best grants available. Securing high research grants works positively towards academics' tenure process as well as peer status within departments. This leads to a skewed system where the research takes a back-seat.

This is an example of how a carefully crafted policy can backfire. A study on the Canadian university system shows how individual faculty's grant success leads to higher funding to the parent university which becomes problematic to the quality of research (Graham, 2000). So this has implications for the larger university ecosystem in Singapore. Policies need to address this by striking a balance. While setting directives are important, it is also necessary to give enough space for researchers to thrive creatively.

### **4.5.2 Encouraging Linear Innovation**

The funding structures followed by Singapore today inadvertently encourages a linear mode of innovation. The process of linear innovation as outlined in the science-push model (Rothwell, 1994) with inputs leading to research to technological development and thus innovation resulting in socio-economic benefits is generally regarded to be outdated. The problem is that causation is not always unidirectional and sometimes the demand pull for innovations matter as much as science push or sometimes a combination of the two. Majority of academic funding functions in such a way that it assumes, for the sake of simplicity, a non-interactive linear process. This excludes or minimizes interactions between multiple actors and institutions in the nation.

While Singapore is introducing various translational funds over the years, it is still limited in scope.

### **4.5.3 Education as a KPI**

Relatedly, when grants become an academics' priority, the mission of education drops lower down the list. In fact, teaching is a key performance indicator (KPI) that is measurable by the number of hours spent on it in the classroom. In reality, undergraduates need diverse methods and not just classroom teaching to be able to achieve their true potential (Chickering and Gamson, 1987).

Many academics compensate for the time spent in applying for grants by reducing time spent on undergraduate education (Polster, 2007). This has implications for long-term sustenance of skilled manpower in Singapore. The government is explicit in its goals for transforming Singapore into a smart nation by 2025 (Chua, 2012). Providing the right education to young members of the nation is crucial in ensuring that it can completely transform into a knowledge-based economy. The primary university mission of education should be preserved in this process.

### **4.5.4 Alienation of Academics**

Academics in Singapore increasingly feel left out of decisions about academic research in the nation. While Singapore has advisory boards consisting of experts from academia and

industry as well as policymakers, the local academics do not contribute to any strategic decision making with regards to R&D or STI policy. This contributes to a sense of alienation for them.

Academics cite 'autonomy' and 'academic freedom' as two qualities imperative for producing good research. Lack of decision-making power negatively impacts their sense of autonomy and freedom. This is not conducive to knowledge production.

#### **4.5.5 Instrumentalizing Innovation**

Academics are motivated to commercialize their research through various monetary schemes in the form of royalties etc. in Singapore. They are also motivated to apply for research grants in part to secure their careers through tenure, to achieve recognition from peers, and to earn more money. This leads to a growing instrumentalism of research and innovation within universities. Financial considerations become important in choosing research problems and in hiring people. Thus, academics are more concerned with securing resources and not in utilizing them to the fullest extent.

The danger is in creating an unstable university environment where academics use opportunities to merely advance themselves without contributing valuable innovations to the public. Creativity and critical thought does not thrive in insecure, unstable environments (Polster, 2007).

### **4.6 Conclusion**

World over, especially in the EU, there has been a change in traditional university funding to a more contract-based approach (Geuna, 1999). This has reduced reliance on government support for funding academic research. This is in direct contrast to the Singapore context. Singapore is following mission-oriented policies to transform its economy into a knowledge-based one and its funding structures are reflective of this. There is heavy reliance on government funding and industry funding is still evolving in the nation with hardly any private sources.

In this context, it is important that policies are designed which takes into consideration the real impact it has on academic research. This chapter describes the situation,

in Singapore, in academics' own words and this could be a first step in connecting the missing dots in the innovation economy puzzle.



# Addendum

## Linking Theory to Practice

There are distinctive dynamics at play in Singapore which is rooted in the geography, political history, development, political structures, and place of Singapore in the global production chain. This study engages with two aspects of innovation in Singapore: the development of NSI in the nation and its impact on academics and there by academic research. And ethnographic sensibility was borrowed and the SCOT approach was employed to reveal new perspectives on the NSI of Singapore. The conceptual and general developmental trajectory of Singapore's innovation system follows the NSI approach as outlined by OECD. In spite of this, several of the intended goals have not been realized and the SCOT approach used in this research reveals some of the functional as well as structural gaps. In South East Asia, the approach to studying NSIs have been at the micro-level, predominantly through the firms' perspective, to understand how innovation happens. The role of technical innovation and its impact on the economic as well as innovative competitiveness of countries have also been studied thoroughly. As a political and social artefact, the NSI concept as it originated in Europe and popularized by OECD, has been used by most of the countries to in the global South. This research attempts to understand the context and takes into account the historical development of Singapore using the SCOT approach, as a newly industrializing economy in Asia and it clearly shows that the NSI approach is not sufficiently developed to explain some aspects of Singapore, such as the disproportionately high number of foreign academics and a predominantly state led narrative of innovation. The dominant narrative of NSI approach, as practiced in the Western context, over emphasizes the importance of GDP. The SCOT approach, by outlining the social groups involved in NSI, reiterates the need

to emphasize local views and the need to study innovation at different levels. This study shows the innovation is indeed path-dependent and actors' practices need scrutiny to understand the linkages better. As a privileged member of the NIEs, with low unemployment rates and high GDP growth, Singapore has seen the application of NSI approach in narrow terms. Knowledge production is measured in terms of patents, scientific production, R&D, spin-offs etc. which are the measures used in European and North American contexts. As revealed by this study, by adopting a constructivist approach, it can be seen that academics emphasize other measures like good practices in research, various relationships across the innovation chain, peer review, and different types of teaching as well as learning. The NSI approach in this regard needs to be expanded as it is too simplistic, and this is imperative if academics are to be important players in Singapore's innovation system. Policy makers are locked into such views of innovation and there is a mismatch with academic realities, National policies need to evolve so as to take into account the educational ecosystem of Singapore and its unique qualities.

# Annex I

## Interview Questionnaire for Policymakers

1. How do you define innovation? What is a 'favorable environment' for innovation?
2. Why does Singapore want to promote innovation?
3. What is the role of EDB/NRF in chartering the innovation policies of Singapore?
4. What are the strength and weakness of Singapore's innovation capacity (in the area of the directorate)?
5. What is goal of the EDB/NRF with regards to innovation in Singapore? (meet strategic needs for the country or otherwise enhance research capacity overall)
6. How do you assess the outcomes of the various programs under EDB?
7. In your opinion, what is the role of the university/academia in enhancing innovation in Singapore? What is the role of the state/EDB/NRF in enhancing innovation?
8. Can you comment on the collaboration between industry and academia? Is it successful?
9. In your view, what should be done to promote innovation (in academia and industry)?



# Annex II

## Interview Questionnaire for Academics from NTU & NUS

### Social Construction of Innovation [adapted from Massa and Testa (2008)]

#### Background

- Please tell me about yourself and your research (career progression and current position).
- Why did you choose SG? Any special features of SG that makes it attractive to you/your work?
- Why NTU/NUS?

#### Basic innovation issues

- What do you mean by innovation? How do you try to innovate in your research?
- What indicators would you suggest to measure innovation?
- How can you define a “favorable” environment for innovation?
- What do you mean by radical innovation? Does the distinction between radical and incremental innovation make sense?

**Innovation support policies**

- What are the needs of universities in terms of innovation support?
- Do you believe in a guided or in an autonomous innovation process?
- Are you aware of the broad innovation policies of SG? Can you suggest an example of effective policy to foster innovation?
- Does your personal goals align with the policies goals?
- Are the innovation policies/funding programs of SG effective? Can you identify some of the weaknesses?

**Active roles in promoting innovation**

- What is the role of the academic/state in promoting the internal innovation process? What could/should it be?
- What is the role of universities and research centers in promoting innovation? What could/should it be?
- What is the role of the intermediary institutions like science parks, innovation agencies, etc. in promoting innovation? What could/should it be?

**Singapore**

- Can you identify the strengths/weaknesses of Singapore's innovation capacity?
- Does SG want to enhance innovation?
- How involved is the SG state in enhancing innovation? Is this similar to your experience in other countries? If not, how is it different?

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## University-Industry Collaborations in Singapore

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- Do you have any collaboration with industries? Is it institutional or individual?
- Please list them
- If not, why? Would you like to initiate a collaboration?
- How would you do this? Do you get any institutional support for this? How can the institution be improved?
- Probe (based on why no collaboration): What is the reason for this? Is it lack of institutional capacity, industrial capacity, SG specific? If in another country, would this have been easier?
- Why did/would you seek industry collaboration?
- Did you initiate it or did the industry initiate it?
- What is the nature of collaboration that you have?
- How is it institutionalized?
- What kind of institutional support did you get from NTU/NUS?
- Are you satisfied with it? How can it be improved?
- How do such collaborations enhance your research?
- Do you involve students in such work? How does it improve their future prospects?
- What are the barriers to U-I collaboration in Singapore?
- How can it be improved?
- Why is it important for academia to collaborate with industry?
- How does I collaborations impact academia (positive or negative)?
- Can you comment on the collaboration between industry and academia in SG? Is it successful? What is lacking? Compare it to other countries

## **Funding and Innovation in Singapore**

- Have you applied for funding in SG? What kind: govt or private?
- Why do you apply for funding?
- How do you choose which funds to apply to? Is there a specific process that you follow?
- How do you keep track of funding opportunities available for you?
- Do you get any institutional support for this process? If so, what kind? If not, do you expect to get any? How can this process be made easier for you? How can the system be improved? The process
- Can you describe your grant writing/fund application process?
- What kind of deliverables do you have in mind when you apply for a fund? Does this align with the funds requirements?
- How do you evaluate these outputs?
- Do you stress on them being “innovative”?
- How do you define innovation? Receiving the Fund
- How do you proceed once you receive the grant?
- What is your project planning process? How does this align with the requirements of funding agencies and their expectations? Can you describe the institutional requirements of the funds in SG.
- What changes would you like to see? How can this be improved to meet your needs?
- What are the specific features of some of the grants that you have received? How is it aligned with your personal goals?

- Do the funding agencies' goals align with your personal goals?
- What are your main goals with a fund that you receive? How do you use the money awarded into making something innovative (paper, patent, publication)?
- How does a research grant impact your creativity? Failure to receive funds
- What happens when you do not receive a fund? (pause and ask: ) Do you change your research topic to align it with funding calls? Give me an example
- How does this impact your goals as a researcher?
- How does this impact your creativity?



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