Malaysia

The Atlas of Islamic-World Science and Innovation
Country Case Study No.1

Natalie Day and Amran bin Muhammad

The Atlas of Islamic-World Science and Innovation is supported by an international consortium of partners listed below. *Malaysia* is the first country case study to be released as part of this project.

The views outlined in this report do not necessarily reflect the policy position of these partner organisations.

Each country report within the Atlas project importantly draws on in-country partners. In the case of Malaysia, special thanks go to the Malaysian Ministry of Science, Technology and Innovation (the National Focal Point) and the University of Malaya (the National Research Partner).

Cover image: A detail of the marble decoration at the Federal Territory Mosque (Masjid Wilayah Persekutuan), Kuala Lumpur. Constructed between 1996 and 2000, the mosque has a floor area of 47,000 square metres and can accommodate up to 17,000 devotees at one time.

An international project, the mosque's architecture is a mix of Ottoman and Malay styles. Detailing includes calligraphy with gold leaf inlay by Iranian craftsmen, stone carving by Indian craftsmen and doors in carved hardwood by Malaysian craftsmen. It also contains an escalator especially designed for bare feet.

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Foreword

Foreword from His Excellency Professor Dr Ekmeleddin İhsanoğlu, Secretary-General of the Organisation of the Islamic Conference

Today there is a growing recognition among the Muslim world that the achievement of development goals cannot be possible without re-dedicating itself to attaining excellence in science and technology. In this connection, the Organisation of the Islamic Conference (OIC) has initiated some well-considered strategies founded on accurate assessment, foresight and planning. The Atlas of Islamic-World Science and Innovation can serve as an important guide to key trends and trajectories in science and technology-based innovation in the OIC member states.

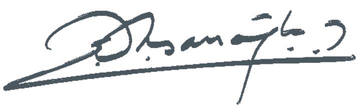
The Atlas is a unique project based on collaboration between institutions across the Islamic world and partners in Europe and North America. It is my hope that this project will serve as a model for initiating broader partnerships in science, technology and innovation (STI) between the OIC member states and other partners. Science diplomacy can have positive spillover effects in issues of high politics and thus act as a means to building trust between the Islamic world and the rest of the world.

I congratulate the project managers, the Statistical, Economic & Social Research & Training Centre for Islamic Countries (SESRIC) and the Royal Society, as well as the designated national focal point, researchers and relevant Malaysian institutions for the completion of this Malaysia report, the first of up to 15 country studies from across the Islamic world.

Science and technology have played a crucial role in Malaysia's economic transformation. Malaysia was able to achieve this due to government commitment to STI, strong policy and management frameworks, and human resources. While highlighting the strengths of the STI framework in Malaysia, the report identifies areas which can be further improved and recommends necessary measures in that regard.

It will not just suffice to produce a high quality product without follow up on its recommendations. The launch of the Atlas country studies should be followed by outreach activities, seminars, workshops and media events in order to draw the attention of the civil society, private sector, policy makers and the broader public to the findings of the Atlas and its recommendations for improvements.

I thank all the partners in the Atlas project including the British Council, COMSTECH, IDB, the International Development Research Centre of Canada, ISESCO, *Nature*, the Royal Society, SESRIC and the Qatar Foundation, and the participating member states for their contributions in the project. I look forward to their continued support in ensuring the timely completion of future country reports.



Introduction and summary

Malaysia has long had the target of becoming a knowledge-based economy by 2020. Creating a vibrant environment for innovation is seen as the best way for the country to escape the middle-income trap—a situation in which the country is neither able to compete technologically with high-income countries, nor compete in terms of cost with low-income countries.[1] The last few decades have seen record levels of investment in education. Shining new labs and special zones for entrepreneurship reflect the government's ambitions. But is the current mix of initiatives and strategies the right model for a more innovative Malaysia?

The right model for innovation? A summary of key findings

Malaysia's science, technology and innovation (STI) strategy has significantly evolved since the country's independence in 1957. Over time, emphasis has shifted from rubber and tin to palm oil, combined with the greater prioritisation of information and communications technology (ICT), then to biotechnology, pharmaceuticals and other high-tech industries in more recent years. A coherent government vision provides a clear framework for Malaysia—with detailed plans, targeted sectors and a reasonably honest assessment of any impediments and obstacles to growth. The challenge now is to consolidate and focus investment through all the layers of the STI system to ensure success.

Modelled on similar analyses of China, India, South Korea and Brazil,[2] this report aims to provide an accessible and practical guide to Malaysia's science and innovation system. The report also focuses on the scientific and technological dimensions of the innovation system, but does not describe in detail the wider aspects of social, business and process innovation.

The following is a summary of each of the chapters in this study:

Chapter 1 is a *mapping* exercise, looking at the main inputs and outputs of STI in Malaysia, and understanding the broader economic, historical and political context of these activities. This chapter identifies the main players in Malaysia's STI within government and beyond. From patents to publications to funding profiles, we provide a snapshot of Malaysian science, including emerging areas of strength.

Chapter 2 looks at the *people* behind Malaysian STI. From the 1970s onwards, Malaysia has invested heavily in human capital. The government focused on primary and secondary education levels before embarking upon a comprehensive transformation of higher education to satisfy increased demand for trained manpower and to stimulate economic growth. Today Malaysia has a pool of

1 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

2 See http://www.atlasofideas.org.

talented young people advancing through the education system, looking to seize opportunities that were not available to their parents or grandparents before them. Yet there remains a shortage of workers educated beyond secondary school level and a limited number of highly skilled jobs—two critical areas which must be addressed if Malaysia is to become a knowledge-based economy.

Chapter 3 surveys the range of scientific capacity across the country through an analysis of the *places* where research is occurring. Understanding the variations in STI capacity across the country is important, with the larger centres of Kuala Lumpur, Selangor and Penang far outstripping the poorer states in terms of R&D budgets.

Chapter 4 considers *business* innovation in foreign and local companies, and identifies new pockets of entrepreneurialism. Leading indigenous companies such as Petronas have demonstrated Malaysia's capacity to nurture high-value industries, but more effort is needed to drive innovation and creativity among small- to medium- sized enterprises. Despite decades of foreign direct investment, technology transfer from multinational companies (MNCs) to local businesses has been weak and new models of fostering collaboration between industry and research are much needed.

Chapter 5 looks at the contribution of Malaysian *culture* to its STI. Malaysia's rich cultural mix of ethnicities including Malay, Indian, Chinese and other indigenous ethnic groups is a great national resource, although sometimes has also been a source of tension. Scientists have established powerful networks—reaching emerging scientific centres around the globe, as well as the more established ones. This chapter also considers issues of governance, gender representation and public attitudes.

Chapter 6 looks at issues of *sustainability* and the natural environment. Recognised as one of the world's 17 mega-diverse countries, biodiversity stands out as one of Malaysia's key strengths. Understanding, valuing and appreciating this biodiversity holds much potential for ground-breaking research if harnessed appropriately. This chapter describes some important developments in taxonomy, rainforest research, and assesses the impact of oil palm plantations.

Chapter 7 identifies new alliances and opportunities and barriers to scientific *collaboration*. While the extent to which Malaysian scientists are collaborating internationally is at a nascent stage, the trends are encouraging, with the number of collaborations steadily increasing and growing evidence that Malaysia's research networks are diversifying.

Chapter 8 offers an assessment of the strengths and weaknesses of Malaysian STI, and offers a *prognosis* for the next decade. A concluding set of recommendations identifies where Malaysia's strategies for science and innovation are working well, and where they might be refined. We hope that these proposals will stimulate further debate about the right initiatives for science and innovation in Malaysia.

The Atlas of Islamic-World Science and Innovation

This report is the first in a series of country case studies which form part of *The Atlas of Islamic-World Science and Innovation*. This three-year project is the work of partners from across the Islamic world, Europe and North America, with the full list of partners included on the inside cover. Inspired by signs of renewed ambition and investment, the project aims to map the changing landscape for STI across a diverse selection of countries with large Muslim populations in the Middle East, Africa and Asia. Importantly, the project is not a study of 'Islamic science', or science exclusively conducted by Muslims. Appendix 1 has further details of its aims, partners and methods.

Reflecting the collaborative nature of the project, this report is jointly authored by Natalie Day, a science policy analyst at the Royal Society in London, and Amran bin Muhammad, a senior academic at the University of Malaya. Thanks also to James Wilsdon, Ian Thornton, Elinor Buxton, Susan Gillespie and Sarah Mee from the Society, who provided assistance. Over several months of fieldwork between July 2009 and May 2010, the authors traversed the country, interviewing around 110 policy makers, entrepreneurs, scientists and economists in nine Malaysian cities: Kuala Lumpur, Penang, Johor Bahru, Kulim, Putrajaya, Kuching, Kota Kinabalu, Lahad Datu and Langkawi.

The authors were accompanied for much of this time by two dedicated PhD students from the University of Malaya, Maisarah Hasbullah and Ezwan Arman Noor Kamar. Malaysia's Ministry for Science, Technology and Innovation (MOSTI), through the Malaysian Science and Technology Information Centre (MASTIC), provided enormous in-kind and intellectual support to the research team, and facilitated two workshops in Kuala Lumpur and Johor Bahru. Special thanks go to Anita Binti Bahari from MASTIC. A full list of the organisations interviewed is available in Appendix 2.

The authors are also grateful to those who peer reviewed this study (listed in the Acknowledgements). Their comments and suggestions, as well as those received from the Atlas project partners and key government stakeholders in Malaysia, were extremely helpful. Any mistakes or shortcomings are the responsibility of the authors.

1 Mapping

Few people are more adept at navigating the terrain of Malaysia's science and innovation system than Tan Sri Datuk Dr Omar bin Abdul Rahman,[3] the first and longest serving Science Adviser to the Malaysian Prime Minister. Omar served Prime Minister Tun Dr Mahathir bin Mohamed from 1984 to 2001, for nearly all of his 22-year premiership. Together, Mahathir and Omar were public champions for science at a critical time in Malaysia's economic transformation. They defined the management frameworks needed to transform Malaysia into a leading player in global research.

Ten years have now passed since Omar left office, but his commitment to science and innovation in Malaysia remains undiminished, and several of the concepts he pioneered are still valuable for policy makers today. He consistently emphasised the importance of planning and coordination across government to support research infrastructure and investment. In addition, he stressed the role of human resources (and policies to shape them), as being crucial for any country to fulfil its potential. 'People—whether scientists, non-scientists, entrepreneurs, industry leaders, teachers—are fundamental to our success.'

This chapter provides a historical and institutional snapshot of STI in Malaysia from the 1980s when Omar was first involved, until the present day. It highlights particularly strong policies, governance structures, key organisations, inputs, outputs and research fields (see summary in Table 1.1).

3 A summary of Malaysian titles is included in Appendix 3.

Table 1.1. Summary of economic and social data in Malaysia.

	Figure	Year	Source
GDP[4] growth	5.1% average annual growth	2008–2012 (predicted)	The World Bank
FDI[5] (net inflows, BoP[6], $US)	$7,375,907,983	2008	World Development Indicators
GNI[7] per capita ($PPP[8])	$13,740	2008	The World Bank
Population	28.3 million	2010	Department of Statistics Malaysia
Incidence of poverty	5.70%	2004	United Nations Development Program
Internet users	62.5 per 100	2008	International Telecommunications Union
Mobile phone subscribers	100.4 per 1,000	2008	International Telecommunications Union
Literacy rate (% population aged 15+)	92.1	2008	UNESCO Institute for Statistics

1.1 A brief history of Malaysian science, technology and innovation

Malaysia's macroeconomic story over the past 50 years is a familiar one. From a heavy reliance on primary commodities, to a focus on manufacturing and Foreign Direct Investment (FDI), to the current emphasis on knowledge and innovation—Malaysia has maintained robust economic growth for several decades (See Table 1.2 for an overview). Although this success has not matched the meteoric growth of South Korea, which followed a similar trajectory, Malaysia's STI developments are nevertheless impressive and show much promise.

From Malaysia's independence in 1957 until the mid-1980s, policies for STI were essentially a footnote to the country's wider macroeconomic development. It was only in 1986, under Mahathir's leadership, that the First National Science and Technology Policy was formulated and included as a distinctive strand within the Fifth Malaysia Plan (1986–1990).

To give a broad sweep of the developments that led to this point: prior to independence, the establishment of the Institute of Medical Research (IMR) in 1901 was initially motivated by the tropical diseases encountered by the British in the region.[9] In 1905, the British established the Department of Agriculture (DOA) to find ways of increasing food crop production to meet the increasing demands of immigrant workers and export markets. As the country was rich in pristine

4 For explanations of all abbreviations, see Appendix 2.

5 Foreign Direct Investment.

6 Balance of Payments.

7 Gross National Income.

8 Purchasing Power Parity.

9 Ooi GL (1991). *British colonial health care development and the persistence of ethnic medicine in Peninsular Malaysia and Singapore*. Southeast Asian Studies **29**, 2.

Ch'ien Lee, Royal Society SEARRP

tropical forest, the Forest Research Institute was created in 1926. In the same year, the Rubber Research Institute (RRI) was set up to devise methods for increasing rubber production. Throughout the 1940s and 1950s, science and technology efforts were directed towards improving Malaysia's most significant economic activities: rice production, water irrigation and rubber plantations.

The period between 1957 and 1970 saw the emergence of a more *laissez-faire* economy, dependent on tin and rubber as the major export commodities. Following ethnic-based social unrest in 1969, the New Economic Policy (NEP) was introduced in 1970, with the aims of poverty eradication and wealth redistribution. By the early 1970s, the government had begun to encourage export-oriented industries through the creation of Free Trade Zones (FTZ), which attracted multinationals including Motorola, Matsushita and Texas Instruments to locations such as Bayan Lepas in Penang and Sungei Way in Selangor.

The election of Mahathir as Prime Minister in the early 1980s refocused Malaysia's economic development on four fronts: first, a steady increase in the flow of FDI; second, the increasing importance of home-grown industrialisation through the creation of national car, iron and steel and cement industries; third, petroleum quickly becoming a major source of income—Malaysia is the third biggest oil reserve holder in the Asia-Pacific after China and India, with reserves of over 4 billion barrels—the majority of which is off-shore;[10] and finally, natural commodities, with palm oil replacing rubber as the main revenue source.

10 US Energy Information Administration, Department of Energy, December 2010. Available online at: http://www.eia.doe.gov/cabs/Malaysia/Oil.html.

The emergence of ICT during the 1990s provided a new impetus for an array of STI policies aimed at knowledge generation and diffusion. From ICT in the 1990s, biotechnology and nanotechnology then emerged as the focus of policy in the first decade of the 21st century.

To understand both the progress and future policy direction of STI in Malaysia, Tan Sri Omar points to his Technology Management Best Practice framework as a helpful tool. This framework outlines the national STI ecosystem required to create a sustainable and prosperous future for the nation. Critical components are listed below, along with some highlights of Malaysia's progress set against this framework:

- *Political commitment:* the development of 'Vision 2020' (Malaysia's blueprint to become a knowledge-based economy) was the first time STI featured so strongly in Malaysia's development plans.
- *Policy integration:* there has been ongoing progress to ensure the integration of STI elements in national strategies but, as this report argues, more could be done.
- *STI advisory system; planning and coordination:* the establishment of a Ministry for Science (1973) as well as key institutions such as the Academy of Sciences Malaysia (1995) and National Councils at government and sector level are critical components of a robust STI system. The appointment of a Science Adviser to the Prime Minister and cross-departmental councils has also improved STI planning and coordination.
- *STI infrastructure; funding and management of R&D:* while there has been much progress in the range of grants and financial incentives from STI (see Section 1.5.2), a secure funding base for STI is still needed. The establishment of agencies such as the Malaysian Science and Technology Information Centre (MASTIC) in 1992 has been critical in tracking Malaysia's progress.
- *Mechanism for commercialisation of research and technology:* venture capital funds were established in the 1980s, while university incubators and technology parks have also increased (see Chapter 4).
- *Integrated human resources development:* as highlighted in Chapter 2, Malaysia underwent a significant expansion of educational institutions during the 1990s.

- *Mechanism for STI popularisation and enculturalisation;* some foundations were laid in order to increase public engagement with science under Mahathir through community-focused activities. The Academy of Sciences Malaysia has been instrumental here.
- *Smart partnership practices:* Malaysia is also increasingly focusing on national and international cooperation, but recognises the need to build Malaysia's domestic capability first.

The aim is to combine government-led or 'vertical' factors, such as a national plan which fosters a competitive STI system, with horizontal factors—such as human capital, culture and opportunities to debate the direction of policy—which help to unite institutions and stakeholders behind a cohesive vision.

1.2 Harnessing STI for Vision 2020

In 1991, an ambitious plan for Malaysia's future, known as Wawasan 2020 or Vision 2020, was launched, which aimed to promote a fully developed Malaysia, based on a knowledge economy with its own distinctive qualities. Vision 2020 highlighted STI as one of its strategic priorities: 'to establish a scientific and progressive society, a society that is innovative and forward-looking, one that is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future'. From this point onwards, there was an increased effort to promote STI capacity from research to commercialisation, in line with Vision 2020.

The current Prime Minister, Dato' Seri Najib Tun Razak, has recently announced a New Economic Model (NEM), which aims to boost incomes, sustainability and inclusiveness for all Malaysians. While Najib reiterated that Vision 2020 remains the ultimate blueprint for the nation, the NEM includes some tactical shifts to reflect political and economic changes that have occurred, such as reorienting from quantity- to quality-based based growth in physical and human infrastructure while also refocusing on emerging markets. Nonetheless, the NEM continues to emphasise STI as integral to achieving the nation's ambitions.

Table 1.2. Phases of Malaysia's growth and major policies.[11]

	1960s	1970s	1980s	1990s	2000s	2010
Population[12] & GDP[13] (at current US$)	8.1 million/ $2.4 billion	10.9 million/ $4.3 billion	13.8 million/ $24.9 billion	18.1 million/$44 billion	23.3 million/ $93.8 billion	28.3 million/ $192.8 billion
R&D budget as % of GDP[14]	—	—	—	0.22	0.47	0.21
Development stage	Primary commodities; agriculture		Investment driven stage; shift to manufacturing		Focused towards knowledge; based/innovation economy	
Major industrial policy direction	Heavy dependence on primary export commodities; decline of rubber prices	Move from net oil importer to exporter as petroleum prices rose sharply; free trade zones (FTZs) attracting multinational companies	Regulatory reforms that led to more liberalised private sector investment	Growth strategies favouring modernisation/ industrialisation	Focus on productivity-driven growth; stimulating knowledge-based indigenous innovation	Greater emphasis on knowledge-based, innovative economic growth
STI policy and role of government	Limited focus	Dedicated Ministry for Science established as well as the National Council for Scientific Research and Development (NCSRD)	First national STI policy; first chapter on STI in Malaysia Plans; Intensification of Research in Priority Areas (IRPA) grants established	Multimedia Super Corridor established; mega-projects era; national industrial technology plan established	National Innovation Council; Biotech strategy announced; IRPAs streamlined	Year of Innovation; Talent Corporation established; UNIK
Macroeconomic policy framework/ conditions	1st Malaysia Plan (1966-1970) launched (to be followed by plans every five years). Substantial increases in public sector expenditure	New economic policy—focused on national unity, restructuring society for greater Malay urbanisation and employment	Large investments in heavy industries; significant growth in Foreign Direct Investment. Major recession in mid-1980s	Vision 2020 announced; National Action Plan for Industrial Technology Development. Asian economic crisis	National Innovation Model; second phase of 2020, focused on key strategic thrusts for sustainable growth	New Economic Model; 10th Malaysian Plan (2011–2015) launched. Global economic crisis
Education policy	Becomes federal responsibility; focus on basic education for all	Focus on improving quality; system begins adjusting to economic needs	Continued focus on improving quality and access	Rapid transformation/ reform; Opening of private sector/ institutions	Ministry of Higher Education established; creation of research universities	Science and maths to be taught in Bahasa Malaysia (one of the official languages of Malaysia) from 2012

11 Adapted and updated from Leete R (2007). *Malaysia from Kampung to Twin Towers: 50 years of economic and social development*. Oxford Fajar: Selangor, Malaysia. Demographic and Economic data from separate sources—see below.

12 1960–2000, World Development Indicators 2009 online: Washington, DC, USA. 2010 figure, Department of Statistics Malaysia: Putrajaya, Malaysia.

13 1960–2000, World Development Indicators 2009 online: Washington, DC, USA. 2010 figure, Economist Intelligence Unit: London, UK.

14 1990 and 2000, UNESCO Institute for Statistics: Montreal, QC, Canada; 2010, Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

1.3 The Malaysian STI system: key actors

The key actors in Malaysia's STI system are predominantly government or government-linked organisations. This section briefly describes the key departments and also introduces the non-government actors, further profiled in Chapter 4.

1.3.1 Ministry of Science, Technology and Innovation

The Ministry of Science, Technology and Innovation (MOSTI, originally formed as the Ministry of Technology, Research and Local Government in 1973) spearheads the development of STI in the country. The Ministry oversees more than 20 departments, agencies and companies, clustered into five focus areas: biotechnology, ICT policy, industry, sea to space, and science and technology core. While this report can only mention a handful of these agencies, they all play an important role in Malaysia's scientific landscape. Please refer to Appendix 4 for additional information about MOSTI and its agencies, including the organisational chart.

MOSTI provides the bulk of grants for research through specialised schemes, while the Malaysian Science and Technology Information Centre (MASTIC) is the official reference centre for STI statistics and indicators.

1.3.2 Ministry of Education

The Ministry of Education (MOE) has oversight of the National Education System at school level—from pre-school to secondary and post-secondary education (excluding higher education). Secondary education is based on a streaming policy—with students allocated into a 'stream': academic; technical or vocational; or religious studies. Within the academic stream, students either pursue arts or science from the age of 16. To encourage bright students from rural areas, some dedicated 'science schools' have also been established.

1.3.3 Ministry of Higher Education

The Ministry of Higher Education (MOHE) aims to turn Malaysia into a hub of excellence for higher education. Its targets include:

- developing at least 20 Centres of Excellence that are internationally recognised in terms of research output, copyrights, publications and research collaborations;
- ensuring at least 75% of lecturers in public institutions of higher education possess a PhD or its equivalent and that 30% of lecturers in polytechnics and community colleges possess a Masters Degree, PhD or equivalent;
- encouraging the internationalisation of the country's higher education by attracting foreign students, to form up to 10% of the total student population at diploma, bachelor and postgraduate levels.

Details of Malaysia's human capital (including numbers of students and graduates) are discussed in detail in Chapter 2.

1.3.4 Other ministries

The scope and demand for science and research naturally extends well beyond MOSTI and its subdivisions (Appendix 4) and the education ministries. Several other departments contribute to aspects of the STI system, including:

- the Ministry of Natural Resources and Environment (MNRE) which oversees (among other agencies) the Forest Research Institute of Malaysia (FRIM);
- the Ministry of Energy, Green Technology and Water (MEGTW);
- the Ministry of Agriculture and Agro-based Industry (MOA);
- the Ministry of International Trade and Industry (MITI), which also oversees the Malaysian Investment Development Authority (MIDA) and the Malaysia Productivity Corporation (MPC);
- the Ministry of Plantation Industries and Commodities (MPIC);
- the Ministry of Health (MOH); and
- Social-based ministries which encourage research such as the Ministry of Women, Family and Community Development and the Ministry for National Unity and Social Development.

1.3.5 The Academy of Sciences Malaysia

The Academy of Sciences Malaysia was inaugurated in 1995. Its vision is to be the 'scientific thought leader in advancing science for Malaysia'. Today the Academy has nearly 200 Fellows from across the natural sciences and around 40 staff, making ASM one of the most prestigious scientific academies in the developing world. The Academy is strongly aligned with national priorities, providing advice to the government, administering certain schemes like 'Brain Gain Malaysia' and working to popularise science. In addition to producing scientific publications, ASM also grants high-level awards such as the Mahathir Science Award, which rewards excellence in research in tropical sciences, and hosts a range of public events to promote greater awareness of scientific issues. At the time of writing, a new President of the Academy had just taken office, Tan Sri Datuk Dr Ahmad Tajuddin Ali FASc, succeeding Tan Sri Datuk Dr Yusof Basiron FASCs who served from 2007 to 2010.

1.4 Streamlining proposed

With so many departments and agencies involved in STI, the government recognises the need to ensure that R&D is appropriately prioritised. The Tenth Malaysia Plan (2011–2015) announced a new governmental structure which aims to reform and streamline the governance of STI, with a more prominent role for the Prime Minister's department and the establishment of a new agency, now known as Unit Inovasi Khas or UNIK, to oversee and drive innovation across the entire system.

Professor Datin Paduka Dr Khatijah Mohd Yusoff, the Deputy Secretary General (Science) of MOSTI, stressed the need for a more energetic, comprehensive and inclusive approach which is output- and result-orientated: 'We need to promote, in the first instance, an appreciation of the value of science across all government departments by working more closely together and talking more to each other and to others.' To achieve this, a streamlined and coordinated effort between MOSTI and UNIK will be critical, with the science adviser acting as an enabler and shaper between the different ministries and agencies.

Ironically, it seems that structures to foster cross-ministerial ownership of the STI agenda have worked effectively in the past. In 1975, the National Council for Scientific Research and Development (NCSRD) was established to formulate, coordinate and evaluate STI policies and activities. In the 1990s, the Council was restructured which resulted in a more balanced representation between government, industry and the research community but by 2006, the Council had lost its effectiveness and ceased to operate.

In late 2010, the Minister for Science, Technology and Innovation, Datuk Seri Dr Maximus Ongkili, announced that a National Science and Research Council (NSRC) would be set up in early 2011 to replace the now defunct NCSRD.[15] Announcing the proposal, Ongkili outlined high ambitions for the Council and for science more broadly. 'Malaysia,' he said, 'must not be satisfied with mediocrity in any form. We have to build teams and centres of excellence that are of international and world class standards (and) prioritize our work to leverage on the value propositions that Malaysia can offer, such as our diversity in both our people and natural resources.'

15 Research Europe (2010), *Malaysia to get research council in 2011* (25 November 2010), Research Europe, London UK

Made up of 25 members from various scientific fields, the research council is independent of MOSTI, although supported by a MOSTI secretariat. It is charged with strategizing and prioritising R&D focus areas to meet the challenge of becoming a knowledge-based economy by 2020, as well as encouraging interdisciplinary research. It is also expected to focus on increasing research collaborations between Malaysia and the rest of the world, with particular focus on renewable energy, biotechnology and nanoscience.[16]

The government should be commended on this initiative. It is suggested that this Council will assist in ensuring greater integration between government departments and organisations. This is urgently needed. Whether through this body or other means, this report recommends the rationalisation of schemes and incentives for R&D and technology development, and the minimisation of associated bureaucracy wherever possible.

Government-linked companies

A number of Malaysia's most high profile companies are linked to the government, including Proton and Petronas. These organisations are also Malaysia's biggest players in terms of private sector R&D. Chapter 4 explores the vital role government-linked companies play in Malaysia' science system.

Other private sector organisations

There are a large number of companies conducting high-end R&D with a presence in Malaysia, including global brands like Hewlett Packard (HP), Motorola and Intel. Dyson, one of Britain's most innovative companies, has also recently located to Johor Bahru.[17] However, it is extremely difficult to extrapolate what percentage of activities are R&D based (as opposed to manufacturing or after-sales support) in Malaysia and, if so, what is the quantum of their R&D budget and the number of scientific personnel they employ.

16 Research Europe (2010). *Malaysia to get research council in 2011* (25 November).

17 Dyson website. http://www.careers.dyson.com/about/default.aspx?panel=whereWeAre, accessed 13 December 2010.

1.5 Inputs to the STI system

1.5.1 Human capital

Table 1.3. Profile of Malaysia's STI human capital.[18]

Year/ indicator	1998	2002		2004		2006		2008[19]	
	Number[20]	Number	% total researchers	Number	% total researchers	Number	% total researchers	Number	% total researchers
Researchers: business enterprise	—	—	—	5,940	25.7	4,160	21.9	563[21]	
Researchers: government	—	—	—	4,347	18.8	2,709	14.2	3,650[21]	
Researchers: higher education	—	—	—	12,805	55.5	12,152	63.9	19701[21]	
Researchers: total	—	17,790	100	23,092	100	19,021	100	23,914	100
Technicians	—	3,090	n/a	2,919	n/a	1,891	n/a	1480[22]	
Other supporting staff (HC)		4,057	n/a	4,972	n/a	3,676	n/a	3017[22]	
Total R&D personnel (HC) – Total	12,127	24,937	n/a	30,983	n/a	24,588	n/a	28411[22]	

Malaysia's talent pool of R&D personnel (including researchers, technicians and support staff) grew significantly at the turn of the millennium from 12,127 in 1998 to 30,983 in 2004 before dropping in 2006 and then recovering to nearly the same levels in 2008 (see Table 1.3).[23] There are some discrepancies, however, with the preliminary 2008 data which are problematic and need to be addressed for a more robust picture.[24]

The majority of Malaysian talent is employed in Institutes of Higher Learning (IHLs) and Research Institutes.[25] In 2005, Malaysia ranked 47th in the world in terms of researcher headcount, with 17.9 researchers per 10,000 workers. Iceland, in comparison, ranked number one in the world with 328.4 per 10,000 workers,

18 1998–2006 data from UNESCO Institute for Statistics: Montreal, QC, Canada.

19 Note: there is a discrepancy in the 2008 data: the report lists the total headcount of researchers as 23,843 which is less than the sum of the breakdown by sector (which we have used in the table). Furthermore, the total R&D personnel headcount (including technicians and support staff) listed in the report is 28,405 but this does not square with using either 23,843 or 23,914 as the total number of researchers. National survey of R&D development 2010, cited in the *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy with provisional data).

20 All of the statistics in this table represent headcount (as opposed to full-time equivalent).

21 National survey of R&D development 2010. Cited in the *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy with provisional data). NB The National survey of R&D development 2010 got an 8% response rate from private sector firms so may not accurately reflect the reality.

22 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

23 Figure 3.1, Government of Malaysia (2008). *Malaysian science & technology indicators 2008 report*. MOSTI, Putrajaya, Malaysia. 2008 data from Figure 3.1, Government of Malaysia (2011). *Malaysian science & technology indicators 2010 report*. MOSTI (pre-publication copy).

24 Refer to Footnote 21.

25 Figure 3.4, Government of Malaysia(2008).*Malaysianscience &technologyindicators2008report*. MOSTI, Putrajaya, Malaysia.

Singapore had 87.4 and South Korea 89.8.[26] These figures show rapid expansion and contraction, and development of adequate human capital remains a major challenge, as Chapter 2 will explore in more detail.

1.5.2 Funding

From 1996 to 2002, funding for STI in Malaysia was on a steady and encouraging climb, as Figure 1.1 demonstrates. However, over the last eight years, the picture has been more mixed. At its height in 2006, investment in R&D accounted for just 0.64% of GDP, meaning Malaysia's capital and human investment in research was well behind leading scientific centres such as the UK (1.8%), the US (2.65%) and neighbouring Singapore (2.31%).[27] Indeed, contrary to claims of STI's critical importance to Malaysia, according to the Tenth Malaysia Plan, gross expenditure on R&D dropped to just 0.21% of GDP in 2008.[28] The government attributes some of this decline to the 2008 global financial crisis and the rapid increase in oil prices which affected Malaysia's economy. There are also significant questions about the quality of the preliminary data upon which these figures are based. Malaysia conducts a biannual survey on R&D in both the public and private sectors from which it derives these numbers. As acknowledged in the 2010 Indications Report, the 2008 survey received a very poor response rate from both the public and private sectors. The response rate for the public sector was 70%, but it is the private sector response that is particularly concerning. Of the 2,890 companies approached, only 231 or 7% of companies responded, with 164 reporting that they conducted R&D.[29] Such unreliable preliminary data makes it extremely difficult to get an accurate picture of R&D in Malaysia, particularly from the private sector. While acknowledging that such data limitations are not unique to Malaysia, it would seem appropriate to reconsider urgently the current collection method in order to deliver a more accurate and robust analysis for future years.

The government now aims to ensure that investment in R&D reaches at least 1% of GDP by 2015.[30] This is, however, disappointingly less than the previous target of 1.5% by 2010 in the Ninth Malaysia Plan (2006–2010) (which was not reached), although government sources believe the revision is necessary in part due to the impact of the economic crisis.[31] Data issues aside, to achieve such targets will require a huge injection of funds from both the private and public sectors, and there are legitimate questions as to whether this is feasible.

26 Table 17, Government of Malaysia (2008). *National survey of research & development 2008 summary*. MOSTI, Putrajaya, Malaysia.

27 Table 13, Government of Malaysia (2008). *National survey of research & development 2008 summary*. Ministry of Science, Technology and Innovation: Putrajaya, Malaysia; UNESCO Institute for Statistics: Montreal, QC, Canada.

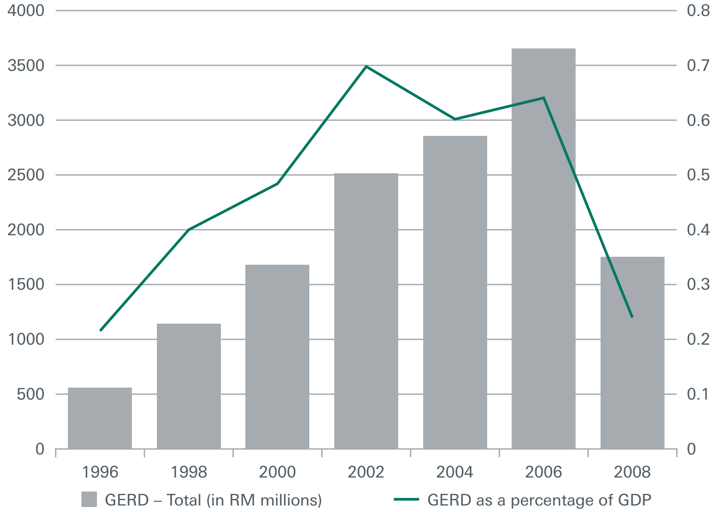
28 Appendix, Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

29 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy with provisional data).

30 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

31 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

Figure 1.1. Malaysia's STI funding profile from 1996 to 2008.[32]



In 2006, Malaysia's Gross Expenditure on R&D (GERD) was RM3.6 billion, which ranks 37th in the world compared to the top-ranking USA's RM1.2 trillion.[33] (Approximately 3.1 Malaysian Ringgit (RM) to the USD[34]). Similar analysis using the Government's 2008 preliminary data gives completely different results with GERD at just RM1.7 billion. The GERD/GDP ratio of 0.24% puts Malaysia much further below regional neighbours and competitors and into the same league as Azerbaijan and Ethiopia.[35] The Malaysian government's own report notes that such results are based on inconsistent data, citing poor response rates to the survey (see sections 1.5.1 and 1.5.2). An analysis of the equivalent report in 2012 (which should be based on refined methodology) will prove crucial for correctly identifying longer term trends.

Table 1.4 provides a more positive comparison of Malaysia's spend in 2008 versus that of other countries, with examples drawn from South East Asia and the OIC membership, together with countries regarded as scientific leaders. With such vastly different analysis, gaining an accurate reflection of the true picture of Malaysia's STI expenditure is difficult. According to OIC data, Malaysia is one of the highest funders of STI out of all the OIC Membership, behind Tunisia, Turkey and Morocco as a percentage of GDP.[36] Yet, compared to emerging science powers regionally, Malaysia spends significantly less than China and South Korea.

32 Data for 1996 to 2006 from UNESCO Institute for Statistics: Montreal, QC, Canada. 2008 data from *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

33 Table 12, Government of Malaysia (2008). *National survey of research & development 2008: summary*. MOSTI, Putrajaya, Malaysia.

34 US$1.00 = RM3.06850 on 5 January 2011. http://www.xe.com, accessed 5 January 2011.

35 OIC Outlook (2010). *Research and scientific development in OIC countries*. Statistical, Economic and Social Research and Training Centre for Islamic Countries: Ankara, Turkey.

36 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

Within government, federal sources provide the vast majority of STI funding in Malaysia, with states having limited financial capacity. However, government is increasingly being overshadowed by business R&D which is highly concentrated amongst very large companies – most of which are government-linked. The private sector funded 84.7% of STI in Malaysia in 2006, up from 71.2% in 2002.[37] Partly as a result of this significant increase, the government's share decreased over the same period from 21.5% to just 5%.[38] Again, an analysis of the 2008 data gives a very different picture, with spending led by the government, so it is difficult to make any precise conclusions.

Table 1.4. Comparison of government R&D expenditure in 2008 from IMD top 50 ranked countries.[39]

	GERD (US$ millions)	World ranking	GERD/ GDP ratio	World ranking	GERD per capita (US$)	World ranking
Malaysia	1,586	34	0.72	42	57.2	42
Regional						
China	66,464	4	1.54	23	not in top 58	n/a
Singapore	5,038	25	2.68	10	1,041.1	12
South Korea	33,686	7	3.21	5	695.2	21
Thailand	593	45	0.22	53	89	53
OIC						
Iran	Not in top 58	n/a	Not in top 58	n/a	Not in top 58	n/a
Turkey	4,686	26	0.72	41	68.0	39
Tunisia	Not in top 58	n/a	Not in top 58	n/a	Not in top 58	n/a
Pakistan	Not in top 58	n/a	Not in top 58	n/a	Not in top 58	n/a
Scientific leaders						
Sweden	17,995	11	3.75	2	1,942.4	1
USA	398,086	1	2.76	8	1,307.9	10
Germany	84,165	3	2.53	13	1,023.7	13
Japan	150,785	2	3.44	4	1,180.1	11

37 UNESCO Institute for Statistics: Montreal, QC, Canada.

38 UNESCO Institute for Statistics: Montreal, QC, Canada.

39 IMD (2010). *World competitiveness yearbook*. IMD: Lausanne, Switzerland; and World Development Indicators, Washington, DC: USA.

Within government STI funding, MOSTI is the largest provider of grants, with a diverse array of research, pre-seed and commercialisation initiatives. Building on an allocation of just RM600 million in the Sixth Malaysia Plan (1991 to 1995), MOSTI's total research, development and commercialisation grants reached RM2,916.5 million in the Ninth Malaysia Plan.[40]

The key schemes include the Science Fund, the Strategic Thrusts of Research Areas programme and the TechnoFund.[41] For a more detailed list of various schemes, from pre-seed initiatives to research and development, please refer to Appendix 4.

The list of grants available within MOSTI and other Ministries is far longer than that provided by this overview. Such support is positive, but critics argue that the sheer range of grant schemes creates unnecessary duplication and is not very efficient. Multiple small funds can make it difficult to navigate the funding system and target applications. An urgent priority for MOSTI and other agencies is to streamline and rationalise the STI funding system to ensure that it is better targeted towards strategic priorities.

1.5.2.1 Funding of engineering research

A recent UNESCO report acknowledged that engineering can often be the unsung partner to science and stressed its importance in economic development.[42] For Malaysia, engineering has grown in terms of investment and student enrolment, but remains a critical area for further investment. While it is difficult to obtain accurate data on the number of engineers in Malaysia, according to the Board of Engineers Malaysia (BEM) there are a total of 53,853 graduate engineers, but only 3,557 are currently professionally registered with the BEM.[43]

Gross expenditure on engineering sciences research and development has risen from RM1,006.5 million in 2004 to RM1,175.4 million in 2006 with the majority (RM1,114.7 million or 36%) funded from the private sector.[44] In 2002, 47% of patents in Malaysia were engineering related,[45] which may partly account for the high levels of private sector investment. Engineering science was once the highest funded field of research by the private sector, attracting 42.8% of funding in 2004. This dropped to 36.0% in 2006, falling slightly behind applied sciences and technology at 39.5%.[46] In order to drive a strong engineering sector, further investments in research are much needed. In 2006, Malaysia had the equivalent of 4,651 full-time researchers working on engineering and technology, while Singapore boasted an impressive 15,470.[47] Further analysis of the human capital behind engineering is included in Chapter 2.

40 Information provided by the Ministry of Science, Technology and Innovation.

41 Information provided by the Ministry of Science, Technology and Innovation.

42 UNESCO (2010). *Engineering: issues, challenges and opportunities for development*. UNESCO: Paris, France.

43 Board of Engineers Malaysia (2011).

44 MOSTI (2009). *National survey of research and development*. MASTIC.

45 UNESCO (2010). *Engineering: issues, challenges and opportunities for development*. (The most up-to-date breakdown available.)

46 MOSTI (2009). *National survey of research and development*. MASTIC.

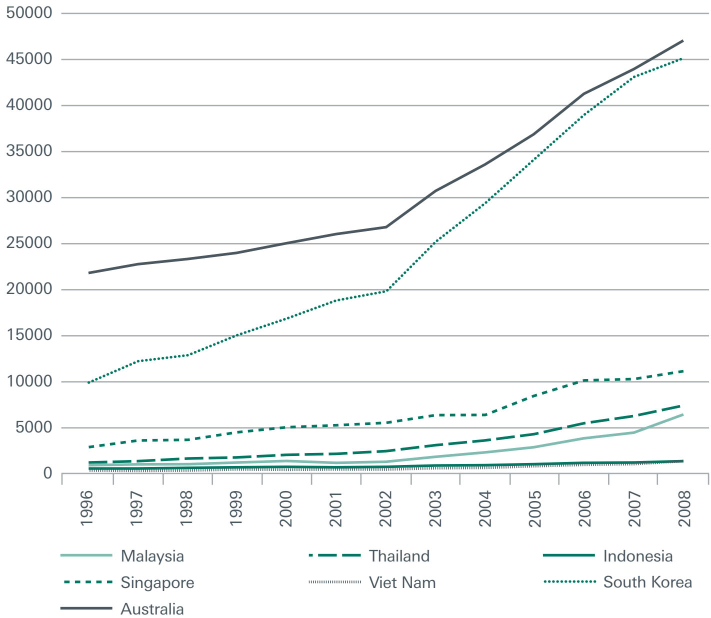
47 UNESCO Data Centre. Available online at: http://stats.uis.unesco.org/unesco/TableViewer/document.aspx?ReportId=136&IF_Language=eng&BR_Topic=0.

1.6 Outputs from the STI system

1.6.1 Publications

The first Malaysian bibliometric study of scientific publications in 2003 highlighted an urgent need for the nation's scientific community to increase their publication output. Based on cumulative article output from 1996 to 2008, Malaysia was ranked 48th in the world with 28,796 publications in international journals, compared to Singapore (31st) with 81,836 and Thailand (42nd) with 41,637.[48] Over the same period, Malaysia's articles were cited on average 5.87 times, compared to Singapore's citation rate of 9.87 and Thailand's of 8.27. While Figure 1.2 reflects how Malaysia's production pales in comparison with South Korea and Singapore, Malaysia's share of world publications has quadrupled from 0.08 to 0.32% in this period, thanks largely to increased priority and incentive schemes put in place by the Malaysian Government. Looking more broadly at publication rates among OIC member states, Malaysia ranked fourth in 2009 behind Egypt and high performers Turkey and Iran.[49]

Figure 1.2. Publication output by country, 1996 to 2008.[50]



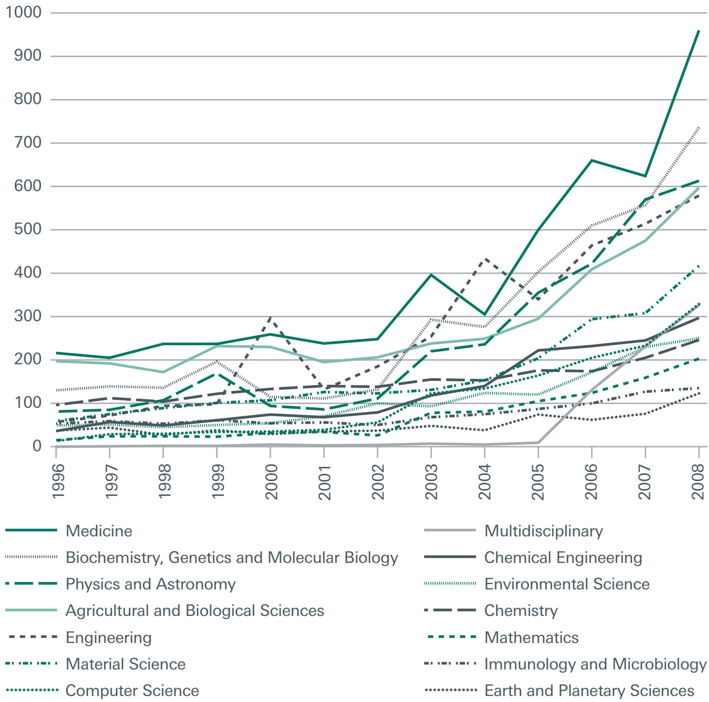
48 Publication in international journals indexed by the Scopus database, Elsevier. SCImago (2007). SJR—SCImago Journal & Country Rank, retrieved 10 August 2010.

49 Data provided by SESRIC.

50 Publication in international journals indexed by the Scopus database, Elsevier. SCImago (2007). SJR—SCImago Journal & Country Rank, retrieved 10 August 2010.

Figure 1.3 shows a breakdown by field of publication, with medicine and biochemistry the standout performers. The number of publications in medicine has steadily increased in the past decade, rising from 216 in 1996 to 960 in 2008. Biochemistry has shown an even stronger rise over the same time period, from 130 to 736 articles.[51]

Figure 1.3. Breakdown of Malaysian publications by field, 1996 to 2008.[52]



51 Scopus database, Elsevier, retrieved 10 August 2010.

52 SCImago (2007). SJR—SCImago Journal & Country Rank, retrieved 10 August 2010.

1.6.2 Patents

Patents are another key indicator of STI capacity, yet, as Table 1.5 demonstrates, the vast majority of patents filed and granted within Malaysia are produced by foreigners. Importantly there are signs of improvement, with the number of patents granted to Malaysians increasing by 2,600% between 1992 and 2009. Similarly to publication rates, this increase is in part due to increasing focus and incentive schemes for patent research within IHLs and Government Research Institutes (GRIs). In terms of patents generated within OIC member states, Malaysia was one of the top performers in recent years, with Malaysian patents accounting for 18.89% of the OIC total.[53]

Table 1.5. Profile of patents filed and granted in Malaysia.[54]

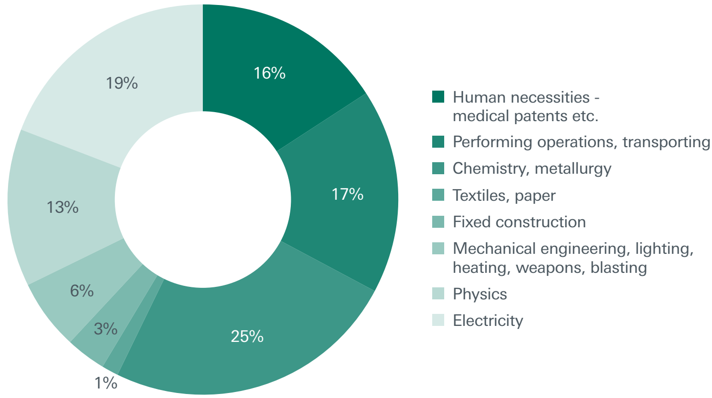
Year	Application			Granted		
	Malaysian	Foreign	Total	Malaysian	Foreign	Total
1988	73	1,547	1,620	0	6	6
1992	151	2,260	2,411	10	1,124	1,134
1996	221	5,354	5,575	79	1,722	1,801
2000	206	6,021	6,227	24	381	405
2004	522	4,920	5,442	24	2,323	2,347
2008	864	4,539	5,403	198	2,044	2,242
2009	1,234	4,503	5,737	270	3,198	3,468
March 2010	246	1,223	1,469	52	580	632
Total (1988 to March 2010)	7,787	94,543	102,330	1,536	39,726	41,262

In terms of US patents granted to Malaysians from 1977 to 2009, just 1,298 patents were awarded, 0.07% of the applications worldwide for that period. Other countries had much more success, such as South Korea which had 72,332 patents granted (3.96%) and Singapore with 4,959 (0.27%). Malaysia, however, easily outclassed Indonesia's 253 patents (0.01%). To give an idea of what world leaders were producing, Japan was granted 756,795 (41.4%) over the same period. A breakdown of the fields from which patents filed in Malaysia are developed is provided in Figure 1.4, with chemistry (metallurgy) and mechanical engineering the most dominant.

53 Data ranging from 2004 to 2008, compiled by SESRIC from the World Intellectual Property Organisation.

54 Intellectual Property Corporation of Malaysia: Kuala Lumpur, Malaysia.

Figure 1.4. Patents filed in Malaysia granted by field of technology,[55] 1993 to March 2010.[56]



1.7 Bright spots: the macro-perspective of innovation in the Malaysian economy

Beyond the specific characteristics of Malaysia's STI system, there are broader areas of innovation in the Malaysian economy. While this report cannot explore individual sectors in detail, below are a number of examples which highlight the country's success in using particular sectors to drive economic growth.

- In 1975, Malaysia attracted 1.5 million international tourists, generating just RM289.5 million. By 2009, it had become the ninth most popular **tourist destination** in the world, with 23.6 million visitors, generating over RM53 billion in receipts.[57] This success is due largely to a 'Visit Malaysia' campaign, as well as a reorientation and expansion of the services sector.
- Malaysia was one of the earliest proponents of **Islamic banking and financing**—a global industry now worth almost US$1 trillion.[58] This sector continues to grow, although the Gulf States are starting to usurp Malaysia's pioneering role as rival centres of Islamic finance.[59]

55 These patents are broken down according to the International Patent Classification. For more information on what is covered by each category please see http://www.wipo.int/classifications/ipc/en/ Accessed 4 February 2011.

56 Intellectual Property Corporation of Malaysia: Kuala Lumpur, Malaysia.

57 Tourism Malaysia: Kuala Lumpur, Malaysia; Virtual Malaysia, available online at: http://www.virtualmalaysia.com.

58 Baltakji E (2006). *'Islamic finance assets may rise to US$5 trillion', Moody says*. Bloomsberg Businessweek (April): New York, NY, USA.

59 Bakri Musa M (2006). *Towards a competitive Malaysia: development challenges in the 21st century*. iUniverse Inc: Bloomington, IN, USA.

- The **oil and gas** industry is another important driver of the economy. The government-listed company Petronas is credited with pioneering both upstream and downstream innovation (see Chapter 4). There are a number of oil and gas firms owned by royalty in Islamic countries (as is often the case in the Middle East). Some of these could use Petronas as a role model, since it is a world-renowned, market-orientated business.[60]
- There is also great potential in improving the yield and productivity of upstream and downstream activities in **palm oil**. Since Malaysia is the world's second largest producer of palm oil after Indonesia, the economic potential here is significant.
- Within the **aerospace** domain, Malaysia's Air Asia has revolutionised low-cost travel in South East Asia. The company CTRM[61] has blossomed to become a leading global player in the aerospace composites industry.
- **Biotechnology** is another priority for investment, with a focus on nutraceutical and pharmaceutical breakthroughs. Three GRIs (the Agro-Biotechnology Institute, the Malaysia Genome Institute and the Institute of Nutraceutical and Pharmaceuticals) are central to these ambitions.
- Finally, the **ICT** sector remains an important part of Malaysia's STI system, with identifiable pockets of innovation. Malaysia's new international airport, for example, is one of the world's first to use a 'Total Airport Management System'. This assures a maximum flow of information for operations, management and security through the central control of over 40 different electronic systems—a model which is now being picked up by international airports across the world.

Building on these successes while fostering new and emerging priority areas is critical to Malaysia's future. The question now is how far and how fast Malaysia can move from here.

60 Bakri Musa M (2006). *Towards a competitive Malaysia: development challenges in the 21st century*. iUniverse Inc: Bloomington, IN, USA.

61 'CTRM' stands for Composites Technology Research Malaysia, Sdn Bhd.

1.8 Bright spots in scientific research

Throughout the report we have tried to highlight the exciting scientific research going on in Malaysia. We have woven the work and opinions of the scientists we met with into the report, and have provided a small number of more detailed case studies:

- Innovation in diagnostics (Section 3.2)
- The Cancer Research Initiatives Foundation (Section 3.5)
- The Institute of Bioscience, University Putra Malaysia (Section 3.5)
- The Department of Pathology, University of Malaya (Section 3.5)
- Biotech spinoffs (Section 4.6)
- Research at the Malaysian Palm Oil Board's Advanced Biotechnology and Breeding Centre (Section 6.1)
- Research and Training in Biodiversity (Section 6.4)
- Hyperspectral technology in forest management (Section 6.5)
- Taxonomy in biodiversity conservation (Section 6.7)
- Research into the effects of deforestation on biodiversity (Section 6.8)
- International collaboration in structural biology (Section 7.5)
- Universiti Sains Malaysia-Cuba collaboration to develop halal vaccines (Chapter 7)

Where possible, examples of scientific papers are provided as further reading. These examples are inevitably selective and arose from consultation with scientists and academics and with Professor Dato' Dr Zakri, Science Adviser to the Malaysian Prime Minister. They give a snapshot but are not comprehensive, and the authors apologise to those many scientists whose work was unable to be included, particularly those in the physical sciences.

2 People

Dato' Professor Dr Zaini Ujang, the Vice Chancellor at Universiti Teknologi Malaysia (UTM) is passionate about education in Malaysia as he talks of the need to 'elevate' learning. He argues that, for Malaysia to advance, knowledge must be valued at all levels of society, not just by students and the academic community. 'We should not be impressed by the number of professors and PhD-qualified lecturers,' he says. 'The progress of knowledge is cultural in character and should not be measured in numbers alone.'

Despite almost 50 years of unprecedented educational reform, Zaini highlights an important question: is Malaysia's education system today producing a skilled and innovative workforce capable of taking the country forward?

This chapter is about human capital in Malaysia—arguably the most important aspect of any innovation model. It assesses the extensive reforms directed towards democratising education, as well as the rapid expansion in educational options, through private and public universities, colleges and finishing schools. In line with Zaini's advice, it also looks beyond the numbers to wider human capital issues in Malaysia.

2.1 Sons of the soil

A country of diverse culture, Malaysia's population of 28.3 million[62] is made up of around 66% indigenous Malays (referred to as 'Bumiputras', literally meaning 'sons of the soil', which also includes indigenous ethnic groups), 25% Chinese and 7.5% Indian.[63] While this ethnic melting pot is often cited by politicians as part of the richness of Malaysia, it has also sometimes been the cause of friction.

Steady growth post-independence led to a deepening of economic and social inequalities, fuelling racial antagonism and frustration. In 1969, ethnic riots spurred a serious rethink of economic policies to reduce poverty and eradicate 'identification of economic function with race'.

This led to a radically restructured Malaysian society with dramatic government intervention in 1970 to introduce quotas for Bumiputras in employment, business and education. In 1970, Bumiputra students accounted for 53.7% of enrolments at public higher institutions. In 1988, it had increased to 65.3%.

62 Government estimate (2009). Department of Statistics Malaysia: Putrajaya, Malaysia.

63 Appendix, Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

Mahathir oversaw a significant increase in Bumiputra commercial, industrial and professional communities. At the core of Vision 2020 was the need to provide a more equitable distribution of wealth across the different ethnic groups, but particularly for the Bumiputra. As most of the indigenous population are based in rural areas, the challenge to extend the benefits of economic development to these more marginalised communities has been an issue. A detailed analysis of the success of these policies in distributing economic prosperity is not possible here. It is, however, important to acknowledge that ethnicity-based affirmative actions have been a core characteristic of Malaysia's human capital policies in recent decades. While many of the rigid quota systems have gradually been removed, there is still an often unspoken understanding within Malaysia's social structures of the need to ensure adequate representation of the Bumiputra. Malaysia needs to exploit all its talent regardless of racial origin or creed.

2.2 Education expansion

Malaysia has consistently been a strong investor in education as a tool for nation building. From 1970 to 2000, education expenditure averaged 17% of total public expenditure and around 5% of GDP. In 1970, only one-third of the country's population aged six and over had attended school. In 2003, inspired by the Millennium Development Goals for universal education, 98.49% attended primary school. Similar trends are evident at secondary school level. Only 24% had any secondary education in 1970, compared to 68% enrolling in 2007.[64]

In the 1990s, Malaysia's entire higher education system underwent a rapid transformation.[65] In the Eighth Malaysia Plan (2000–2005), nearly 47% of the total development allocation for education was designated for tertiary education, equalling approximately RM8.9 billion.[66] Another area of expansion was in privately provided education. Mahathir decided to open the gates to private and foreign universities, in part to assist public institutions in catering for increasing demand. This capacity issue was exacerbated by the expansion in secondary education and the ethnic quota system which was biased against non-Bumiputra, as well as the impact of the 1997 Asian economic crisis which forced many middle-income families to turn to locally based institutions rather than to education abroad.[67]

64 UNESCO Institute of Statistics: Montreal, QC, Canada. The percentage given is the gross enrolment ratio.

65 The World Bank & Economic Planning Unit of Malaysia (2007). *Malaysia and the knowledge economy: building a world-class higher education system*, March 2007. The World Bank: Washington, DC, USA.

66 Note that the mid-term review of the Eighth Malaysia Plan decreased the share of education as share of investment from RM18.7 billion to RM11.3 billion.

67 Lee M. (2004). *Restructuring higher education in Malaysia*. Monograph series 4. Penang School of Educational Studies, Universiti Sains Malaysia: Minden, Penang, Malaysia.

Prior to this crisis, Malaysian students overseas (approximately 20% of the total student population) cost the country some US$800 million in currency outflow, constituting nearly 12% of Malaysia's current account deficit.[68] By expanding higher education, more students were encouraged to study at home, which helped reduce this deficit.[69] The government also aimed to turn Malaysia into a 'global hub of educational excellence' and a net exporter of tertiary education. As a result of this expansion, the number of private universities went from zero in 1995 to 16 in 2001, while private colleges expanded from 156 in 1992 to 690 in 2001.[70] Foreign university campuses were also encouraged, with Australia's Monash University, Swinburne University, Curtin University and the UK's Nottingham University all establishing Malaysian campuses.

Naturally, there were some teething problems of accreditation and quality assurance associated with such rapid expansion. The government acknowledged these issues; through the 2007 establishment of the Malaysian Qualifications Agency which monitors quality and accreditation, perceptions of substandard education from private providers are being addressed.

Overall, these changes have paid dividends, with students enrolled in undergraduate programmes at public higher education institutions increasing by 37.6% between 2000 and 2003. Enrolments in private universities and colleges, particularly from urban middle-income families, increased by 19.2% between 2000 and 2005. By 2005, almost 650,000 students were enrolled in higher education, representing 29.9% of the 18- to 24-year-old population.[71] International student numbers also experienced an average 36.8% year-on-year growth between 1997 and 2000. By 2008, 70,000 international students were enrolled in Malaysian universities, with China (10,355), Indonesia (10,020), Iran (6,245) and Nigeria (6,054) the most common countries of origin.[72]

Table 2.1 provides an overview of the impressive expansion in education enrolments from 1997 to 2005, as well as the latest, albeit incomplete, data for 2008–2009.

68 Arokiasamy A (2010). *The impact of globalization on higher education in Malaysia*. Genting Inti International College (figures from 1995): Gohtong Jaya, Malaysia.

69 Arokiasamy A (2010). *The impact of globalization on higher education in Malaysia*. Genting Inti International College (figures from 1995): Gohtong Jaya, Malaysia.

70 The World Bank & Economic Planning Unit of Malaysia (2007). *Malaysia and the knowledge economy: building a world-class higher education system*, March 2007. The World Bank: Washington, DC, USA.

71 The World Bank & Economic Planning Unit of Malaysia (2007). *Malaysia and the knowledge economy: building a world-class higher education system*, March 2007. The World Bank: Washington, DC, USA.

72 International Students Statistics (as at 31 December 2008). Ministry of Higher Education: Putrajaya, Malaysia.

Table 2.1. Education enrolments from 1997 to 2010.

	Field/Year	1997	1999	2001	2003	2005	2008	2009	(2010*)
Enrolment of students at bachelor's level	Arts	59,967	71,083	87,482	90,925	95,686			
	Science	27,100	40,202	58,029	65,235	69,218	185,733	187,254	
	Technical	19,995	32,686	37,138	36,128	44,244			
	Total	107,062	143,971	182,649	192,288	209,148			(428,200)
Enrolment of students at doctoral level	Arts	858	1,450	1,898	2,514	3,981			
	Science	531	1,037	1,331	2,034	2,398	6,542	7,584	
	Technical	261	525	627	520	1,260			
	Total	1,650	3,012	3,856	5,068	7,639			(21,680)
Output of students at doctoral level	Arts	57	117	199	279	310			
	Science	51	61	159	193	207	481	396	
	Technical	5	15	128	144	64			
	Total	113	193	486	616	581			

Data from 1997 to 2005 sourced from[73]; data from 2008 and 2009 sourced from[74]. This data includes science and technical subjects and includes both public (90% of individuals) and private institutions (10% of individuals).

*2010 numbers are estimates from the Ninth Malaysia Plan, Ministry of Higher Education. Detailed breakdowns are not available.

This expansion has led to an increase of 144.6% in the number of students enrolled in science and technical subjects at both undergraduate and doctoral levels between 1997 and 2005. According to the latest government indicators, this impressive trend has continued with a rapid escalation in student numbers from 2005 to 2009, with enrolment in S&T subjects at undergraduate level growing a further 39% to 185,733 students; while doctoral level numbers grew by over 50% to 7,584.[75] Graduate numbers are also encouraging, with over 40,000 undergraduates finishing their studies in 2009.[76]

Government policy is now focused on shifting the balance of student enrolment to a 60:40 ratio in favour of science-based studies at doctoral level.[77] This will largely depend on an increased focus within secondary education upon these fields, as well as ensuring sufficient career opportunities and incentives within the broader economy.

73 Adapted from The World Bank & Economic Planning Unit of Malaysia (2007). *Malaysia and the knowledge economy: building a world-class higher education system* (March). The World Bank: Washington, DC, USA. This report cites Statistics 2005, Department of Higher Education, Malaysia. However, no indication is provided as to whether these data are limited to the public system or if they include the private system.

74 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

75 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

76 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

77 Ministry of Higher Education (2007). *National Higher Education Action Plan 2007–2010*. Ministry of Higher Education: Putrajaya, Malaysia.

Such heightened investment and expansion in education in recent decades is not unique to Malaysia. It reflects a broader trend across much of the region, with Singapore the standout performer. Thailand has also announced a 10-year Science and Technology Action Plan, which aims to increase the number of Thais entering tertiary education and to attract 150,000 foreign students by 2015, up from 97,000 in 2008.[78] Indonesia has doubled its R&D budget in the past five years, and increased its spending on education to 3.5% of GDP in 2006, compared to 2.5% in 2001.[79] These regional neighbours present opportunities for collaboration, but also highlight the need for Malaysia to continue investing in order to stay competitive.

2.3 Out-ranking

According to the globally recognised international university rankings, Malaysia is some way from achieving its ambition to become a global leader in higher education. Currently, no Malaysian university comes close to the top 100 universities of the world. Malaysia is unrepresented in the 2010 Shanghai Jiao Tong index.[80] The University of Malaya, the country's oldest university (established in 1949), is the nation's top performer, ranking 180th in the 2009 Times Higher Education Index; however, UM disappeared off the 2010 chart.[81] If one uses publication rates as a benchmark for comparison, output from UM would need to increase over six times to match the neighbouring National University of Singapore, ranked 34th in the 2010 rankings, and more than seven times to match the American academic powerhouse of MIT (ranked 3rd).[82] Such comparisons demonstrate the scale of the task Malaysia has set itself.

However, such rankings do not capture the positive advances that have occurred in Malaysian higher education, nor do they appreciate how young these institutions are. While the University of Oxford has had over 800 years to develop into the world-class institution it is today, Malaysia's oldest university is just over 60 years old. In 2008, the Ministry of Higher Education outlined its 'transformation plan' which places greater emphasis on quality, competitiveness, creativity and innovation. It also sought to encourage a more international outlook, autonomy and accountability.

78 Irandoust S (2010). *Thai higher education needs public–private investment*. The Nation (February): Bangkok, Thailand.

79 The World Bank (2007). *Investing in Indonesia's education: allocation, equity, and efficiency of public expenditures*. The World Bank: Washington, DC, USA.

80 *Shanghai Jiao Tong Academic ranking of world universities* (2010).

81 *Times Higher Education–QS world university rankings* (2009). The University of Malaya ranked 230th in the same index in 2008. In 2010, Times Higher Education published a new ranking system; no Malaysian university was present in the top 200.

82 *Times Higher Education world university rankings* (16 September 2010). Times Higher Education: London, UK. Between 2004 and 2008, UM published 2,955 articles—an average of just under 600 per year. MIT (ranked 3rd) published 22,367 articles over the same five years, and the National University of Singapore published 18,521 articles.

Central to this strategy was transforming a number of established universities into focused 'research universities'. Within this process, universities were encouraged to participate in a competitive process to carry out an 'Accelerated Programme for Excellence'—in what became known as APEX Universities. Nine universities applied, of which four were shortlisted. In 2008, the Universiti Sains Malaysia (USM), which was established in 1969 and based in Penang, became the first APEX University. With this title came promises of greater autonomy in governance, finance, admissions (within an appropriate ethnic balance[83]), as well as prioritised infrastructure investments[84]—highly valued prizes in the controlled structure of Malaysia's education system. The extent to which such flexibility has been applied is still yet to be determined.

The USM Vice Chancellor, Professor Tan Sri Dato' Dzulkifli Abd Razak, sees the APEX initiative as part of a recognition within government that autonomy is critical for the fostering of excellence and accountability in higher education. He explains that 'the command-and-control mode of operation that has long beleaguered our universities is being gradually dismantled. The new relationship is now based on trust and respect, instead of fear.'[85]

But the dismantling of state control has some way to go. In non-APEX institutions, the Ministry of Higher Education still tightly controls all student admissions, course structure, remuneration and financial management. Academic mobility between universities is extremely limited and can even jeopardise retirement benefits.

If Malaysian universities are to become more globally renowned, autonomy and academic freedom must extend beyond just one APEX university. According to Dzulkifli, such reforms could make Malaysian universities more dynamic and competitive, and enable them to attract better local and international talent. Worldwide experience suggests that competition drives excellence, while greater autonomy will empower the student, academic and broader research community. Facilitating this shift should be an urgent priority of MOHE, working with universities to develop more flexible yet robust models for accountability. Within universities, closer links between research and teaching have also proved to inspire more inquiry-driven teaching mechanisms, rather than the rote-learning models often applied in Malaysia. In many universities a greater emphasis needs to be placed on discussion, to create a climate in which staff and students can debate and question the aims of the research and the outputs.

83 Ministry of Higher Education (2007). *National Higher Education Action Plan 2007–2010*. Ministry of Higher Education: Putrajaya, Malaysia.

84 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

85 Razak, *Audacity of hope*, available online at: http://notes.usm.my/VC's%20Article.nsf.

2.4 Skilled graduates wanted

One might assume that an expansion in higher education opportunities would result in an impressive supply of knowledge workers ready to enter the Malaysian economy. The reality is more mixed. According to government figures, the number of science and technology researchers in the workforce has been steadily climbing from *circa* 6,000 in 1998 to *circa* 24,000 in 2008, representing 21.6 per 10,000 jobs in the total labour force.[86,87] The Malaysia Higher Education Plan 2007–2010 has set an ambitious target of 100 researchers per 10,000 jobs in the total labour force by 2020.[88] It seems unlikely that this will be achieved at the current rate of progress.

Yet, despite these improvements, an analysis of the local talent base as part of the NEM, released by Prime Minister Najib in April 2010, cited significant talent shortfalls as a clear impediment to economic growth. According to the Tenth Malaysia Plan, 77% of the workforce is only educated to secondary school level, and only 28% of Malaysian jobs are in the higher skilled bracket.[89]

According to Associate Professor Dr K Thiruchelvam, a science policy analyst from the University of Malaya, 'such statistics present a very sad picture for Malaysia. It's like we are trying to run this race to become a knowledge-based economy, but our legs are tied. We can replicate the buildings of Stanford or Silicon Valley, but it's the soft skills—the skills of critical and innovative thinking in our students that we need to work on.'

A recent World Bank report found that Malaysia's 'tertiary education system is fundamentally disadvantaged by a secondary system that is not preparing its students for university education'.[90] Only 14% of tertiary entrants went on to graduate in 2004, compared to 24% in neighbouring Thailand, 34% in Korea and 35% on average across the OECD.[91] For Malaysia to truly advance, this significant imbalance needs urgent attention.

This also poses serious issues for the government's stated target of 'fast-tracking' towards 100,000 PhD holders by 2020, under the 'MyBrain15' initiative announced in 2007.[92] In 2008, Malaysia had under 4,000 PhD students[93]—over half of whom are educated outside Malaysia. If the current education system is underpreparing students for undergraduate education, the targets for expansion at PhD level seem unrealistic.

86 Government of Malaysia (2008). *Malaysian science & technology indicators 2008 report*. MOSTI, Putrajaya, Malaysia.

87 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

88 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

89 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

90 The World Bank & Economic Planning Unit of Malaysia (2007). *Malaysia and the knowledge economy: building a world-class higher education system*, March 2007. The World Bank: Washington, DC, USA.

91 The World Bank & Economic Planning Unit of Malaysia (2007). *Malaysia and the knowledge economy: building a world-class higher education system*, March 2007. The World Bank: Washington, DC, USA.

92 Ministry of Higher Education (2007). *National Higher Education Action Plan 2007–2010*. Ministry of Higher Education: Putrajaya, Malaysia.

93 *The Star newspaper* (28 September 2008): Petaling Jaya, Malaysia.

2.4.1 Engineering and technical talent

As a key component of Malaysia's ambition to become a knowledge-based economy, engineering education in Malaysia is also rapidly expanding. According to the recent UNESCO Report on Engineering, over 128,000 students in Malaysia were enrolled in tertiary level engineering education in 2005—a total of 18.4% of all students in the country.[94] This compares to 292,623 in Turkey (13.9%) and 70,089 (16.4%) in Sweden.[95] In 2004, 47,620 engineering students graduated from tertiary education, accounting for 23.5% of all graduates for that year. This is slightly higher than the 19.3% in Turkey and 20.1% in Sweden.[96] These numbers need to be treated with caution, however, as they are not compatible with government figures on overall student numbers. UNESCO also acknowledge the need for improved statistics and indicators on engineers *per capita*, just as can be done for doctors and teachers.

In 1996, the duration of the engineering degree programme was reduced to increase the supply of trained engineers. This change was opposed at the time by the Institute of Engineers Malaysia and several higher education institutes. The shortened engineering degree does not encompass non-technical skills such as communication and management,[97] deemed critical if engineers are to play a more prominent role in the country's development. In part to address this, it has been proposed that engineering degrees should include humanities training.

Malaysia is trying to tie the growth of the manufacturing industry to the supply of engineers not only in terms of numbers of trained people, but also in the specificity of their qualifications. There are ambitions to move from a focus on fabrication in the manufacturing industry towards higher value, front-end aspects such as design. This needs to be reflected in the training offered by universities.

With the government aiming to establish Malaysia as an outsourcing destination, a strong supply of trained engineers will be vital to meet this ambition. Engineering plays an important part in wealth creation[98]; however, there are fears that Malaysia may be facing a shortfall in engineers. In 2009, Professor Chuah Hean Teik, President of the Institute of Engineers Malaysia, predicted that the present 60,000 engineers in the country would need to be increased to 200,000 engineers by 2020 in order to meet the economic needs of Malaysia.[99] As of 2010, there are a total of 53,633 registered graduate engineers in Malaysia.[100] In his annual 2010–2011 presidential address, Professor Chuah drew attention to the predicted global

94 UNESCO (2010). *Engineering: issues, challenges and opportunities for development*.

95 UNESCO (2010). *Engineering: issues, challenges and opportunities for development*.

96 UNESCO (2010). *Engineering: issues, challenges and opportunities for development*.

97 Megat Johari MMN et al. (2002). *A new engineering education model for Malaysia*. International Journal of Engineering Education 18, 8–16.

98 Azami Zaharim M et al. (2009). *International trends and the profiles of Malaysian engineers*. European Journal of Scientific Research 2, 301–309.

99 UNESCO (2010) Engineering: issues, challenges and opportunities for development

100 Board of Engineers Malaysia. http://www.bem.org.my/v3/index.html, accessed 8 December 2010.

demand for engineering services throughout most sectors, with only around 10% of the world's work taking place in the US and other developed countries. With appropriate investment in both human capital and business development, this could represent a significant opportunity for Malaysia.

Another critical aspect of human capital is the development of a talented pool of technicians and other support staff who are essential in the maintenance of highly complex scientific instruments and machinery. In Malaysia, the number of technicians has declined from over 3,000 in 2002[101] to 1,480 in 2008.[102] Some argue that a perception of vocational training as inferior to university qualifications is deterring would-be technicians. Yet these are rewarding careers that are fundamental to the STI system and should be promoted as such. Similarly, innovation can be further strengthened by having a greater number of engineers and technologists with vocational skills. The Tenth Malaysia Plan has introduced some new measures to improve and streamline technical education and vocation training, including initiatives to improve perceptions and to more closely match curriculum with industry needs. Such initiatives are much needed.

101 UNESCO Institute of Statistics: Montreal, QC, Canada.

102 *Malaysian science and technology indicators 2010*. MOSTI (pre-publication copy).

Box 2.1. Examples of priority driven engineering

Associate Prof Dr Robiah Yunus, Acting Dean and Deputy Dean of Research and Post Graduate Studies, Universiti Putra Malaysia

The Faculty of Engineering at the Universiti Putra Malaysia has eight research areas: agriculture and biosystem engineering, food and process engineering, civil engineering, mechanical and manufacturing engineering, chemical and environmental engineering, computer and communication engineering, electrical and electronics engineering, and aerospace engineering.[103] In the last five years, the faculty members have obtained almost RM44 million worth of research grants from various public and private sectors. Over half of UPM patents are filed by engineering faculty members. The faculty gives priority to multidiscipline research in green technology, cleaner processes and alternative bio-based materials. The search for energy saving systems, renewable energy supplies and use of environmental friendly materials is pursued, strongly motivated by public demand. The intelligent use of waste resources to produce bioenergy represents one area where the faculty aims to innovate new technology. There is an active program in agricultural process engineering, which emphasises the use of engineering principles in post-harvest handling, preservation and processing of agricultural materials. In food engineering, research includes the application of process and biochemical engineering principles in food-processing operations. Water and wastewater engineering research involves three disciplines—agriculture, chemical engineering and civil engineering. The civil engineering projects also encompass structural engineering, construction and building materials, transportation and highway engineering, geological engineering, and remote sensing. The engineering faculty also includes computer and communication engineering, intelligent systems engineering, photonics, and fibre optic systems engineering. Research in power system quality and reliability, micro- and nano-electronic systems, control systems, and signal processing are the niche areas in the electrical and electronics engineering department while in aerospace engineering areas such as aerodynamics, propulsion and thermofluids, avionics systems and technology, and aerospace vehicle design are active.

103 Selected recent publications: Ahmad Hambali NAM *et al*. (2010). *Single-wavelength ring-cavity Brillouin-Raman fiber laser*. Laser Physics Letters **7**, 454–457; Sahazamanian MM *et al*. (2010). *Finite element analysis of thermoelastic contact problem in functionally graded axi-symmetric brake disks*. Composite Structures **92**, 1591–1602; Abd Aziz S *et al*. (2010). *Using spatial uncertainty of prior measurements to design targeted sampling of elevation data*. Transaction of ASABE Journal **53**, 349–357.

2.5 Critical thinkers required

In our interviews across Malaysia, the need to strengthen the critical thinking skills of university students and graduate employees was consistently raised as one of the country's biggest challenges. Many experts spoke of the need to inspire a more questioning mindset among students.

Even among those who do complete university, problems of employability permeate the system. Since 2000, the number of unemployed persons with tertiary-level qualifications has grown by 74.5%, from an estimated 42,500 to 74,182 by 2004.[104] According to The World Bank, there are numerous factors at play here, including the rapid expansion of higher education which has increased the supply of graduates, and the slowing of growth in the wider Malaysian economy. Yet some universities are now investing in 'finishing schools' to ensure that their students have the skills they need to get ahead, and the government has announced a new RM500 million scheme to assist unemployed graduates with their confidence, IT and language skills.[105]

The Penang Skill Development Centre (PSDC), for example, aims to bridge the gap between industry and education within the island state. Established in 1989, it now offers short courses in finance, administration and experiment design, as well as longer diplomas and degrees in several fields of engineering. According to its Chief Executive, Dato' Boonler Somchit, the last 10 years have seen a marked decrease in students' ability to be creative. 'They are good at knowing their subject matter,' he says, 'but not the creative part. PSDC is trying to revive a spirit of life-long learning.' The fact that such 'finishing schools' are needed, particularly post-university, is not necessarily a positive sign.

2.6 Absorption, retention and reaching out

This capacity of the private sector to absorb graduates with an appropriate skill base is important for Malaysia's future economic growth. In most advanced scientific nations, the vast majority of R&D personnel work in the private sector. In Malaysia, the majority work in IHLs (44.5%) or GRIs (16.8%), rather than the industrial sector (38.6%). While this far exceeds emerging research powers like Brazil (with only 1% employed in industry), there is still much room for improvement.[106] The lower numbers of R&D personnel in the private sector is reflective of the MNC-driven industrial structure of Malaysia, with activities still at the lower end of the value chain.

104 The World Bank & Economic Planning Unit of Malaysia (2007). *Malaysia and the knowledge economy: building a world-class higher education system*, March 2007. The World Bank: Washington, DC, USA.

105 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

106 Bound K (2008). *Brazil—the natural knowledge economy*. Atlas of Ideas, Demos: London, UK.

As well as absorbing new stocks of home-grown graduates, Malaysia must stem the continuous flow of talent from its borders, and reach out more effectively to its diaspora communities. It is currently estimated that 1.5 million Malaysians live abroad, with Singapore, Australia, the USA and the UK among the most common destinations.[107] This issue is compounded by skilled expatriates leaving Malaysia. Between 2000 and 2008, the number of skilled expatriates in Malaysia fell from 85,000 to under 50,000.[108]

2.7 Talent incorporated

The Malaysian Prime Minister's personal support for talent development, attraction and retention has led to the creation of a Talent Corporation, announced recently in the Tenth Malaysia Plan. This corporation is set to drive talent initiatives across Malaysia, with an impressive RM2.26 billion dedicated to funding more PhD students, and another RM500 million for educational loans through the Skills Development Fund.[109] The Tenth Malaysia Plan also acknowledges the contribution of highly skilled migrants to the national economy, and outlines greater visa flexibility to fulfil public and private sector skill gaps, managed through the new Talent Corporation.

Diaspora communities are also in the sights of the Talent Corporation. Inspired by China's 'Hundred Talents' programme and India's dedicated Ministry of Overseas Indians, the government launched its 'Brain Gain' programme in December 2006 to attract back the Malaysian diaspora of all ethnic groups. So far, this initiative has had limited success. According to one recent returnee, 'there is a strong desire amongst Malaysians abroad to come back and serve our country, but the government doesn't seem too serious about it all—the system is too rigid and inflexible'. The government recently announced further incentives to target talented Malaysian students and professionals abroad in 'critical fields'.[110] Top students currently overseas will have the final year of their study paid for by the government on condition that they return.

Such schemes send an important signal to diaspora communities, but the real enticement home will be the availability of high-quality, rewarding careers and appropriate infrastructure. Beyond tax incentives, it is the intellectual environment, equipped with first-rate, internationally competitive research facilities and a good supply of bright, well trained graduate students or research assistants, which will prove the stronger magnet—both for diaspora and talent generally. Newly established research facilities in the Middle East are a case in point. Saudi Arabia's

107 *South–South migration and remittances* dataset (2006). University of Sussex and The World Bank: Washington, DC, USA. The emigration rate of tertiary-educated Malaysians in 2000 was 10.4%: see *The World Bank migration and remittances factbook* (2008). The World Bank: Washington, DC, USA.

108 Sheng (2010). *Re-energising the private sector: the role of government and government-linked companies (GLCs)*, presentation.

109 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

110 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

King Abdullah University for Science and Technology (KAUST) and the Masdar Initiative in the UAE are two of the best known examples of how large-scale investment in research facilities can enable countries to attract the world's best, despite the perceived disadvantages of climate, governance and social restrictions. Greater investments are still urgently needed in Malaysia. At present, structures to encourage academic excellence remain limited. Peer review processes are sometimes weak because the pool of expertise in particular fields is limited.

Even if the diaspora remain overseas, there is much to be gained from drawing more effectively on the networks and experience of foreign-based Malaysian researchers and entrepreneurs. Malaysia's ethnic diversity provides a unique link to the emerging economic superpowers of China and India which could be more effectively exploited. As innovation becomes increasingly global, these collaborative networks will be crucial—a theme explored in Chapter 7.

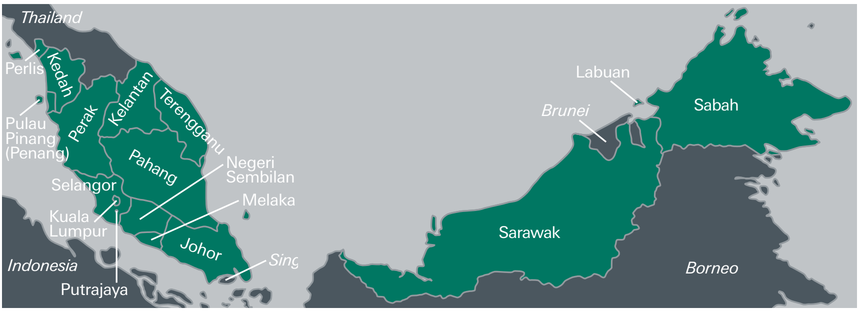
3 Places

Long distance relationships can be tough. Separated by approximately 500 km of South China Sea, the two main regions of East and West Malaysia, of broadly equal size, are testimony to this type of challenge. Ever since independence, the need to create a national identity and unity between these distant lands has been paramount. Fifty years later, Malaysia's policy makers still worry about how to ensure a more equitable distribution of wealth, while maintaining social cohesion and national unity. In the area of research activities the results are mixed. Peninsula Malaysia dominates, with Kuala Lumpur the clear epicentre for science and innovation. However, this is changing slowly. This chapter explores these patterns and highlights emerging hotspots of innovation.

3.1 National ambition, uneven distribution

Situated in the heart of South East Asia, Malaysia is comprised of a federation of 13 states and three federal territories—the Federal Territory (which is essentially Kuala Lumpur), Putrajaya on the peninsular side (the federal administrative capital, established in 1999) and Labuan in Sabah. See Figure 3.1.

Figure 3.1. Malaysia and its states.[111]



In Chapter 1, we described the Federal Government's central role in developing the national STI system. How closely this aligns with regional authorities and industries outside Kuala Lumpur and its surrounding state of Selangor is another question.

111 Wikimedia Commons.

Table 3.1 reflects the uneven distribution of national R&D expenditure across the states and federal territories. Pulau Pinang (commonly referred to as Penang) and the Klang Valley (comprised of Kuala Lumpur and Selangor) account for almost 79% of the total R&D in 2006, which reflects the concentration of institutions of higher education and technology-based industries in these areas. Sabah and Sarawak, however, account for just 2.5% between them.

Table 3.1. Share of regional R&D expenditure (%).[112]

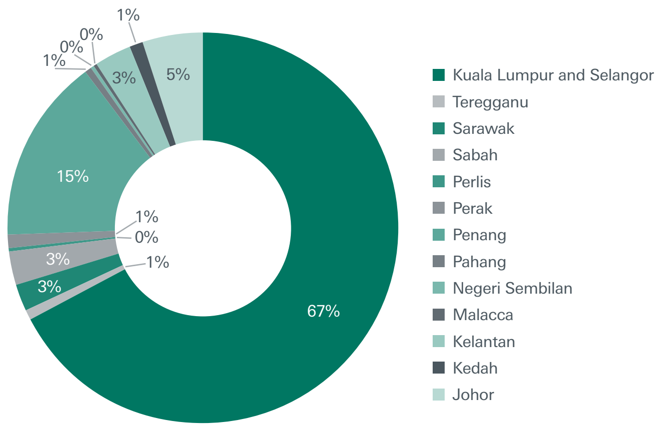
	1992	1994	1996	1998	2000	2002	2004	2006
More developed regions								
Johor	5	3.3	4.4	6.5	11.1	7	9.9	3.6
Melaka	0.9	1.5	2.5	1.3	2	0.8	3.9	1.0
Negeri Sembilan	1.6	2.1	1.9	1.2	3	0.6	1.2	1.0
Perak	2.4	2.3	3.4	4	6.1	1.7	5.1	1.5
Pulau Pinang	15.8	7.6	12	21	9.3	22.4	10.2	54.5
Selangor	55.2	54.8	57.1	42.6	36.5	45.9	35.5	23.9
FT Kuala Lumpur	5	12.5	7.1	15	13.7	13.7	15.0	7.5
Sub-total	*85.9*	*84.1*	*88.4*	*91.7*	*81.9*	*92.2*	*80.8*	*93.0*
Less developed regions								
Kedah	3.1	3.7	2.8	1.9	3.1	2.2	6.0	1.8
Kelantan	1.4	0.5	0.7	0.5	1.4	0.9	1.1	0.5
Pahang	1.5	1	0.4	0.4	2.3	0.8	1.7	0.8
Perlis	0.2	0.4	0.3	0.2	1.4	0.5	1.0	0.2
Sabah	3.1	5.9	3.8	1.8	4.5	1.2	3.3	1.6
FT Labuan	0	0	0.1	0	0.4	0.2	0.1	0.1
Sarawak	3.3	2.9	3.2	3.2	3.4	1.4	2.6	0.9
Terengganu	1.6	1.5	0.4	0.4	1.6	0.6	1.3	0.3
Subtotal	*14.1*	*15.9*	*11.6*	*8.3*	*18.1*	*7.8*	*17.1*	*6.2*
Grand total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*

112 Government of Malaysia (2008). *National survey of research and development 2008: summary.* MOSTI, Putrajaya, Malaysia.

Such uneven distribution of STI investment is by no means unique to Malaysia. The geographic distribution of scientific spending and capacity is highly concentrated in most countries, particularly those which are more scientifically advanced. For example, in the USA almost two-thirds of R&D spending was concentrated in 10 states in 2003—with California alone accounting for more than one-fifth.[113]

Malaysia's R&D distribution is influenced by settlement patterns as well as economic realities. Sabah and Sarawak, for example, are sparsely populated and largely covered in mountainous terrain. More populated industrial areas such as Kuala Lumpur and Penang have proved more able to absorb ideas, attract talent and create opportunities—albeit with continuous room for improvement. The dominance of these cities is reflected in the regional variation in scientific publications, as demonstrated in Figure 3.2.

Figure 3.2. Share of publications by state (%), 2004 to 2008.[114]



113 Wagner C (2008). *The new invisible college: science for development*. Brookings Institution Press: Washington, DC, USA.

114 Data provided by Elsevier.

With policy (and financial support) directed at the Federal level, the challenge for Malaysia is how to develop a national STI strategy that takes into account where strengths and capacity lie throughout the country, as well as recognising where there are duplications. Investment in regular but coordinated technology foresight exercises which look 10 to 20 years ahead is a vital tool for national planning. Such exercises not only help in trying to predict the future, but also in shaping and harnessing future opportunities.[115]

At present, there is only limited adaptation of national priorities to individual state characteristics. According to one state official in Sabah, for example, 'We don't have a clear policy for STI, so we don't know what we should focus on. We try to follow the national policy, but we lack expertise and there are other priorities.'

3.2 Small island, big connections

Penang, a small island off the west coast of Malaysia, is one example of a place with innovation ambitions. According to the Chief Minister, Lim Guan Eng, Penang is in the process of transforming itself into a knowledge-intensive city, driven by energy, expertise and entrepreneurship. It also aspires to be the first state in Malaysia where universal WiFi is provided free of charge, and has pledged to create Malaysia's first 'eco town'.[116]

While other states have yet to find their niche, Penang has a strong manufacturing base, specifically in the electrical and electronics industries. Manufacturing contributes almost 43% of the state's GDP and 12% of its employment.[117] Since the 1970s, Penang's proactive campaigns to attract MNCs through targeted incentives, competitive overheads and available talent have paid off, and Penang has established a comparative advantage in electronics, telecommunication equipment and computer-related products.[118]

Unfortunately, Penang's ability to attract high-tech MNCs has yet to translate into the nurturing of local innovative capacity. Despite generous incentives at State and Federal levels, few innovative local firms have been established, and academic–industry linkages remain weak. With cheaper manufacturing options emerging in China, Vietnam and elsewhere, there is legitimate concern that Penang will lose its competitive edge.

According to Professor Dr Asma Ismail (see Box 3.1), Deputy Vice-Chancellor (Research and Innovation) at USM, most businesses in Penang are interested in property development rather than genuine R&D. 'That takes a deep pocket

115 Tegart G (2003). *Technology foresight: philosophy and principles*. APEC Center for Technology Foresight: Bangkok, Thailand.

116 Lim GE (2010). *Think globally, act locally: a blueprint for Penang's transformation*. Penang Economics Monthly 2 (February), 10.

117 Amri A & Thiruchelvam K (2006). *Public governance of the national innovation support system on regional technological capability building: case studies from Malaysia*. Malaysian Journal of Science and Technology Studies; Volume 4. Malaysia.

118 Yusuf S & Nabeshima K (2009). *Can Malaysia escape the middle-income trap? A strategy for Penang*. Policy Research Working Paper, June 2009. The World Bank: Washington, DC, USA.

Spanning 13.5km to provide a link between Gelugor on Penang to Seberang Prai on the mainland, the Penang Bridge is the longest in Asia (travel2malaysia.com)

investment', she says, 'but who is willing to invest and then wait 4–5 years to see if it pays off? We need MNCs who are willing to work with us to build STI capacity.'

Penang could draw important lessons from Singapore's industrial policy which was similarly dependent on MNCs to underpin its successful technological manufacturing sector in the 1970s. Singapore has since transformed its economy to a more balanced model that places greater emphasis on indigenous innovation and the creation of local high-tech firms. To facilitate this transformation, the Singaporean Government invested in strategic research institutes as well as enticing foreign firms to perform more local R&D.[119]

Encouragingly, Penang has a strong base from which to build. It is home to the country's APEX university (USM), which produced 1,354 PhD students in 2007,[120] has developed over 100 patents, and successfully attracted over 190 research grants in 2009.[121] Respected research institutions such as the Malaysian Institute of Pharmaceuticals and Nutraceuticals (I-Pharma) are based in Penang. A new science park is being created by USM in collaboration with Khazanah Nasional and six other corporations. The park, called sains@USM (to be completed by 2013), will house incubator laboratories and a graduate business school, as well as MNC-linked research centres.[122] The Penang Science Council, led by the Chief Minister, has also been established to inspire interest in science and facilitate stronger linkages between industry and academia.

119 Monroe T (2006). *The national innovation systems of Singapore and Malaysia*, in collaboration with Professor Samphantharak.

120 USM student profile, Universiti Sains Malaysia: Penang, Malaysia.

121 Ismail A (2009). *USM R&I: from BRAINS to BUSINESS to HUMANITY, creating national and global impact*. Presentation.

122 Sains@USM, Universiti Sains Malaysia: Penang, Malaysia.

Box 3.1. A snapshot of science: innovation in diagnostics

Professor Dr Asma Ismail understands the challenges for researchers in developing countries, struggling with a lack of adequate facilities and funding. Trained in the US, Dr Ismail returned to Malaysia passionate about conducting research that could be applied in her lifetime and that would provide solutions which were accessible to all society. She chose to focus on diagnostics rather than vaccines or drugs because bio-diagnostics benefit from little regulation, fast turnover for product development, lower costs, and minimal skills required by the user.[123] Combining scientific discovery with the technology platform she had learned in the US, Dr Ismail's research team at USM created *typhidot* —a diagnostic kit to detect acute typhoid. This kit enables treatment for the carrier, creation of a carrier registry, isolation of *S. Typhi* from the carriers, and the monitoring and reduction of transmission of the disease—all factors which help reduce overall health costs incurred by the government. With support from the Malaysian Government, USM were able to patent the product in 1994—at a time when patenting and commercialisation were highly unusual in Malaysia. *Typhidot* became the flagship product of USM and the government created a spin-off company to commercialise the product globally. Over 15 years later, it is still on the market and generating royalties for USM. More importantly, the kit launched the biodiagnostic industry in Malaysia and the research is genuinely benefiting Malaysians today—just as Dr Ismail wanted.

Building on this experience, Dr Ismail also helped to establish the Institute for Research in Molecular Medicine (INFORMM) at USM—the first multidisciplinary cluster-based research institute in Malaysia. In just five years, researchers at INFORMM have successfully commercialised rapid diagnostic tests in filariasis, cholera, dysentery and for typhoid carriers. But, as Dr Ismail explains, 'what's more important is that it has created a pathway for a lot more research to be able to see success out of the R&D rather than just working in the lab and producing publications'.[124]

123 Ismail A (2010). *Translating for the people*. Universiti Sains Malaysia: Penang, Malaysia.

124 Ismail A (2010). *Translating for the people*. Universiti Sains Malaysia: Penang, Malaysia.

3.3 Something to look up to

Dominating the skyline of Kuala Lumpur, the Petronas towers—the tallest in the world from 1997 to 2004 and still the tallest twin towers—symbolise Malaysia's transformation into a modern economy. But they are just one of many mega-projects initiated by former PM Mahathir in order to put Malaysia on the map. Others included the development of Kuala Lumpur International Airport (KLIA), the creation of two 'smart cities' (Putrajaya and Cyberjaya) and the establishment of Malaysia's own 'Proton' car company with a complementary Formula 1 circuit. With the majority of this based in the capital, there was a clear strategy to develop Kuala Lumpur as the heart of Malaysia's Vision 2020, with regional initiatives to follow in time.

The ambitious Multimedia Super Corridor (MSC) was one project specifically designed to catapult the Malaysian economy into the digital age.[125] Roughly equivalent in size to Singapore, the MSC expands from the centre of Kuala Lumpur as far as the KLIA. With an estimated final cost of US$20 billion, this 20-year project was envisaged to 'be an island of excellence in multimedia-specific capabilities' and 'a test bed for invention and research'.[126] Since its creation in 1996, the MSC has attracted some big names including Shell, BMW and Ericsson, as well as many local businesses. According to the MSC, it boasts over 1,500 operational businesses (as at 2007), supports approximately 19% of Malaysia's total ICT workforce, and MSC companies contribute 1.2% to the local economy.[127]

Yet these figures do not tell the whole story. MSC has fallen short of Mahathir's original aspirations to attract US$4 billion of investment.[128] Critics claim the MSC is no more than a tax haven for offshore financial and call centres, and point out that few major ICT companies are using the MSC as a central hub in their global R&D effort. With steep competition from neighbouring Singapore and Hong Kong, such ambitions now seem overblown.

South Korea again provides a useful comparison here in terms of the value of long-term, large-scale investments in technology infrastructure. Since the late 1990s, the South Korean Government has heavily invested in its broadband infrastructure, particularly in rural areas as a key tool in bridging the digital divide. A key aspect of its strategy has also been to encourage private investment. This investment is now paying dividends, with Korea now ranked number one in the Economist Intelligence Unit's Broadband Index.[129] This index assesses countries on the basis of government broadband planning, including factors like speed and regulation.

125 Abbott J (2004). *Mahathir, Malaysia and the Multimedia Super Corridor: development catalyst, white elephant or cultural landmark. In: Public Policy, Culture and the Impact of Globalisation in Malaysia*. Shah M & Lit P (eds). Persatuan Sains Sosia: Kuala Lumpur, Malaysia.

126 Lie Sien Cha (2003). *Southeast Asia transformed: a geography of change*. Institute of Southeast Asian Studies: Singapore.

127 *MSC Malaysia impact survey* (2008). Multimedia Development Corporation: Cyberjaya, Malaysia.

128 Abbott J (2004). *Mahathir, Malaysia and the Multimedia Super Corridor: development catalyst, white elephant or cultural landmark. In: Public Policy, Culture and the Impact of Globalisation in Malaysia*. Shah M & Lit P (eds). Persatuan Sains Sosia: Kuala Lumpur, Malaysia.

129 The Economist Intelligence Unit (2011). Government Broadband Index, February.

While developed countries like Australia, the UK and the US are still grappling to provide even basic broadband access, most South Koreans can enjoy high-speed fibre-optic services for just $30 a month.[130] With similar careful planning, financial support and private sector engagement, MSC could also achieve its ambitions. To do so will require long-term government commitment and prioritisation.

3.4 One corridor leads to another

Following the MSC, the original plan was to roll out similar technology corridors and cyber-cities across the country. There are currently plans for five key 'corridors for development', in Sabah, Sarawak, Johor and in the north and east of Peninsular Malaysia. Some critics argue that Malaysia's solution to everything is simply to brand it a corridor. In Sarawak, for example, there is a new 'Sarawak Corridor of Renewable Energy' or SCORE, a 22-year initiative designed to attract RM334 billion of investment.[131] What makes this a corridor targeted towards 'renewable' energy as opposed to a broader investment drive across the state can be difficult to distinguish.

3.5 The quiet achievers: new models for research

Professor Teo Soo-Hwang is the Chief Executive of the Cancer Research Initiatives Foundation (CARIF). She explains how her centre focuses on the diseases most commonly found in Asian countries, such as oral, mouth and throat cancers. Established in 2001, CARIF now has 24 staff[132] and a growing reputation in cell and molecular biology, gene expression, proteomic and drug discovery techniques. With over 77 publications in international journals already, CARIF has helped to advance research in cancers which may not generate as much attention in the UK and the US, while also working hard to influence Malaysian policy makers about the importance of cancer research. They may not be a big player on the world stage, but CARIF's research is focused on fighting cancers which affect Malaysians,[133] using Malaysian resources. In collaboration with the University of Malaya, the centre's research has identified significant differences between the risk profile of Malaysians compared to Caucasian women in breast cancer. This knowledge is now being used to develop an Asian-specific risk prediction model.

130 The Economist (2011). *Broadband's big spenders*. The Economist (11 February).

131 Business Times (2010). *RM244.3b invested in development corridors so far* (4 May). New Straits Times: Kuala Lumpur, Malaysia.

132 Cancer Research Initiatives Foundation: Subang Jaya, Selangor, Malaysia.

133 Ng CC *et al.* (2009). *A genome-wide association study identifies ITGA9 conferring risk of nasopharyngeal carcinoma*. Journal of Human Genetics **54**, 392–397; Lim KP *et al.* (2007). *HPV infection and the alterations of the pRB pathway in oral carcinogenesis*. Oncology Reports **17**, 1321–1326; Toh GT *et al.* (2008). *BRCA1 and BRCA2 germline mutations in Malaysian women with early-onset breast cancer without a family history.* PlosOne **3**, 4, e2024.

'When we first started', explains Professor Teo, 'cancer research was seen as a low priority. This has started changing over the past five years, but there is still much to be done to build national networks of scientists, clinicians, hospital analysts and others to work collaboratively.'

One of CARIF's clinical projects is to identify new photosensitisers for Photodynamic Therapy (PDT). PDT is a relatively new cancer treatment which uses the combined effects of light and light-activated compounds (photosensitisers) to specifically target tumour cells for destruction. CARIF has initiated a clinical trial on PDT in Malaysia for the treatment of recurrent or residual nasopharyngeal cancer.[134] The Foundation is also working with many Malaysian and international organisations to systematically develop new cancer therapies by using Malaysia's rich biodiversity and abundant natural resources. The Foundation has several productive international collaborations particularly on mutations or upregulation of genes in cancer.

CARIF symbolises more than just a centre for good research in Malaysia. It is also the only independent research foundation funded by individual and corporate donors such as Sime Darby and Petronas along with government assistance. Professor Teo and others identified a gap in research capacity and, rather than relying on the government, sought to fill that gap independently. As Malaysia develops its knowledge economy, such independent institutions will become increasingly important.

134 Kamal N *et al*. (2009). *Light-activated cytotoxic compounds from Malaysian microorganisms for photodynamic therapy (PDT) of cancer*. Antonie van Leeuwenhoek **95**, 2, 179–188.

Box 3.2. Snapshots of science: emerging centres of research excellence

The Institute of Bioscience, The University of Putra Malaysia[135]
(Professor Fatimah Yusoff, Director)
Established in 1996, this Institute has five laboratories covering: Natural Products, Molecular Biomedicine, Industrial Biotechnology, Marine Science and Aquaculture and Cancer Research. Closely aligned with the National Biotechnology Policy, the research programmes span phytomedicine, metabolomics, plant biotechnology, drug discovery, biodiversity, nutragenomics, molecular biotechnology, vaccine technology and immunotherapeutics, cancer research, fermentation and enzyme technologies, bioprocess engineering, aquatic bioremediation and marine biotechnology.

In addition to its world-class imaging facilities which include confocal microscopy, electron microscopy, NMR, mass spectrometry and X-ray crystallography, IBS also maintains a 2-ha Agriculture Conservatory Park with a collection of more than 500 species of medicinal plants for research and teaching, ranging from aromatics, medicinals, gingers, spices, aquatics, orchids, ferns, aroids, ulams (traditional salads), and pitcher plants. The main research plants are the slipper orchids (*Paphiopedilum*), and *Zingiberaceae*. IBS also has Certified Biosafety Level-3 laboratory that complies with the European and World Health Organisation standards. This is the first research facility in Malaysia capable of handling Class III pathogens including H5N1 bird flu virus, nipah virus, SARS coronavirus, yellow fever virus, *Mycobacterium tuberculosis* and *Bacillus anthracis*. In 2010, IBS was recognised as one of the six HICoEs (Higher Institution Centres of Excellence) in the country, with a niche area in Animal Vaccines and Therapeutics. For example, a live recombinant *Lactococcus* lactis vaccine expressing aerolysin genes was developed which protected tilapia (*Oreochromis niloticus*) against *Aeromonas hydrophila*, and a further oral vaccine for the protection of the Asian Sea Bass against the disease vibriosis has shown promising efficacy. In 2011, IBS will undergo further restructuring to focus on Molecular Biomedicine and Therapeutics.

The Department of Pathology, The University of Malaya (Professor Lai-Meng Looi)[136]

Located within the first medical school established in Malaysia, the Department of Pathology at the University of Malaya was established in 1964 with three primary responsibilities: teaching, patient care and research. Beyond its service obligations, the Department has pioneered a number of scientific developments—from the establishment of the first laboratory information system to the introduction of immunohistochemistry and microwave-stimulated antigen retrieval techniques into Malaysian histopathology laboratories. It has also developed diagnostic renal histopathology, cardiac transplant pathology and the use of immunoelectron microscopy and non-isotopic *in situ* hybridisation. The Department has introduced diagnostic and prognostic markers for various cancers into routine pathology practice and for combating the life-threatening Nipah virus in collaboration with hospital teams.

Current research work focuses on hepatocellular carcinoma, nasopharyngeal carcinoma and its link to the Epstein-Barr virus (EBV), unique forms of amyloidosis, patterns of lymphoma, molecular genetics of hepatitis B and cytopathology.

135 Selected publications from this Institute include: Shadid KA *et al*. (2007). *Cytotoxic caged-polyprenylated xanthonoids and xanthone from* Garcinia cantleyana. Phytochemistry **68**, 2537–2544; Ismail M *et al*. (2010). Nigella sativa *thymoquinone-rich fraction greatly improves plasma antioxidant capacity and expression of antioxidant genes in hypercholesterolemic rats*. Free Radical Biology and Medicine **48**, 664–672; Wang Y *et al*. (2009). *Photodegration of polycyclic aromatic hydrocarbon pyrene by iron oxide in solid phase*. Journal of Hazardous Materials **162**, 716–723; Anuradha K *et al*. (2010). *Live recombinant* lactococcus lactis *vaccine expressing aerolysin genes D1 and D4 for protection against* Aeromonas hydrophila *in tilapia* (Oreochromis niloticus). Journal of Applied Microbiology **109**, 1632–1642; Shamsudin MN *et al*. (2008). *First community-acquired methicillin-resistant* Staphylococcus aureus *in Malaysia*. Journal of Medical Micro-biology **57**, 1180–1181; Abdullah S *et al*. (2010). *Gene transfer into the lung by nanoparticle dextran-spermine/plasmid DNA complexes*. Journal of Biomedicine & Biotechnology; doi:10.1155/2010/284840; Ramasamy R *et al*. (2008). *The immunosuppressive effect of human bone marrow derived mesenchymal stem cell targets T cell proliferation but not the effector function*. Cellular Immunology **251**, 131–136; Wong SW *et al*. (2010). *Rapamycin synergizes cisplatin sensitivity in basal-like breast cancer cells through up-regulation of p73*. Breast Cancer Research & Treatment. PMID: 20686837.

136 Selected recent publications include: Tan SY *et al*. (2011). *Nuclear expression of MATK is a novel marker of type II enteropathy-associated T-cell lymphoma*. Leukemia (in press; available online 14 January); Lee ES *et al*. (2010). *Expression and alteration of p16 in diffuse large B cell lymphoma*. Pathobiology **7**, 96–105; Ong CS *et al*. (2010). *Evaluation of PCR-RFLP analysis targeting hsp65 and rpoB genes for the typing of mycobacterial isolates in Malaysia*. Journal of Medical Microbiology **59**, 1311–1316; Wong KT *et al*. and the Nipah Virus Pathology Working Group (2002). *Nipah virus infection: pathology and pathogenesis of an emerging paramyxoviral zoonosis*. American Journal of Pathology **161**, 2153–2167; Ohshima K *et al*. (2008). *Proposed categorization of pathological states of EBV-associated T/natural killer-cell lymphoproliferative disorder (LPD) in children and young adults: overlap with chronic active EBV infection and infantile fulminant EBV T-LPD; CAEBV Study Group*. Pathology International **58**, 209–217.

4 Business

It is not often that Malaysia pips countries like the UK, Germany, France and Japan in the international rankings. However, in May 2010 Malaysia joined Singapore, the US and Sweden in the top 10 countries of the Switzerland-based IMD World Competitiveness Index.[137] It had moved up nine places to secure 10th position. As an internationally renowned ranking of economic strength and business efficiency, this result was widely welcomed.

Yet behind these macroeconomic headlines, the story of business and entrepreneurship in Malaysia is more mixed. Despite decades of significant FDI in Malaysia, there has been limited spillover into high-tech indigenous businesses. In an economy driven by small- to medium-sized enterprises (SMEs), genuine entrepreneurship can be difficult to spot. After recovering from the devastating 1997 Asian economic crisis, Malaysia is again emerging from one of its worst export slumps.

A recent World Bank report highlighted the need for Malaysia to move away from an economic model predominantly based on capital accumulation, to focus on targeted high-value-added, innovation-based sectors.[138] It suggested that for Malaysia to become a high-income country, it must focus on technology, innovation and urbanisation policies which nurture existing strengths in electronics, resource-based industries and Islamic finance. This chapter explores the size and scale of private sector innovation, entrepreneurship and R&D in Malaysia.

4.1 An opportunity missed?

As Figure 4.1 demonstrates, Malaysia's quest to acquire FDI, beginning in the 1970s, has been hugely successful. From a low base of just US$94 million in 1970 to a peak of US$8.46 billion in 2007,[139] Malaysia's structural transformation towards more manufacturing and export-orientated businesses has paid dividends. At its peak in 2007, Malaysia was among the top attractors of FDI among the OIC member states alongside Egypt, Indonesia, Kazakhstan, Saudi Arabia, Turkey and the UAE.[140]

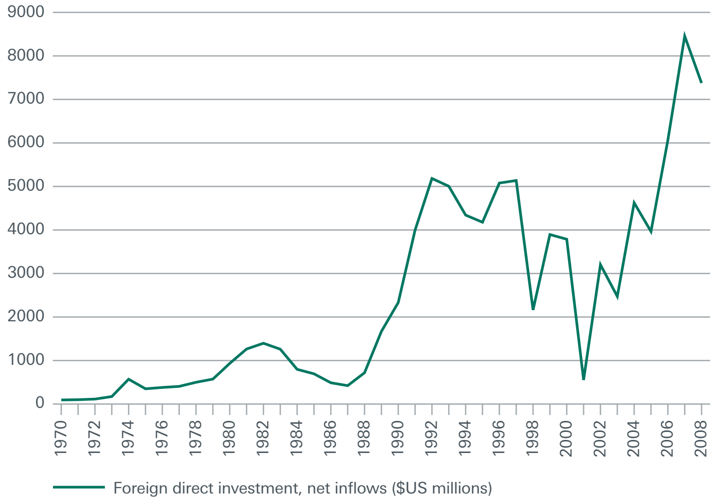
137 IMD Business School (2010). *World competitiveness yearbook results 2010*. IMD: Lausanne, Switzerland.

138 The World Bank (2009). *Malaysia economic monitor: repositioning for growth*. The World Bank: Washington, DC, USA.

139 World Development Indicators. The World Bank: Washington, DC, USA.

140 Data from UNCTAD, provided by SESRIC.

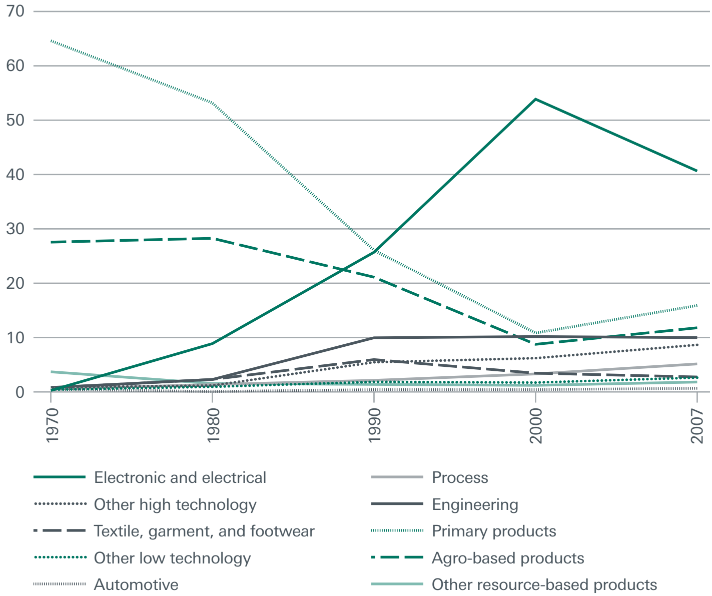
Figure 4.1. Net inflows of foreign direct investment ($US millions) (1970 to 2008).[141]



Strategic legislative changes coupled with the establishment of FTZs in the late 1960s targeted labour-intensive industries, offering an abundance of inexpensive labour and low production costs. In 1986, the introduction of the Promotion of Investment Act shifted the focus towards technology-intensive industries, with fiscal incentives to strengthen domestic industrial linkages as well as to promote R&D. Figure 4.2 shows this shift from an export structure focused on primary agro-based products to higher-value electronic and electrical exports in recent decades.

141 World Development Indicators. The World Bank: Washington, DC, USA.

Figure 4.2. Malaysia's export structure (%) 1970 to 2007.[142]



While these policies have been successful in shifting the industrial composition of Malaysia, there is little evidence of FDI building up the indigenous capacity of domestic firms to design, to innovate and to diversify.[143] Product and process innovation is still largely the domain of the MNCs. It was only in the 1990s that efforts to promote domestic industrial links began.

Mohd Yusoff Sulaiman, Chief Executive of the Malaysian Industry-Government Group for High-Technology (MIGHT), admits that government and industry, both foreign and local, have been disjointed. 'Previously we thought of FDI as just filling the GDP gaps—we looked at volume rather than synergy. The idea of promoting technology transfer to our local business from FDI simply wasn't on the agenda. Now we understand the benefits and we're trying to find synergies, particularly within our niche areas like electronics and automotives, but it will take some time.'

142 Adapted from Table 1.3 in The World Bank (2009). *Tiger economies under threat: a comparative analysis of Malaysia's industrial prospects and policy options*. The World Bank: Washington, DC, USA.

143 The World Bank (2009). *Tiger economies under threat: a comparative analysis of Malaysia's industrial prospects and policy options*. The World Bank: Washington, DC, USA.

Strategic policy efforts include the establishment of specialised technology finance mechanisms, the building of science parks to attract high-tech industries, as well as ensuring that technology transfer and development are embedded in foreign investment negotiations. Importantly, Malaysia ranks well as a place in which to do business—23rd out of 189 countries in a recent World Bank and International Finance Corporation survey.[144] The challenge is how to leverage this to drive local innovation.

4.2 Science and Technology Parks

There are numerous ambitious projects aimed at fostering high-tech clusters in Malaysia. In addition to the high profile MSC, the government has supported a number of science parks across the country. The first park established was the Kulim High Tech Park in 1993, another of Mahathir's flagship projects. Today it hosts 23 companies, including branches of Fuji and Intel, and houses 16,000 employees, of which 4,000 are skilled professionals.[145]

While Kulim caters to high-tech manufacturing, the Technology Park Malaysia (TPM), established in 1996, is targeted more at R&D-based businesses. Based in Kuala Lumpur, TPM has achieved a turnover of RM6.3 billion since its establishment, and is home to over 160 technology-driven businesses.[146] The third biggest park is the ICT-focused cluster of Cyberjava—located within MSC—which has attracted Dell, HP, Motorola and Ericsson.

Additional parks are located in Johor and Subang, with more planned across the country. There are high hopes for sains@USM, and a second park in Selangor is projected to create 20,000 jobs with more than 100 tenants.[147] The bigger challenge is not only to ensure appropriate crossover and exchange within the park itself, but also within local universities and industry. Malaysia's science and technology parks are credited with strong government support, adequate funds for infrastructure and tax incentives, yet university links are relatively weak.[148] Addressing this shortcoming is critical, particularly given the stiff competition for other science and technology parks in the region such as the Singapore Science Park, the Daeduck Science Park in Korea, and Hsinchu in Taiwan. Since entering the World Trade Organisation in 2001, China's parks are also becoming increasingly attractive to foreign investors.

144 The World Bank and International Finance Corporation (2009). *Doing business 2010—Malaysia*. The World Bank: Washington, DC, USA.

145 Interview notes with Kulim Vice President Awang Solahudin Hashim, 19 February 2010.

146 Technology Park Malaysia website.

147 *Korean interest in Selangor science* (August 2009). Available online at: http://www.MalaysiaPropertyNews.com.

148 Lai M-C & Yap SF (2004). *Technology development in Malaysia and the newly industrializing economies: a comparative analysis*. Asia-Pacific Development Journal (December).

Against such competition, it is worth reflecting on the strengths of leading parks internationally to understand some of the missing elements in Malaysia's parks. The Cambridge Technology Park, for example, provides some useful examples for strengthening linkages between SMEs and university-led research. These include pursuing technology transfer opportunities at a national and global level, rather than only looking to local industry. The role of R&D consultancies to identify and encourage local spin-out opportunities is also considered important, as part of a critical and integrated web of supportive organisations who work to build bridges between industry and university.[149] While it is difficult to compare Malaysian universities to institutions like Cambridge, the university's more liberal regulations of research and its encouragement of commercialisation are also considered important elements of its success.

Whether inside or outside the science and technology parks, more needs to be done to make Malaysia stand out from its competitors. Luring major R&D investments by multinational firms would indicate confidence in the local intellectual capital and innovation capacity. When Rolls Royce relocated its maritime R&D to Singapore, and GSK developed a new neurobiology research unit in Shanghai, it sent an important signal to the global science community. Malaysia has not yet attracted such high profile investments. It needs a more aggressive strategy to target business R&D which complements the country's research priorities, while also promoting creativity and competition among local companies—particularly SMEs.

Korea presents some valuable lessons in how to balance FDI investment and the fostering of indigenous capacity. In contrast to Malaysia's less strategic FDI policies of the 1980s, Korea followed a determined strategy of maintaining economic dependence through its restrictive stance towards FDI, while investing heavily in national R&D programmes, education and fiscal incentives for innovation.[150] From a country whose economy was devastated in the 1960s after a civil war, Korea is now one of the most technologically advanced and best educated societies in the world.[151]

149 Keeble D (2001). *University and technology: science and technology parks in the Cambridge region*. Cambridge University (December).

150 ERAWATCH (2010). *Research inventory report: the Republic of Korea*. European Commission and CORDIS: Brussels, Belgium.

151 Webb M (2007). *South Korea: mass innovation comes of age*. Atlas of Ideas, Demos: London, UK

The unmistakable Petronas Twin Towers in Kuala Lumpur (photo courtesy of Ian Thornton)

4.3 Homegrown heroes

Beyond the towers that bear its name, there is one Malaysian business success that stands out: Petronas. With a presence in over 30 countries, this government-linked company is responsible for 68.2% of Malaysia's total oil and gas production, both upstream and downstream.[152] The only Malaysian company listed in the Fortune Global 500, Petronas ranked 107th in 2010.[153] Despite declining profits in recent years, Petronas is a huge revenue provider for the government, making a financial contribution of RM57.6 billion in 2010 on top of a dividend of some RM30 billion.[154]

A significant investor in research and training, the company established its own Universiti Teknologi Petronas in 1997 specifically to focus on petroleum technology and engineering. In 2006 it set up a separate Research and Technology division to drive technological excellence, focused on all aspects of the supply chain.

Petronas plays a vital role in promoting the country, as is evidenced by its extended sponsorship of the FIA Formula One World Championship—which will now be known as the Formula 1 Petronas Malaysia Grand Prix.[155] In addition to providing a boost to Malaysia's tourism, transportation and automotive industries, Petronas believes that this partnership has paved the way for technological and

152 Petronas (2010). *Summary of consolidated financial results*. Petronas: Kuala Lumpur, Malaysia.

153 *Fortune magazine* (2010), Annual list of the top 500 U.S. companies, ranked by revenues

154 Petronas (2010). *Petronas Group results for the financial year ended March 2010*, financial media release. Petronas: Kuala Lumpur, Malaysia.

155 motorsports@Petronas (1 September 2010). *Petronas extends Formula 1 Grand Prix sponsorship*. Petronas: Kuala Lumpur, Malaysia.

knowledge acquisition relevant to the oil and gas industry for Malaysia. Just as it has shown on the race track, Petronas could play a stronger role in supporting domestic R&D. As one of the few homegrown heroes of Malaysian industry, Petronas is a role model, and could more effectively support local innovators by using its procurement policies to encourage domestic innovation and new products.

4.4 Industry R&D

As noted in Chapter 1, the private sector funded 84.7% of Malaysia's R&D expenditure in 2006. According to UNESCO, this is one of the highest ratios of business R&D in the world.[156] The government claims the increases in private sector R&D expenditure are, in part, stimulated by strategic grants in high-tech sectors.[157] The majority of business R&D expenditure is directed towards applied research, engineering or experimental development, and it is also highly concentrated in large companies, particularly GLCs.[158]

According to a recent World Bank report, firms in the automotive sector are the biggest spenders in R&D (RM646.3 million); followed by office equipment manufacturers (RM414 million) and electronic firms (RM393.3 million). The oil and gas industry, thanks largely to Petronas, is the fourth biggest spender on R&D (RM150 million).[159] Malaysia's strength is that its business sector R&D is spread reasonably widely, providing greater flexibility and potential for spin-off companies. It should be noted, however, that this level of spending is small by global standards. The Toyota firm alone spent over RM30 billion in 2009, topping the UK Governments 2010 R&D Scoreboard.[160]

4.5 From sagas to spin-outs

In 1983, Mahathir oversaw the establishment of Malaysia's national car company, Proton, with the aim of building a national car. Two years later, Malaysia's first domestically produced car—the Proton Saga—was launched. According to Tan Sri Omar, Proton had social and industrial objectives. 'Mahathir wanted Malaysia to develop expertise in precision engineering and to develop products which people needed and appreciated in their everyday lives—the Proton car aimed to inspire national pride. It symbolised Malaysia's drive towards a more high-tech economy.' In the early days, the cars were largely copies of models by Mitsubishi and other Japanese brands. It wasn't until the late 1990s that the company started to generate its own home-grown automotive innovation and design through high-end R&D.

156 UNESCO Institute of Statistics: Montreal, QC, Canada.

157 Government of Malaysia (2008). *Malaysian science & technology indicators 2008 report*. MOSTI, Putrajaya, Malaysia.

158 Government of Malaysia (2008). *Malaysian science & technology indicators 2008 report*. MOSTI, Putrajaya, Malaysia.

159 The World Bank (2009). *Tiger economies under threat: a comparative analysis of Malaysia's industrial prospects and policy options*. The World Bank: Washington, DC, USA.

160 Author's own calculation. Based on statistics from the *2010 R&D Scoreboard*, UK Department for Business Innovation and Skills, accessed 13 December 2010.

With 42% of Proton owned by the government, heavy state subsidies and other protectionist measures ensured that at its peak it controlled 80% of the local market.[161] However, by 2010 its share had fallen to 28%.[162] Perodua, the second national car project founded in 1994, takes a similar 30% share.[163] Many are critical of the enormous government subsidies that have gone to these firms. Yet while they may not have inspired the spinoffs and innovation that were hoped for, they have led to some success stories.

Every two months, Datuk Rameli bin Musa sits down with some of his 2,274 employees[164] for an open session to share ideas and discuss issues. He is Executive Vice Chairman of Ingress Corporation, a Malaysian company, spun off by former senior managers of Proton. Started in 1991, Ingress has expanded from producing automotive parts to become a high-tech company. 'We've developed technology that can treat metal as if it is rubber, giving rise to tremendous flexibility and product innovation.' With clients across the South East Asia region and a brimming trophy cabinet, Ingress now boasts revenues of over RM650 million.[165] They are different, Rameli says, because they focus on training and talent development, with staff offered incentives to develop new product and process innovations.

Companies like Ingress are the exception rather than the rule. SMEs, often family-owned, contributed 32% to Malaysian GDP in 2005[166]—a relatively small amount compared to 53.5% in neighbouring Indonesia[167] and 51% in the UK.[168] In terms of total national R&D expenditure, businesses with revenues under RM10 million accounted for only 9.7% in 2006.[169] This is partly because 86.5% of the enterprises are concentrated in the services sector, rather than in manufacturing (7.3%) and agriculture (6.2%)[170]—but it also reflects inertia. The CEO of SME Corp, Dato Hafsah Hashim, acknowledges that, to survive in the competitive global environment, Malaysian SMEs have to become more innovative. Yet fewer than 20% of Malaysian SMEs had access to the internet in 2007.[171] A more concerted focus is needed to inspire and reward a culture of innovation among SMEs, through better links to educational institutes and larger, more research-intensive companies.

161 Ellis E (2006). *Protonomics* (July). Fortune Magazine: New York, NY, USA.

162 Press release (19 February 2010). *Proton increases car sales, revenue, profit and domestic market share*. Proton: Shah Alam, Malaysia.

163 *Market watch 2010—the automotive sector*. Malaysian–German Chamber of Commerce and Industry: Kuala Lumpur, Malaysia.

164 *Financial Times* markets data.

165 Ingress (2010). *Ingress Corporation annual report (2010)*. Ingress: Kuala Lumpur, Malaysia.

166 *SME annual report 2007*. National SME Development Council: Kuala Lumpur, Malaysia.

167 Tambunan T (2008). *SME development, economic growth, and government intervention in a developing country: the Indonesian story*. Journal of International Entrepreneurship **6**, 4, 147–167.

168 National Federation of Self-Employed and Small Businesses (FSB): Blackpool, UK.

169 Government of Malaysia (2008). *National survey of R&D 2008: summary*. MOSTI, Putrajaya, Malaysia.

170 Government of Malaysia (2005). *Census of establishments and enterprises*. Department of Statistics Malaysia: Putrajaya, Malaysia.

171 United Nations Development Program (2007). *Malaysia small and medium enterprises: building an enabling environment*. UNDP: Kuala Lumpur, Malaysia.

4.6 Down the valley

Looking out from the 23rd floor across the business district of Kuala Lumpur, Dr Wan Abdul Rahaman Wan Yaacob, Chief Operating Officer of Malaysia Biotechnology Corporation, has big plans. A former director of the Rubber Research Institute, Rahman wants for biotech what Malaysia has already achieved in the rubber industry—to become a world leader. 'My job', he explains, 'is to harness Malaysia's rich biodiversity, to attract the big industry players, and create a hub for biotechnology here.'

Biotechnology was first mooted as a national priority in the late 1980s, but it was not until early this century that the government identified it as one of the core technologies to springboard economic growth. Four years on from the launch of the National Biotech Policy in 2005, the biotechnology industry recorded a total investment of US$1.3 billion, of which 57.8% is funded by the government.[172] Table 4.1 gives the breakdown of Malaysia's biotechnology sector, where it is estimated some 54,000 people are employed.[173]

Table 4.1. Overview of Malaysia's biotechnology industry.[174]

Sector	Ownership						Revenue		Investment	
	Domestic		Foreign		Total					
	Number of companies	%	Number of companies	%	Number of companies	%	$US million	RM million	$US million	RM million
Healthcare	88	33.6	46	52.9	134	38.4	47.4	165.8	235.1	822.8
Industrial	56	21.4	16	18.4	72	20.6	44.8	156.9	297.6	1,041.6
Agricultural	118	45	25	28.7	143	41	57.9	202.7	287.5	1,006.3
Total	262	100	87	100	349	100	150.1	525.4	820.2	2,870.7

Professor Farida Shah is one scientist who has taken advantage of the new opportunities for biotechnology start-up companies. An expert on the molecular biology of oil palm and with a honorary professorship at Universiti Tunku Abdul Rahman, Kuala Lumpur, Professor Shah has already spun off two companies—Invitrotech Sdb Bhd, which is focused on tissue culture, and Tropical Bioessence Sdn Bhd, a phytochemistry (or plant chemistry) company, while also working closely with the State of Melaka to foster biotechnology. Professor Shah has

172 BioTechCorp (2010). *Malaysian biotechnology country report 2009/2010*. Malaysian Biotechnology Corporation: Kuala Lumpur, Malaysia.

173 BioTechCorp (2010). *Malaysian biotechnology country report 2009/2010*. Malaysian Biotechnology Corporation: Kuala Lumpur, Malaysia.

174 Adapted from BioTechCorp (2010). *Malaysian biotechnology country report 2009/2010*. Malaysian Biotechnology Corporation: Kuala Lumpur, Malaysia.

done extensive research on understanding gene expression and the function of photosynthesis and fatty acid synthesis during oil formation and the genetic engineering of oil palm.[175] Now she is keen to help aid and facilitate the translation of biotechnology research into commercial ventures and training and now has ambitions to establish a biotech start-up and consultancy in this important area.

The government wants the biotechnology industry to contribute 5% of GDP by 2020, and to employ 160,000 people.[176] Yet some doubt that this ambition is realistic. As Keiichi Kiyota, president of the Toyko-based Nimura Genetic Solutions, told *Nature*, 'With no history in biotechnology and little industrial presence, the risk is high. The greatest problem is the lack of manpower.'[177] Others point to the failed BioValley project as evidence that the government is not genuinely committed to this agenda. Launched in 2003 with much fanfare, the US$160 million BioValley project was intended to become a hub for biotech companies—symbolic of the nation's biotechnology ambitions, just as the MSC was for the ICT sector. But BioValley never even got off the ground, and eventually morphed into the far less ambitious BioNexus scheme, which was built around existing labs.

Dr Fatimah binti Mohd Amin, from the government's Economic Planning Unit, was frank in her assessment of BioValley. 'It just never took off. You need an ecosystem, not just a piece of land. How are you going to attract companies when there is nothing there but jungle? We need to be clustering activities where there are already strong foundations.'

The experience of BioValley stands in stark contrast to Singapore's high-tech biomedical park, Biopolis. Announced in the same year as BioValley, the US$370 million Biopolis now spreads across 37,000 square metres, houses over 2,000 scientists, researchers, technicians and administrators, and has attracted some global players such as Pfizer, GlaxoSmithKline and MIT.[178]

MOSTI officials argue that it is still early days for Malaysian biotechnology, and that investments in research and universities need time to mature. However, a sharper, more concerted focus is needed, so university research matches local industrial needs, particularly around agricultural, palm oil and biomedical research.

175 San CT & Shah FH (2005). *Differential gene expression and characterization of tissue-specific cDNA clones in oil palm using mRNA differential display*. Molecular Biology Reports **32**, 227–235.

176 BioTechCorp (2010). *Malaysian biotechnology country report 2009/2010*. Malaysian Biotechnology Corporation: Kuala Lumpur, Malaysia.

177 Cyranoski D (2005). *The valley of ghosts*. Nature (4 August), 436.

178 Agency for Science, Technology and Research, Singapore (2010), http://www.a-star.edu.sg/

4.7 On a smaller scale

In addition to investing in biotechnology, nanotechnology is now also being targeted. The government launched the National Nanotechnology Initiative in 2006 with an overall mission aimed at making nanotechnology a national priority. Major goals included expanding infrastructure and human resources and establishing a national centre for nanotechnology. The National Nanotechnology Directorate is now charged with facilitating nanotechnology development, and in 2010 the Prime Minister launched the National Nanotechnology Statement which outlines the government's strategy to foster research and collaboration as well as commercialisation opportunities.[179]

Beyond such strategies, actual research is at very nascent stages but it is growing. Amongst OIC countries, Malaysia has the third highest share of nanotechnology publications behind Iran and Turkey, up from 8.3% in 2009 to 11% in 2010. In global rankings, however, Malaysia still has some way to go—ranking 29th with 0.64% share of total nanotechnology publications in 2010. China and the US had the largest shares with 25.70% and 21.89%, respectively.[180]

Maerogel is an exciting example of Malaysia's nanotech potential. Patented in 2007 by Professor Halimation Hamdon of UTM, maerogel is a novel way to manufacture aerogel (a silicon-based nano-material, used in insulation) using rice husks.[181] This innovation claims to have reduced the manufacturing costs of aerogel by around 80%.[182] With predictions that the global aerogel market will reach over US$646 million by 2013, this could be a significant breakthrough for Malaysia's nanotech sector.[183]

4.8 New friends

Whether in biotechnology, nanotechnology, the automotive industry or electronics, strong linkages between industry and academia are essential. Appropriately, much effort has been directed towards building a stronger research base within universities. The quality of R&D within such institutions could, however, be enhanced by ensuring greater linkages to those with practical industrial and commercial experience. While the movement of people from universities to companies is not uncommon, the opposite flow is more constrained. More fellowships that straddle the boundary between universities and industries could be instrumental to bridge the gap between the commercial mindset and market understanding, and scientific excellence.

179 Government of Malaysia (2010). *National nanotechnology statement*. MOSTI, Putrajaya, Malaysia.

180 Data provided by the Iran Nanotechnology Initiative Council.

181 Universiti Teknologi Malaysia Innovation Channel (2010). *Maerogel*. UTM: Malaysia. Available online at: http://www.innovation.utm.my/biotech/maerogel/.

182 Universiti Teknologi Malaysia Innovation Channel (2010). *Maerogel*. UTM: Malaysia.

183 McWilliams (2010). *Nanotechnology: a realistic market assessment*. BCC Research: Wellesley, USA.

In recent years, the Malaysian Government has also introduced incentives for university researchers and inventors to publish, patent and commercialise their research. There are cash rewards of RM500 on disclosure of an invention, and up to RM10,000 when a patent is granted.[184]

Professor Dr Mohammad Shariff, Director of the Innovation and Commercialisation Centre at the Universiti Putra Malaysia (UPM) says these initiatives are starting to bear fruit. His university has commercialised several products, from vaccines to organic fertiliser, with a gross sale price of RM27.2 million. It has also spun off five companies.[185] 'This is new for universities, but we have world-class scientists and innovators; we need to be more proactive. At the moment, the private sector is still looking for technology and ideas from advanced countries, but they should look here', he says.

These are positive steps, yet collaboration between industry and academia is still rare. The Malaysian Palm Oil Board is a good example of how industry and academia can work well together to shape a commodity-based sector, but such examples are limited.

The government recently announced proposals for the joint funding of postgraduate courses with employers, including incentives for employees to undertake industry-focused PhD studies. In the new Knowledge Transfer Partnership scheme, funding is also provided to increase R&D collaboration and exchange between universities and industry. The government hopes such schemes will help to address the perceived disconnect between industry needs and graduate employability, while also fostering more innovative spinoff companies.

4.9 Fostering that entrepreneurial spirit

Dato' Seri Anthony Fernandes is the CEO of Malaysia's own Air Asia. At the World Islamic Economic Forum held in Kuala Lumpur in 2010 he explains that, in his business, there is a completely flat structure: 'No titles, no offices, no suits. Just 7,500 brains, all encouraged to take risks, take chances, and to come up with innovative ideas.' Fernandes says it is absolutely critical for Asian businesses to focus more heavily on branding, to constantly invest in their people—be they bag carriers or highly skilled pilots. While Air Asia are not doing high-end R&D, they are an increasingly important role model for young Malaysian entrepreneurs. They started eight years ago with two planes, a staff of 250 and RM200,000 behind them.[186] Today AirAsia Group and AirAsia X have a combined fleet of over 90 planes with orders for 175 new Airbus A320s,[187] and are valued at an impressive RM3.2 billion.[188]

184 Government of Malaysia (2009). *Intellectual property commercialisation policy for R&D projects funded by the Government of Malaysia*. MOSTI: Putrajaya, Malaysia.

185 *UPM commercialised products and technologies*, presentation. Universiti Putra Malaysia: Serdang, Selangor, Malaysia.

186 AirAsia (2009). *AirAsia annual report*. AirAsia: Kuala Lumpur, Malaysia.

187 Aircraft orders (June 2010). *Orders, deliveries, operators—worldwide*, spreadsheet. Airbus: Toulouse, France.

188 AirAsia (2009). *AirAsia Annual Report*. AirAsia: Kuala Lumpur, Malaysia.

In a quiet culture where rote learning is standard and questioning authority is taboo, Malaysia is not renowned for entrepreneurialism. When Jonathan Addis, Deputy CEO of HSBC Malaysia, compares it to others in the region, he thinks Malaysia is stuck in the middle. 'There are fantastic examples of Malaysian entrepreneurship, but you don't get that feeling within society generally. Of the four countries where I've worked in South East Asia, I rank them Hong Kong, Malaysia, Thailand and then Indonesia in terms of innovation, energy and application.'

4.10 Venture capital

Venture capital (VC) industries were established at roughly the same time in Malaysia and Singapore. However, whereas Singapore is now considered world class in this area, Malaysia is still at a developing stage despite the availability of sizeable funds and relevant companies.[189] Malaysia's first VC fund, Malaysian Venture Berhad, was established in 1984 with RM13.8 million. In the 1990s, the Malaysian Government liberalised regulations for venture capital companies (VCC) to allow companies to invest up to 75% in high tech or risk projects in order to qualify for tax holidays or pioneer status. At this time, there were six VCCs, managing a total of RM92.8 million.[190] In 1992, the government established the Malaysian Technology Development Corporation (MTDC), charged with driving commercialisation and technology transfer between universities and business as well as providing VC services and expertise. By 1998, there were 23 active VCCs which had supported almost 250 companies with funds totalling RM1 billion, and total investments of RM952.1 million.[191]

Today, the range of VC funding is growing, particularly for high-tech businesses. The MTDC has invested over RM500 million in local and foreign high-tech firms since its establishment in 1992.[192] Over the years, it has offered six different private equity funds, totalling over RM200 million, and has now launched the country's first biotechnology VC fund, worth US$150 million.[193] Similarly, the GlobinMed Seed Fund covers up to RM2.5 million in start-up costs for biotechnology companies,[194] while the MSC Malaysia Intellectual Property Grant Scheme can subsidise up to 70% of the initial costs of applying for trademarks, patents and industrial designs.

At the end of 2009, the total of committed VC funds in Malaysia was RM5.4 billion, of which 52.9% came from the government.[195] Yet comparative studies with the more established Singaporean VC industry claim that Malaysia has been hamstrung by restrictive investment criteria, poorly communicated business plans, low public awareness and a general disconnect between the potential

189 Freedom N (2003). *Financing Southeast Asia's economic development*. Institute of Southeast Asian Studies: Singapore.

190 Freedom N (2003). *Financing Southeast Asia's economic development*. Institute of Southeast Asian Studies: Singapore.

191 Freedom N (2003). *Financing Southeast Asia's economic development*. Institute of Southeast Asian Studies: Singapore.

192 Malaysia Technology Development Corporation: Kuala Lumpur, Malaysia.

193 Malaysia Technology Development Corporation: Kuala Lumpur, Malaysia.

194 Intellectual Property Corporation of Malaysia: Kuala Lumpur, Malaysia.

195 Malaysian Venture Capital Development Council: Kuala Lumpur, Malaysia.

entrepreneurs and the VC industry.[196] In contrast, Singapore's success is largely due to the government's assiduous support of this industry. Through appropriate regulatory and fiscal changes, the Singaporean Government has been able to attract top-tier international VC firms to establish a regional base in their country. At the same time, using both government agencies and government-related companies, Singapore has also funded a number of new local and foreign VC funds.[197] In 2000, approximately 19% of the US$7.4 billion of VC in Singapore originated from government funding—a significant sign of the government's desire to ensure a vibrant VC industry.[198]

Improving the environment for VC to thrive is central to Malaysia's entrepreneurial activities. Entrepreneurs turn to VC to finance the development of new ideas and technologies, while also gaining access to professional management skills and the strategic support of experienced venture capitalists.[199]

There are positive signs, however. In September 2009, the Securities Commission of Malaysia introduced new VC tax incentives guidelines whereby VCCs could be eligible for a five-year tax exemption. This is subject to them investing at least 30% of their invested funds in the form of seed capital, start-up and/or early-stage financing.[200]

Fostering creativity and entrepreneurship was also listed as one of the central aims of the government's recent Tenth Malaysia Plan. The Plan outlines a RM20 billion fund to ease private sector investment in projects which are of strategic national interest. It also created a RM500 million Mudharabah Innovation Fund to provide risk capital to government-backed enterprises.[201]

These are positive signs, but there is some way to go before entrepreneurship becomes entrenched in Malaysian society. Linkages between industry and academia are still weak—an area in which a stronger VC industry could be useful. Venture capitalists can often forge linkages between diverse organisations, including universities and industry, but also investment banks, entrepreneurial companies and larger international corporations.

Some commentators point to Malaysian culture as one reason for this lack of entrepreneurship. It is true that science, innovation and research do not happen in isolation. They are influenced by social, economic and cultural factors. It is to these that we turn in the next chapter.

196 Freedom N (2003). *Financing Southeast Asia's economic development*. Institute of Southeast Asian Studies: Singapore.

197 Koh FCC & Koh WTH (2002). *Venture capital and economic growth: an industry overview and Singapore's experience*. Singapore Management University: Singapore.

198 Koh FCC & Koh WTH (2002). *Venture capital and economic growth: an industry overview and Singapore's experience*. Singapore Management University: Singapore.

199 Koh FCC & Koh WTH (2002). *Venture capital and economic growth: an industry overview and Singapore's experience*. Singapore Management University: Singapore.

200 Securities Commission Malaysia (2009). Venture Capital Tax Incentives Guidelines (September). Available online at: http://www.sc.com.my/eng/html/resources/guidelines/VC/VC_TaxIncentivesGuidelines_090929.pdf, accessed 7 February 2010.

201 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

5 Culture

Muhammad Asyraf Mohd Ridzuan is a household name in Malaysia. The 26-year-old from Penang is the first winner of 'Imam Muda' or 'Young Leader'—a new Malaysian reality television show based on 'The X Factor' or 'American Idol', but with some important differences. Abrasive judges, skimpy clothing and soulful pop songs have been replaced with religious debates, Koranic recitals and Islamic burial preparation. The ten original contestants, selected from over 1,000 Malaysian applicants, are judged on their ability to master the duties of an Imam and their knowledge of Islam. Rather than a record deal, Muhammad has gone home with a new Proton car, cash, an expenses-paid trip to Mecca and a scholarship to study in Saudi Arabia. Record numbers tuned into the show, while the show's Facebook page has nearly 75,000 fans.

Aimed at making Islam more relevant to young Malaysians, 'Imam Muda' reflects the parallel strands of Malaysian culture—a highly devout religious nation, balanced with more 'Western' ambitions and high-tech dreams. With its rich multiculturalism, Malaysia is a melting pot of influences, values and ideas. In this chapter, we offer a brief and imperfect overview of Malaysia's character and values, from its cultural diversity to questions of creativity, language and gender balance. We consider the implications and opportunities for STI against this rich cultural backdrop.

5.1 Multicultural Malaysia

As the call for prayer echoes across central Kuala Lumpur at sundown, the vendors in bustling Chinatown set up their stalls with practised precision. In the next district, Indian restaurateurs prepare for the evening rush of hungry locals and tourists. Malaysia is a multi-religious country: 60.4% of the population is Muslim, 19.2% are Buddhist, 9.1% Christian, 6.3% Hindu and 2.6% follow traditional Chinese religions.[202] However, whereas the integration of diverse communities can sometimes reflect a forced acceptance by the minority of the norms of the majority, the Malaysian model has attempted to maintain the separate heritage and identity of different cultures.[203]

202 Government of Malaysia (2000). *Population and housing census 2000*. Department of Statistics Malaysia: Putrajaya, Malaysia.

203 Bakri Musa M (2006). *Towards a competitive Malaysia: development challenges in the 21st century*. Strategic Information and Research Development Centre (SIRD): Petaling Jaya, Selangor, Malaysia.

Western culture is another strong influence on Malaysian society today, particularly with regard to science and technology. During the 1970s and 1980s, Malaysian students were major recipients of education abroad, a path which remains popular today. Many of Malaysia's current leaders in STI were educated and influenced in the UK, Australia and the USA—returning home with ideas, practices and concepts influenced by those systems and cultures. Today, Malaysia's universities are adopting Western structures and research incentives in an effort to compete in the international rankings.

5.2 The changing dynamic of Islamic influence

USM Vice Chancellor, Tan Sri Dato' Dzulkifli Abd Razak, argues that the values of Islam should more explicitly drive the decisions, directions and attitudes of Malaysia. Uncomfortable with the increasing push for Malaysian universities to focus on commercial outputs like patents, Professor Dzulkifli believes that alternative structures are required, based on the principles of Islam. His university, USM, has been completely restructured to focus on enabling the 'bottom billions' to improve their socioeconomic status. This mission, he says, is underpinned by Islamic values and philosophies.

Dzulkifli is not alone in this quest. Many prominent Malaysian philosophers—including Professor Dr Syed Muhammad Naquib al-Attas, known as the founding father of the Islamisation of knowledge in Malaysia—are strong proponents of the need to strike a balance between modern science and Islamic values and worldview.

Islam is a huge influence in Malaysia, for Muslims and non-Muslims alike. Although it has long been the official religion of the country, it was not until the early 1970s that, in line with a broader phenomenon of Islamic revivalism, it became a more assertive force. The flow of petrodollars around the Islamic world also had a profound impact, as such wealth facilitated opportunities for education abroad, and young Muslims began espousing a more assertive version of Islam, especially in the political sphere.[204]

At the same time, there was a groundswell of change in social habits including dressing, eating, entertainment and business, in part influenced by globalisation and economic liberalisation. Foreign investment, open television rights, the gradual weakening of internet censorship and the rising wealth of the middle class saw Malaysia transform into a modern global economy, underpinned by a more assertive Islam.

204 See SMNA (1995). *Prolegomena to the metaphysics of Islam: an exposition of the fundamental elements of the worldview of Islam*. International Institute of Islamic Thought and Civilization: Kuala Lumpur, Malaysia; Nagata J (1982). *Islamic revival and the problem of legitimacy among rural religious elites in Malaysia*. Man: Journal of the Royal Anthropological Institute of Great Britain and Ireland **17**, 1; and recently, Mandaville P *et al*. (2009). *Transnational Islam in the South and Southeast Asia: movements, networks and conflict dynamics*. National Bureau of Asian Research: Washington, DC, USA.

5.3 Islamic pathways to innovation

Professor Dr Yaackob Che Man stands at this crossroads between the Islamic faith and global innovation. He is the Director of the Halal Product Research Institute at the Universiti Putra Malaysia. Yaackob explains how his centre's research ranges from the development of halal chocolate, to e-nose technologies which can detect alcohol and pork in food, and a halal-based gelatine replacement for use in drug capsules. 'Malaysia is aspiring to become a global halal hub', he says. 'Our Centre wants to provide the research and training to underpin this ambition.'

Malaysia has strong credentials when it comes to Islamic innovation. Widely recognised as the pioneer for Islamic banking and finance, Malaysia boasts the world's largest market in Islamic banking assets and private debt securities, valued at US$30.9 billion and US$34 billion respectively.[205] The international finance community now appreciates the growth potential of Shariah-based banking practices and Malaysia's central role within these.

Malaysia has also played a key role in Vision 1441H, the OIC's blueprint for science and technology,[206] which was adopted by OIC heads of state in Kuala Lumpur in 2003. This framework seeks to inspire innovation as part of its quest to tackle inadequate economic development and education, and a dependence on borrowed technologies.[207]

5.4 Politics and governance

In any country, governance structures make a strong impression on national character. At independence, Malaysia was established as a democracy, modelled on the British parliamentary system. The immediate priority of the first government was to engender a sense of national identity, unity and culture—a challenging task as previously independent states and prominent sultans grappled with their perceived loss of sovereignty and identity.

This challenge of national unity continues today as evidenced by the much publicised '1Malaysia' policy of the Najib Government, the latest in a stream of efforts to ensure social cohesion. '1Malaysia' is driven by the need to recognise the cultures, religions, languages and legitimate interests of all Malaysian communities, beyond the indigenous Malays.

Unlike most developed democracies, Malaysia has had one dominant ruling party since Independence: Barisan Nasional, a coalition formed from a number of political parties, the largest of which is Najib's United Malays National Organisation

205 *BNP Paribas to make Malaysia the hub for Islamic finance* (June 2010). Global Islamic Finance Magazine: London, UK.

206 '1441H' (1441 Hijriyah) is a reference to the Islamic calendar, which equates to year 2020 in the Gregorian calendar.

207 *Vision 1441: Kuala Lumpur declaration on science and technology for the socio-economic well-being of the Ummah* (October 2003). Organisation of the Islamic Conference: Kuala Lumpur, Malaysia.

(UMNO). Such political stability is a trademark of Malaysian society, with some 76% of Malaysians stating that they were satisfied with the country's direction in a 2007 Pew Global Attitudes Survey.[208] Figure 5.1 provides a comparative analysis of governance and accountability indicators. Indicators of public voice and accountability indicate that there is some room for improvement.

Figure 5.1. Comparison of governance and anti-corruption indicators (%), 2008.[209]

There are signs of change emerging on the political landscape. By Malaysian standards, the 2008 election was a political upset. The Barisan Nasional coalition suffered its biggest ever defeat and lost its long-held two-thirds majority. This suggests a strengthening of alternative voices in a society where dissenting views in public are uncommon, and where a broadly conservative approach underpins the majority of government decisions.

208 Pew Global Attitudes Project. Pew Research Centre: Washington, DC, USA.

209 Worldwide Governance Indicators. The World Bank: Washington, DC, USA. These are based on several surveys, reports and indexes including the Asian Development Bank Country Policy and Institutional Assessment, the Bertelsmann Transformation Index, the EBRD's Transition Report, the Economist Intelligence Unit Country Risk Service and Democracy Index, Gallup World Poll, Institutional Profile Database, and Global Insight Business Conditions and Risk Indicators.

5.5 Attitudes to science and innovation

In a 2004 government survey of Malaysian public attitudes, 83% of respondents said that there was a need to place greater emphasis on science and technology, while 71% thought the government should provide more funds for scientific research.[210]

However, as discussed in earlier chapters, despite positive attitudes towards science, younger Malaysians demonstrate a worrying lack of scientific curiosity, creativity and critical thinking. Debates on how to overcome this crucial shortfall revolve largely around the employability of graduates and the respective responsibilities of university and industry, as well as the merits of examination-oriented education. Yet there seems to be limited analysis of the root cause. Perhaps the lack of critical thinking is not merely an educational issue, but more a social–cultural issue. Some commentators believe the recent election might symbolise the increasing influence of alternative voices, critical analysis and growing avenues for free speech in Malaysian society through the internet and other new media channels. If so, this might bode well for the future of science in Malaysia. In societies where open debate is encouraged, critical thinking, creativity and innovation are more likely to thrive.

5.6 Science and mathematics or sains dan matematik

Today, Mahathir remains one of Malaysia's most prominent bloggers. When the government announced in July 2009 that it intends to reverse its commitment to English as the prime language of instruction in science and mathematics, Mahathir spoke out to the blogging community. 'It seems to me', he writes, 'like the Government is not listening to the voice of the people. Perhaps a blog vote might enlighten them.'[211] Over 100,000 people voted against the government's decision. It remains a contested issue as to whether weaker English skills hinder some students from succeeding in STI, and whether students, particularly in rural areas, might perform more effectively if they were taught in the national language of Bahasa Malaysia or indeed in other vernacular languages. This is a complex policy debate, versions of which have occurred in Indonesia,[212] Canada[213] and Hong Kong. As Dr Fatimah argues, 'English or Malay, it doesn't really matter at the end of the day. The key thing that we need is good teachers and role models in our education system, and we need consistency in our approach.'

210 Government of Malaysia (2004). *Public awareness of science and technology in Malaysia 2004*. MOSTI, Putrajaya, Malaysia.

211 Mahathir M (2009). *The teaching of maths and English*. Blog (July).

212 Onishi N (2010). *As English spreads, Indonesians fear for their language* (July). New York Times: New York, NY, USA.

213 Gallagher M (2009). *Bilingualism in Canada—the great language debate* (October). http://www.Informedvote.ca: Toronto, Ontario, Canada.

5.7 The gender factor

A group of undergraduate students agreed to talk to us about their motivations for studying science. Inspirational teachers in secondary school, the hope of a well-paid job, and career development were among the reasons cited. Of the 11 students, only one was male. The gathering reflected the prominent role of women in Malaysian society, and their increasing influence in STI. Female students outnumber males with a ratio of about 2:1 in higher education, in both enrolment numbers and graduates alike.[214] In 2007, the number of women graduates was 38,899, compared to 20,572 males.

This offers grounds for optimism with regard to the future of gender balance in research careers. According to 2006 UNESCO data, women constituted 39.8% of the 9,694 full-time researchers in Malaysia, while UN figures show that only 24% of senior officials, legislators and managers in Malaysia are women.[215] With further advancements in educational opportunities for women as well as new policies for family support services, it is hoped that the number of women in research will continue to grow. Contrary to many perceptions about Islamic cultures, the empowerment of women in Malaysia is a source of national pride. In preparing this report, we encountered a high proportion of scientific leaders who were women. Whatever the future holds for STI in Malaysia, women will be central to it.

214 Ministry of Higher Education (2008): Putrajaya, Malaysia.

215 *Indicators on women and men*. United Nations Statistics Division: New York, NY, USA.

6 Sustainability

Looking out of the plane window over Borneo, trees cover the ground below as far as the eye can see. Closer inspection reveals two very different types of tree cover: tropical rainforest and oil palm (*Elaeis guineensis*) plantations. The plantations are distinctive: uniform trees tessellated onto the hillsides, cut through with ochre access roads. Oil palm is big business in Malaysia. The tree produces up to eight times more oil than any other tropical or temperate oil crop.[216] Extracted from fruit bunches, the oil is found in a tenth of everyday supermarket products,[217] and used as a feedstock for applications like biofuel production.[218]

Yet the view from the plane window has changed numerous times in Malaysia's history. Once almost completely covered in dense tropical rainforest, Malaysia's ecosystem has been reshaped first by settlements, then for timber and agricultural land. In the colonial era, the forests were cut down to make way for rubber plantations. More recently, oil palm plantations have been the big drivers of deforestation. According to UN estimates, in the 15 years to 2005, at least 55% of oil palm expansion in Malaysia occurred at the expense of natural forest (with the remainder being pre-existing cropland).[219]

This chapter considers the challenge of sustainability in Malaysia and asks whether the country is balancing today's needs without compromising the ability of future generations to meet their own needs.[220]

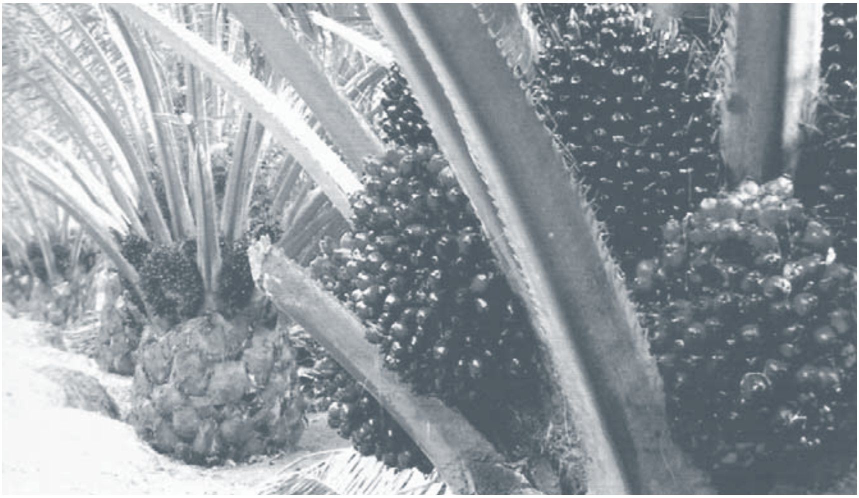
216 Sheil D et al. (2009). *The impacts and opportunities of oil palm in Southeast Asia: what do we know and what do we need to know?* Center for International Forestry Research (CIFOR): Bogor, Indonesia.

217 Buckland H (2005). *The oil for ape scandal—how palm oil is threatening orang-utan survival*. Friends of the Earth, The Ape Alliance, The Borneo Orangutan Survival Foundation, The Orangutan Foundation (UK) and The Sumatran Orangutan Society: London, UK.

218 Salmiah A (2000). *Non-food uses of palm oil and palm kernel oil*. MPOPC Palm Oil Information Series; cited in Teoh CH (2002). *The palm oil industry in Malaysia*. WWF Malaysia: Petaling Jaya, Selangor, Malaysia.

219 Koh LP & Wilcove DS (2008). *Is oil palm agriculture really destroying tropical biodiversity?* Conservation Letters **1**, 60–64. The figure is relatively uncertain (55–59%) because the FAO definition of forests includes degraded forests and secondary regrowth as well as plantations, although the authors attempted to take account of this in their assessment.

220 United Nations General Assembly (1987). *Report of the World Commission on Environment and Development: our common future. Annex to Document A/42/427, development and international co-operation: environment; our common future. Chapter 2: towards sustainable development; paragraph 1* (March). United Nations General Assembly: New York, NY, USA.



Palm oil fruit ready for harvest (cikgusejarah.com)

6.1 Palm oil: cashing in, but at what cost?

Tan Sri Yusof Basiron, CEO of the Malaysian Palm Oil Council, states, 'Oil palm is the most effective energy plant. It leverages Malaysia's natural advantages—strong sunlight, ample rain, rich soil, and provides a critical source of economic growth.' While some despair at the sacrifice of forest required, this economic story rings true. The palm oil sector contributed a massive RM17.0 billion or 3.3% to GDP in 2009 and accounted for RM49.6 billion in exports.[221] With such returns, it is not surprising that the expansion of the plantations in Malaysia increased from 2.03 million ha in 1990[222] to 4.69 million ha in 2009 (as demonstrated in Figure 6.1).[223] Sabah and Sarawak are expanding their oil palm plantations particularly rapidly.

Scientific research into improving palm oil is of great importance to Malaysia. The sector contributes strongly to economic prosperity and most of the large palm oil companies are at least partly state owned. The government, through the Malaysian Palm Oil Board, funds the Advanced Biotechnology and Breeding Centre (see Box 6.1) to spearhead its development of the crop. This Centre in Selangor carries out a wide range of research from traditional breeding and selection work to tissue culture, genomics, genetic engineering and phenolics. It has forged a number of partnerships with world-class institutions (including MIT, and the John Innes Centre in the UK) to help it achieve these aims.

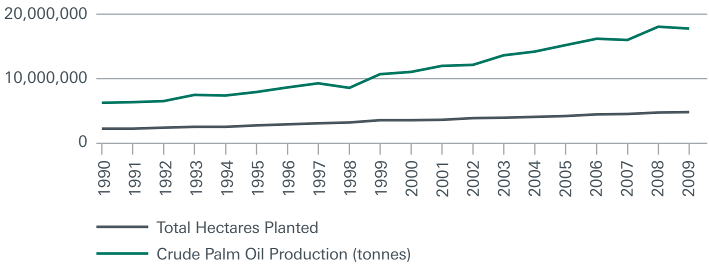
221 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

222 Teoh CH (2002). *The palm oil industry in Malaysia*. WWF Malaysia: Petaling Jaya, Selangor, Malaysia.

223 Malaysian Palm Oil Board (2009). *Overview of the Malaysian palm oil industry 2009*. Malaysian Palm Oil Board: Bangi, Malaysia.

An example of a typical Malaysian oil palm plantation (Ch'ien Lee, Royal Society SEARRP)

Figure 6.1. The growth of oil palm plantations in Malaysia.[224]



224 Malaysian Palm Oil Board: Bangi, Malaysia.

While the economic boost from the palm oil boom is undeniable, the revenue itself comes at a price. Tensions over palm oil versus rainforest conservation are part of the debate about Malaysia's right to choose its own course for economic development. The same countries that have cashed in on their natural assets to stimulate economic growth, admittedly centuries ago, are now trying to dissuade Malaysia from taking the same path. Yusof Basiron describes some parts of the conservation movement—which is predictably critical of Malaysia's oil palm preferences—as 'one huge conspiracy to stop developing countries from developing. Developed countries can replant all their forests and forfeit economic growth', he says. He is not alone in this view. Dr Mahathir fervently upheld the right to development of the poorer countries of the south, against the 'eco-imperialist' position of the wealthy countries of the north.

Box 6.1. A snapshot of science: research at MPOB's Advanced Biotechnology and Breeding Centre[225]

Current oil palm breeding populations only draw from a narrow genetic base. To widen this base, the Centre has mounted several expeditions to the centre of origins in Africa and Central-South America to collect oil palm germplasm. Now, the MPOB has the largest oil palm germplasm collection in the world with about 100,000 palms in land banks. Current breeding programmes are looking to improve all aspects of the crop, from oil quality and quantity to tolerance to pests and diseases.

Tissue culture research (propagating oil palms under sterile conditions, often to produce clones of a particularly desired plant) have shown great promise—field trials have indicated that as much as 30% increase in yield can be obtained by planting clonal material. However two factors are impeding the full commercialisation of tissue culture:

- the inefficiency of the tissue culture process (specifically embryogenesis);
- clonal/floral abnormality.

Molecular markers are being developed to help in diagnosing floral abnormality and improving embryogenesis. A family of genes, known as MADS-box genes, has been shown to play a role in oil palm floral abnormality. Based on the sequences of these families of genes, a protocol has been developed which monitors the changes in DNA methylation pattern in normal and abnormal flowers. Several genes have been identified that may

225 Selected publications include: Huynh K *et al*. (2009). *Sequence and expression analysis of EgSAPK, a putative member of the serine/threonine protein kinases in oil palm* (Elaeis guineensis Jacq.). International Journal of Botany **5**, 76–84; Masani AMY *et al*. (2009). *Construction of PHB and PHBV multiple-gene vectors driven by an oil palm leaf-specific promoter*. Plasmid **62**, 191–200; Singh R *et al*. (2009). *Mapping quantitative trait loci (QTLs) for fatty acid composition in an interspecific cross of oil palm*. BMC Plant Biology **9**, 114. Ta-ha A *et al*. (2009). In vitro *regeneration of garden balsam,* Impatiens balsamina *using cotyledons derived from seedlings*. Biotechnology **8**, 44–52; Ramli US *et al*. (2009). *Use of metabolic control analysis to give quantitative information on control of lipid biosynthesis in the important oil crop,* Elaeis guineensis *(oil palm)*. New Phytologist **184**, 330–339.

be potentially useful in future manipulations of embryogenesis regulation. Studies were initiated to investigate the global expression pattern changes that occur during embryogenesis, using microarray technology. This tool will prove invaluable in assessing the performance of oil palm cells cultured in bioreactors, thus assisting in the continual improvement of bioreactor design and operation.

The genomics research at MPOB is directed towards the development of diagnostic tools for oil palm tissue culture and breeding, to aid in the production of elite planting materials. The research areas include construction of genetic linkage maps for oil palm for the location of genes associated with economic traits. There is also a major effort in sequencing as many oil palm genes as possible. At the end of 2009, MPOB and its consortium partners announced the successful sequencing of oil palm genomes from *Elaeis guineensis*[226] and *E. oleifera*. The combined 68.4 times genome coverage with almost 94% completeness is the most comprehensive genetic blueprint for the oil palm to date. MPOB and its partners also determined the transcriptome (expressed genes) of over 30 tissue types. The Centre is building a core bio-informatics team to exploit the genome and epigenome data.

The milling of oil palms (one of the first steps in producing palm oil) produces 45 million tonnes of water-based waste each year in Malaysia. This extract is rich in phenolic antioxidants in addition to water-soluble vitamins and organic acids, and so MPOB has developed a novel process to recover the desired chemicals from the waste. Several important applications of oil palm phenolics have been demonstrated that include cardio-protective, anti-cancer and anti-diabetic properties. These could be taken up by the nutraceutical and pharmaceutical industries. Fourteen patents are pending on these discoveries.

226 Chan PL *et al*. (2010). *Normalized embryoid cDNA library of oil palm* (Elaeis guineensis). Electronic Journal of Biotechnology **13**, 1 (15 January).

6.2 The carbon factor

The loss of forests can have disastrous implications for indigenous peoples, biodiversity and climate change. The amount of carbon stored in different land uses varies hugely from location to location and from crop to crop. Where there is peat[227] at various depths, the levels of carbon emissions on deforestation can increase dramatically. A greater understanding of the complexity of carbon storage, particularly below ground, is urgently needed. Recent research from Danum Valley (see Section 6.8) also shows that deforestation can cause increases in ground level ozone which is potentially harmful to human health.[228]

Deforestation is not just a scientific issue, but a political one too. Yusof Basiron argues that oil palm plantations have replaced rubber plantations or timber before them, and that the days of Malaysia chopping down forest areas, both pristine and secondary, are long gone. Environmental groups dispute this, and the truth probably lies somewhere in the middle.

6.3 A mediator that is up to the task?

The creation of the Roundtable on Sustainable Palm Oil (RSPO) is a positive sign that issues of sustainability are gaining traction. Founded in 2004, this consortium of stakeholders includes oil palm growers and environmental NGOs. It aims to 'promote the growth and use of sustainable palm oil'[229] and has developed robust sustainability criteria to assess the sector, both in plantation management and production. Critics claim that progress has been painfully slow. Only a small number of producers have so far met the RSPO criteria, with over 3.5 million metric tonnes of sustainable palm oil being sold to date.[230] Given that Malaysia alone produces over 17 million tonnes per annum, the road ahead is long and steep.

Despite these challenges, the RSPO could be the sector's best hope. Palm oil is here to stay. An increasingly common ingredient, demand will only increase[231] — particularly since the world's two biggest importers are India and China.[232] The RSPO's approach of working *with* smallholders, commercial growers and millers to promote best practice is the right course of action. However, far greater muscle in terms of promotion, enforcement and ongoing monitoring is needed if the RSPO is to succeed.

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227 Peat is the partially decomposed remnants of organic material that once grew on the peatland surface. It is classed as an 'organic soil' (carbon content above 40%).

228 Hewitt C *et al*. (2009). *Nitrogen management is essential to prevent tropical oil palm plantations from causing ground-level ozone pollution*. Proceedings of the National Academy of Sciences USA, 106, 18.

229 Roundtable on Sustainable Palm Oil, Petaling Jaya, Selangor, Malaysia.

230 1,944,162 metric tonnes of crude sustainable palm oil as of 4 February 2011, according to the Roundtable on Sustainable Palm Oil, Petaling Jaya, Selangor, Malaysia.

231 Henderson J & Osborne D (2000). *The oil palm in our lives: how this came about*. Endeavour **24**, 63; cited in Turner E *et al*. (2008). *Oil palm research in context: identifying the need for biodiversity assessment*. PLoS ONE **3**, 2, e1572; doi:10.1371/journal.pone.0001572.

232 *BisInfocus 2006 Prospek Perkebunan and Industri Minyak sawit Di Indonesia 2006–2020*. PT Bisinfocus Data Pratama: Jakarta, Indonesia; United States Government. *Palm oil: world supply and distribution* (online reference). United States Department of Agriculture (USDA): Washington, DC, USA; cited in Sheil D *et al*. (2009). *The impacts and opportunities of oil palm in Southeast Asia: what do we know and what do we need to know?* Center for International Forestry Research (CIFOR): Bogor, Indonesia.

6.4 Logging out

Dr Waidi Sinun is the manager of the Conversation & Environmental Management Division at the development agency, Yayasan Sabah.[233] 'I represent the generation gap in Malaysia', he says. 'My parents were both illiterate, yet I've managed to get a PhD in hydrology, funded by the government. Over my lifetime, I think awareness and interest in conservation issues and education is increasing, particularly amongst the younger generation.' Waidi symbolises the dramatic changes in Malaysia in recent decades. Awareness of the importance of conserving Malaysia's natural resources has increased—and at the same time, rapid economic growth (sometimes at the expense of those same natural resources) has yielded increased opportunities for education and career development over that which was available to previous generations.

Waidi Sinun explains that Sabah was once, like the other states that make up Malaysia, covered in dense rainforest. Today, the forest covers 61% of the land area[234] and is classified in a myriad of different ways, each with its own level of protection. Only 92,400 ha of untouched pristine rainforest remain, fragmented across the state.[235] Another 3.5 million ha of forest are classified as Permanent Forest Estate; these form a patchwork of reserves, estates, timber concessions and National Parks.

The pressures on Malaysia's forests are considerable. Timber, though no longer the export earner it once was, still contributed 2.9% to GDP in 2009[236] with exports of almost RM19.5 billion.[237] The population is growing rapidly and the temptation to further log the forest is significant. Genuinely sustainable logging practices are rare, while the awarding of concessions and punishment for poor practice can be more opaque than is desirable.

While the timber industry is not known for its innovation, the Forest Research Institute Malaysia (FRIM) has been a consistent and important facilitator of forestry research, often with commercial spinoffs. Their research has developed fast-growing high-quality timber clones, as well as identifying alternative uses for an array of oil palm by-products. In 2009 FRIM were awarded the Mahathir Science Award for their work in transforming rubber wood from a waste product into a furniture industry worth billions of ringgit.[238]

233 The Yayasan Sabah Group acts as a strategic development vehicle of the State Government of Sabah. Its mission is 'to enhance the quality of life of Malaysians in Sabah'. For more information see http://www.ysnet.org.my/.

234 JPSM (2007). *Annual report*. Forestry Department Peninsula Malaysia: Kuala Lumpur, Malaysia; Thang HC (2007). *An outlook of the Malaysian forestry sector in 2020*. Consultancy report to the Asia Pacific Forestry Commission. FAO; cited in Shamsudin AM, Ismai P & Fletcher SC (eds) (2009). *The role of FRIM in addressing climate change issues*. Forest Research Institute Malaysia: Kepong, Selangor, Malaysia.

235 Forest Resources (2008). Sabah Forestry Department: Sabah, Malaysia.

236 Calculated using export data available from the Malaysian Timber Industry Board, and the GDP for 2009 at current prices as provided by the Economic Planning Unit.

237 Malaysian Timber Industry Board: Kuala Lumpur, Malaysia.

238 Ongkili MJ (2009). Speech by the Minister of Science, Technology and Innovation, Datuk Dr Maximum Johnity Ongkili, at the Mathathir Science Award 2008 and 2009: Kuala Lumpur, Malaysia.

Box 6.2. A snapshot of science: combining research and training in biodiversity

Established in 2008 through a collaboration between Cardiff University and the Sabah Wildlife Department, the Danau Girang Field Centre is a base for research and training in biodiversity.[239] Its location in the Kinabatangan floodplain (Sabah, Borneo) gives researchers direct access to a vast array of wildlife; studies mapping the ecology, density, behaviour and genetics of species ranging from elephants to insects are currently under way. By studying the intricacies of the lives of different species, researchers at the Centre develop conservation and sustainability plans along with habitat suitability models to address the changes brought about by rainforest fragmentation and palm oil monoculture.

As well as being equipped for research, the centre is also used to provide training and field courses in biodiversity assessments of plants and animals. Training is run in parallel with research activities so that students can learn while contributing to long-term data collection. The centre has hosted international students from the UK, Germany and America and has welcomed more than 470 visitors.

6.5 A hyper-eye in the sky

Hyperspectral technology, as the name suggests, detects more than just visible light. Mounted to an aeroplane or helicopter, electromagnetic radiation reflected from the rainforest canopy can be recorded simultaneously from visible light to infrared. The technology has sufficient spatial resolution to identify individual trees in the rainforest canopy, which allows for extremely detailed maps and analyses of the forest below, a task that would be difficult and time consuming using traditional ground surveys. The Forest Department Sarawak is the first government agency in Malaysia to practically implement this for forest management, using sensors for the detection of illegal logging by mapping with very high accuracy where the forest is being opened up.

In addition, the technology has sufficient spectral resolution to identify differences between plants that cannot be detected by the human eye. The Forest Department take advantage of this to detect oil palms infected with the fungus *Ganoderma boneninse*, which causes basal stem rot and can lead to major losses in oil palm plantations. Interestingly, *Ganoderma* infection of forest trees belonging to the *Aquilaria* genus are highly prized as they develop a dark aromatic heartwood ('agarwood', or 'gaharu' in Bahasa melayu) that produces a resin with myriad functions in the perfume, pharmaceutical and furniture industries. This is

239 Cardiff University School of Biosciences website. http://www.cardiff.ac.uk/biosi/facilities/danaugirangfieldcentre/index.html.

an important export product for Malaysia: such is the demand that there are now plantations of trees artificially infected with the fungus.

It is not possible to distinguish infected trees from uninfected trees with the human eye. As the heartwood is a valuable source of income to local people, it means that uninfected trees growing in the wild are lost to random logging. Hyperspectral technology can distinguish these trees and so protect them from unnecessary destruction.

Sarawak's leadership in the use of this technology is thanks to Dr Affendi Suhaili. An experienced forester with a PhD from UPM, Affendi has taken this Finnish technology and adapted it to a Malaysian context. Affendi is already in collaboration with scientists at Harvard and Stanford to develop a data reference library for forest imaging. In a sector not renowned for innovation, such entrepreneurial ingenuity should inspire others in forestry and beyond.

6.6 By land and sea

Malaysians are incredibly proud of their biodiversity, and rightly so. As part of the Sandaland biodiversity hotspot, Malaysia is one of just 17 recognised mega-diverse countries in the world.[240] The number of plant species is estimated at more than 25,000.[241] The surrounding tropical waters are home to some of the world's richest coral reefs, mangrove forests and seagrass beds.[242] There is a sense, however, that this biodiversity is there to be exploited. Assessments of the inherent values of the biodiversity are sparse, while the perception that millions of dollars-worth of yet undiscovered drugs and products are locked up in the rainforest and oceans is widespread.

There are important issues at stake in terms of marine biodiversity. In coastal regions, marine degradation results from over-fishing, destruction of the mangrove swamps where fish spawn and sedimentation of coral reefs due to up-stream logging and changes in land use. The coast of Sabah is one edge of the Coral Triangle—the global epicentre of marine biodiversity.[243] Current plans to build a coal-fired power plant on this precious coastline are provoking anxiety. The Strait of Malacca, located between the Indonesian island of Sumatra and peninsular Malaysia, is the shortest route between the Pacific and Indian Oceans. It is estimated that 40% of world trade passes through it each year, the effects of which are difficult to measure.[244]

240 The United Nations Environment Programme World Conservation Monitoring Centre recognised 17 countries as being mega-diverse in July 2000, including Malaysia.

241 van Steenis C (1971). *Plant conservation in Malaysia*. Bulletin du Jardin Botatinique National de Belgique **41**, 189–202; Aiken S & Leigh C (1992). *Vanishing rain forests: the ecological transition in Malaysia*. Oxford University Press: New York, NY, USA; Shuttleworth C (1981). *Malaysia's green and timeless world: an account of the flora, fauna and indigenous peoples of the forests of Malaysia*. Heinemann Asia: Kuala Lumpur, Malaysia; Whitmore T (1984). *Tropical rainforests of the Far East*. Oxford University Press: London, UK; all cited in Hezri A & Hasan MN (2006). *Towards sustainable development? The evolution of environmental policy in Malaysia*. Natural Resources Forum **30**, 37–50.

242 WWF. *Malaysia's marine environment*. WWF-Malaysia: Petaling Jaya, Selangor, Malaysia.

243 Allen G (2008). *Conservation hotspots of biodiversity and endemism for Indo-Pacific coral reef fishes*. Aquatic Conservation: Marine and Freshwater Ecosystems **18**, 5.

244 Reuters Factbox (2010). *Malacca Strait is a strategic 'chokepoint'*. Reuters.

6.7 Taxonomy

Being able to catalogue the huge species diversity in Malaysia is an important precursor for conserving it. This cataloguing work requires training in animal and plant taxonomy, and courses are taught at the Universiti Kebangsaan Malaysia, the University of Malaya, the University of Malaysia Sarawak and the University of Malaysia Sabah.

There are three main herbaria for plant species of Malaysia where taxonomic research is carried out, taught and published. One is part of FRIM in Kepong, a few miles from Kuala Lumpur. The other two are in Borneo, in the Sarawak Forestry Department and the Sabah Forestry Department. Two reports on Malaysian flora are currently being written. Each has a core of authors and editors based in Malaysia with specialist contributors drawn from the international plant taxonomy community. For one of these, six volumes of the planned eight have been published. The second is *The Flora of Peninsular Malaysia*. A committee of editors is running and editing this project and, importantly, employs and trains young Malaysian plant taxonomists. The first of what will be a long series of volumes, produced with the financial support of MOSTI, was published last year.[245]

One of the scientists at FRIM said that five years ago under the Ninth Malaysia Plan, the government gave a generous grant to initiate work on *The Flora of Peninsular Malaysia* and another project, *Threatened Plants of Peninsular Malaysia*. Both of these have produced good outputs in the form of publications, among which is a Red List for the *Dipterocarpaceae*, the species that plays such a critical role in tropical forests. Sadly, within the Tenth Malaysia Plan, funding is poor and the scientists involved are now forced to look for outside support. To take its conservation agenda seriously, Malaysia needs to continue and even increase its support for these dedicated scientists. If it is true, as many Malaysians believe, that there is a wealth to be obtained from forest plant products, then local expertise in taxonomy needs to be safeguarded.

245 Kiew R, Chung RCK, Saw LG, Soepadmo E & Boyce PC (eds) (2010). *Flora of Peninsular Malaysia, Series II: Seed plants, vol 1*. Forest Research Institute of Malaysia: Kuala Lumpur, Malaysia.

6.8 Away from it all

Evenings at the field centre of Sabah's Danum Valley Conservation Area are memorable. Located adjacent to the protected lowland tropical rainforest, the sounds of insects and other creatures remind us that we are amongst the privileged few to appreciate such an untouched natural environment. Scientists and research assistants eat together on the balcony overlooking the forest and talk about the research activities of the day. Tom Fayle, a post-doctoral ecologist from Cambridge, has been comparing the ant species in the forest and the adjacent oil palm plantations, determining the effects on diversity consequent of a change in land use. Meanwhile, Mohd. Jamal Hanapi Jamil, a local researcher based in Danum for 17 years, has been monitoring the latest meteorological data to feed into climate change research.

Danum Valley is significant because it is one of the largest, best-protected expanses of pristine lowland forest remaining in South East Asia. It covers nearly 45,000 ha and is embedded within an exceptionally large timber/plantation concession that covers over 1 million ha and is managed by Yayasan Sabah. The field station was set up 25 years ago with support from the UK's Royal Society and is the research base of the Royal Society's South East Asia Rainforest Programme (SEARRP). The research is multidisciplinary. In the early days, SEARRP's objective was to describe the diversity of the forest and underlying mechanisms that maintain it. Today the focus is on understanding how changing climate and landscape due to agricultural practices affects the forest ecosystem, and how the forest can contribute to a sustainable future. Current research includes measurements of gas emissions into the atmosphere to determine how this is altered by changing land use, large-scale rainforest regeneration experiments, and studies on the effects of forest fragmentation on species diversity. It is recognised that plantation and forest have to exist together because of the economic implications to Malaysia. Work at Danum seeks to understand how to manage this problem and provide evidence-based advice to policy makers, not just in Malaysia, but throughout the tropics.

SEARRP has attracted generous funding from Sime Darby, a large Malaysian multinational conglomerate, as well as other international organisations, and its future is secure for many years to come. The Sabah Government is extremely proud of its commitment to maintaining the forest and its unique research facilities. The work done at Danum is recognised as world class, making it the leading rainforest research centre in the Old World tropics.

As well as facilitating research by individual scientists and small research groups, SEARRP has major funding from international and local sources to run three large programmes:

- the Sabah Biodiversity Experiment, a large-scale forest restoration experiment which investigates the links between biodiversity and ecosystem functioning and establishment of best practice for forest restoration;
- the 50 ha CTFS (Center for Tropical Forest Science) plot, one of a network of investigatory plots set up throughout tropical and temperate forests by the Smithsonian Institute, aimed at monitoring long-term forest dynamics and the effects of changing climate; and
- the Stability of Altered Forest Ecosystem (SAFE) project, which will investigate the impacts of forest clearance to oil palm plantation over a range of parameters, both biological and physical.

The SAFE project is funded by Sime Darby to the tune of 30 million ringgits (US$10 million). It was launched on 29 January 2011 by the Malaysian Prime Minister and received considerable publicity worldwide.[246] A main aim of the study is to develop guidelines on how to design and manage oil palm plantations to minimise environmental impacts. Up to 7,000 ha of forest within the Maliau Basin in Sabah will be converted into an oil palm plantation. This is a remarkable opportunity for trained scientists to follow in detail the species that survive or are lost as the level of logging intensifies and the land is fully converted into plantation. Researchers will also investigate how much land is needed around the plantation to minimise the pollution of waterways by plantation runoff. They will also be able to study how patches of conserved forest contribute to the environmental effects of logging.

In addition to the science, an important legacy of Danum Valley is the people that it trains. Many senior figures we met with from academia and the government had done their PhDs at Danum, and form a cadre of people pushing Malaysia towards a more sustainable future. They contribute to practical conservation, environmental education and sustainable forest/plantation management in Malaysia and beyond. Dr Waidi Sinun is one of these leaders.

246 Gilbert N. (2011). *Malaysia leads way in study of deforestation*. Nature (28 January). doi:10.1038/news.2011.56, accessed 6 February 2011.

6.9 Heating up: the politics of climate change

Sitting on stage with world leaders from Indonesia, the Maldives, Senegal and Bangladesh at the recent World Islamic Economic Forum, Prime Minister Najib provided a clear and direct message on climate change. 'The current reality must be recognised', he said, 'and we all stand accused of doing too little too late.' He proposed a Clean Energy Development Bank, and called on his friends on the stage to work with Malaysia to establish it. Such an initiative builds on his announcement at the Copenhagen conference in December 2009 that Malaysia would make '40% cuts in terms of emissions intensity by the year 2020',[247] conditional on adequate financing and technology transfer from developed countries.

These statements reflect the rising political and public awareness of climate change in Malaysia, albeit from a low base. An HSBC survey at the time of the Copenhagen talks found that only 35% of Malaysians agreed that 'climate change and how we respond to it are among the biggest issues they worry about today.'[248] At present Malaysia contributes only 0.7% to global CO_2 emissions.[249] Using an alternative measure, Malaysia's emission intensity levels, calculated as a ratio of greenhouse gas (GHG) emissions to the country's GDP, are above the global average in the energy sector.[250] The potential impacts of climate change in Malaysia are serious, with the IPCC's Fourth Assessment Report warning that climate change is likely to 'impinge on sustainable development of most developing countries of Asia as it compounds the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development.'[251]

There are still those in Malaysia who do not see climate change as important. With 78% of Malaysia covered in trees,[252] it can be difficult for discussions about the environment to seem relevant. There is a sense that Malaysia is playing a globally altruistic role at the expense of economic development, while not being remunerated for it. Climate change is a problem that was, in a large part, not created by countries like Malaysia, and the pressure to conserve forests (based on a much deeper understanding of the pivotal role of forests in climate change)[253] largely comes from countries who exploited theirs decades or centuries ago.

247 Prime Minister of Malaysia Najib (27 December 2009). Speech by the Right Honourable Dato' Sri Mohd Najib Tun Abdul Razak, Prime Minister of Malaysia at the 15th Conference of Parties (Copenhagen 15): Copenhagen, Denmark.

248 HSBC Climate Partnership (2009). *Climate confidence monitor 2009*. HSBC: London, UK.

249 Human Development Report (2007). *Fighting climate change: human solidarity in a divided world (2007/8)*. United Nations Development Program: New York, NY, USA.

250 World Energy Outlook (2009). International Energy Agency: Paris, France.

251 Cruz R (2007). *Asia, climate change 2007: impacts, adaptation and vulnerability. In: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Parry M *et al.* (eds). Cambridge University Press: Cambridge, UK.

252 Percentage tree cover includes natural forest and plantations.

253 'Nearly one-fifth of today's total annual carbon emissions come from land-use change, most of which can be traced back to tropical deforestation.' Stern N (2007). *The economics of climate change: the Stern review*. Cambridge University Press: Cambridge, UK.

The Malaysian Government makes the right noises about climate change[254] but more could be done. The responsibility for climate change sits with the relatively junior Ministry for Natural Resources and the Environment, instead of being seen as a cross-departmental issue. The national Climate Change Policy was launched in 2009[255] and there is a Steering Committee on Climate Change, but some question the efficacy of these policies.

A wider acknowledgement of sustainability is also slowly becoming embedded in government thinking and broader policy. It is one of three key themes identified as part of the country's NEM. The Tenth Malaysia Plan outlines a range of new initiatives, from energy performance labelling to gazetting forests, in partnership with the states. Within academia, the APEX vision of USM is to become a sustainability-led university which places sustainability at the core of its programmes and activities. In partnership with the United Nations University, USM also acts as the Regional Centre of Expertise on Education for Sustainable Development. When combined, all these are promising, but more effort is needed to genuinely embed sustainability into Malaysian decision-making frameworks.

6.10 A new way to frame the debate?

Malaysia's environmental policy so far has been marginal to the overall pursuit of socioeconomic progress.[256] While issues of sustainability and climate change are growing in importance, the alleviation of poverty and the improvement of living standards remain paramount. Yet recent thinking at the interface of ecology and economics ("ecosystems services") could offer a useful bridge between the two. New modelling attempts to put a monetary value on the services provided by natural ecosystems, and could eventually be factored into the analysis of the economic health of countries.[257] This is a difficult task and the subject of much debate, but if such initiatives gain global traction, the potential benefits for Malaysia, given its natural resources, are substantial.

The challenge is to encourage a change in mindset among policy makers, industry leaders and the broader community so the protection of Malaysia's rich biodiversity is not always seen as secondary to economic priorities. An ecosystem services lens could be a good first step towards achieving this—bringing a wide range of factors into decisions, and highlighting the future costs of *not* thinking sustainably.

Greater attention could also be directed to developing new partnerships between government and industry as well as with partners further afield. It is to the subject of collaboration that we turn now.

254 Malaysia ratified the UNFCCC in July 1994 and Kyoto Protocol in September 2002. See Razali W (2008), cited in FRIM (2009).

255 Government of Malaysia (2010). *Tenth Malaysia Plan 2011–2015*. Economic Planning Unit: Putrajaya, Malaysia.

256 Hezri A & Hasan MN (2006). *Towards sustainable development? The evolution of environmental policy in Malaysia*. Natural Resources Forum **30**, 37–50.

257 European Academies Science Advisory Council (2009). *Ecosystem services and biodiversity in Europe* (February). EASAC: Halle, Germany.

7 Collaboration

Cuba and Malaysia are not obvious allies. Yet the USM and the Finlay Institute in Havana have teamed up to develop a halal meningitis vaccine, created in accordance with Islamic rules. Bringing together Cuba's medical research expertise and Malaysia's credentials in halal techniques, this collaboration sought to address a market need. Most meningitis vaccines are produced from pig-based products and are thus forbidden to Muslims, but thousands of Muslims are required to be vaccinated against the disease during the annual Haj pilgrimage to Mecca. The two institutions have been collaborating for almost 10 years, and it seemed a natural next step from their previous work on tuberculosis. A RM3.6 million project, of which more than half was funded by Malaysia,[258] this project is symbolic of Malaysia's growing global ambition, particularly as a halal hub. It also demonstrates the country's increasing willingness to look outside its borders for collaboration and partnerships.

In February 2010 the two organisations signed an agreement to jointly develop and commercialise a specific product: the halal tetravalent meningococcal ACW135Y vaccine.[259] USM's Vice-Chancellor Professor Tan Sri Dato' Dzulkifli Abdul Razak said, "This is the first time USM and Finlay has concluded a definitive Agreement towards the joint-production of a vaccine that addresses the bottom billions, which is in line with USM's vision of becoming a world renowned sustainability-led university."

Partnerships of this scale are limited in Malaysia. Incentives to collaborate abroad are a relatively recent phenomenon and are often hamstrung by bureaucratic processes and tight government controls. This chapter considers the development of collaborative research, both among Malaysian institutions and partners further afield, while also looking at Malaysia's patterns of collaboration and areas of potential growth.

7.1 Patterns of collaboration

In Chapter 1, we explored Malaysia's recent push to increase its scientific publications output from a low base. It follows then that the extent to which Malaysian scientists are collaborating internationally is also at a nascent stage, as demonstrated through co-authorship and joint projects.

Of the 14,731 scientific publications produced in Malaysia from 2004 to 2008, 39% were internationally co-authored.[260] This is encouraging, given the country's limited collaborative experience, and it also reflects the importance placed on developing strong independent research in the first instance. This initial

258 The Times (2007). *Pilgrims to get halal vaccine* (19 October). The Times: London, UK.

259 Abdullah M (2010). *USM and Finlay lead the way In halal vaccine development*. Research Asia: medicine news (11 February). Available online at: http://www.researchsea.com/html/article.php/aid/4946/cid/3/research/usm_and_finlay_lead_the_way_in_halal_vaccine_development.html?PHPSESSID=oo9q9t2d7m4rhgdamhv6ledn77, accessed 4 February 2011.

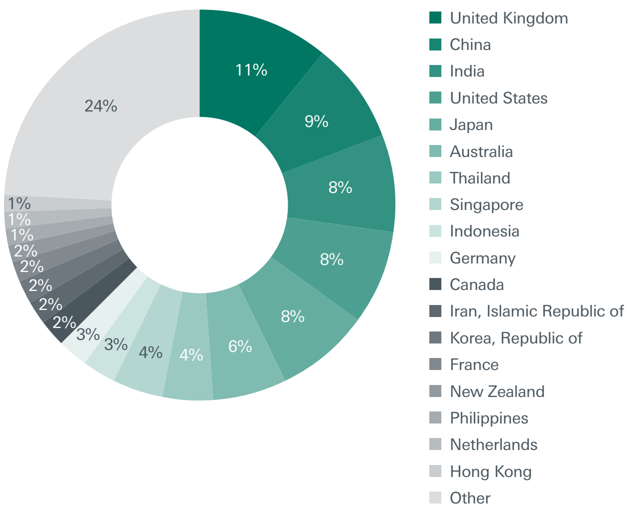
260 Data provided by Elsevier.

consolidation may also explain why Malaysia's collaboration rates are considerably lower than some of Malaysia's neighbours, with Indonesia and Vietnam's co-authorship at 80% or above, the Philippines at 68% and Thailand at 47% (admittedly with vastly different quantities).[261]

Professor Dato' Dr Zakri, Science Adviser to the Malaysian Prime Minister, says one of the reasons why Malaysian scientists do not look abroad is because there is ample R&D funding available within the country, so scientists are not dependent on EU or other funding sources. Similarly, the way R&D funding is structured does not encourage scientists to look elsewhere. 'On the one hand, it is good that Malaysia is so independent, but on the other, we tend to be a little complacent. We aren't encouraging our scientists to benchmark against the rest of the world. International collaboration needs to become one of our top priorities.'

There are signs that things are changing. Overall, international collaboration has increased from 375 papers in 1996 to 2,066 in 2008, an increase of 451%,[262] with the UK, China, India and the US being the strongest collaborators. While the UK and China have been long-term partners, there is growing evidence that Malaysia's research networks are diversifying as their research output increases, reaching out to more of Europe as well as Africa.[263] Figure 7.1 provides a breakdown of Malaysia's collaborative network.

Figure 7.1. Malaysia's top collaborators in 2008.[264]



261 Data provided by Elsevier.

262 SCImago (2007). SJR—SCImago Journal & Country Rank, retrieved 2 August 2010.

263 Data provided by Elsevier.

264 Data provided by Elsevier.

Box 7.1. A snapshot of science: productive collaborations in structural biology

Structural biology is progressing in Malaysia, for example with the structures of lipases solved in Professor R.N.Z.A Rahman's laboratory at the Institute of Biosciences, UPM.[265] A productive international collaboration between a network of scientists at UKM, the Malaysian Genome Institute, USM, UPM and Professor David Rice at Sheffield University, UK, has resulted in exciting work on the bacterial pathogen, *Burkholderia pseudomallei*. This pathogen is the causative agent of melioidosis, a serious disease of man and animals. Disease occurs after bacterial contamination of breaks in the skin or by inhalation after contact with water or soil.

There is no licensed vaccine and the bacterium is resistant to many antibiotics. The complete genome sequence is known. The Malaysian/Sheffield team have identified a previously uncharacterised toxin that is a key component of pathogenicity and determined its structure, function and how it kills. The structures of 20 other proteins from *Burkholderia* have been solved, each of which is either a drug target or a protein of unknown function. A further project has involved the structures of a superfamily of surface proteins that are involved in invasion by the chicken parasite *Eimeria*. *Eimeria* infects about 2 billion chickens a year in South East Asia and the work has clear relevance to the economy of the region. The programme has involved a series of exchanges of material and personnel (part funded by the British Council) and has led to an understanding of the contributions structural biology can play in diseases of relevance to the region and to the local biotech industry.

7.2 Colonial ties

Just a stone's throw from the Royal Society in London, Trafalgar Square was recently transformed into a Malaysian street food bazaar. A strategic exercise in 'gastro-diplomacy', the Malaysian Government was using its rich cuisine to strengthen national ties and sell its wares to the British public. In science, these ties are already strong but if the way to a country's heart is through its stomach, this is a wise strategy.

265 Matsumura H *et al*. (2008). *Novel cation–π interaction revealed by crystal structure of thermoalkalophilic lipase*. Proteins: Structure, Function, and Bioinformatics **70**, 592–598; Nyon MP et al. (2009). *Catalysis by* Glomerella cingulata *cutinase requires conformational cycling between the active and inactive states of its catalytic triad*. Journal of Molecular Biology **385**, 226–235.

The food bazaar reflects the importance of Malaysia's relations with the former colonial power. While many of their neighbours look to the US for collaborative research, Malaysia prefers the UK. The number of co-authored articles between the two almost doubled from just 543 articles between 1996 and 2000, to 963 between 2004 and 2008.[266] Producing a total of 334,418 internationally co-authored articles between 2004 and 2008,[267] there is ample opportunity for growth according to the UK's former High Commissioner to Malaysia, Boyd McCleary.

Collaboration to date has largely focused on engineering, medicine, physics and astronomy, and material sciences. However, Boyd argues that, as Malaysia's research strength grows, UK scientists should increasingly look to Malaysia, particularly given its unique biodiversity and the potential for pharmaceutical and climate change focused research.

In 2007–2008, there was a major drive for collaboration between Malaysia and the UK through the UK Prime Minister's 'Connect' initiative, generating much interest on both sides. Of the £4 million directed towards collaborative research programmes in 2007–2008 between the UK and 12 East Asian countries, over £1.2 million was allocated to 25 different collaborative projects with Malaysia—more than to China, Singapore, Thailand and Japan.[268] Such research funding is disappointingly no longer available to the same degree but, given the strong interest, governments of either country might consider reconstituting such a scheme in the future.

Ties between the UK and Malaysia run deep, with British-born Francis Light first settling in Penang as early as 1786. Relationships have remained strong since independence in 1957, with initiatives such as the Colombo Plan providing a strong base for continued collaboration and exchange.

The Colombo Plan was established in 1950 by the seven governments of the Commonwealth, and was later extended to include the USA and others within South and South East Asia.[269] Initially created to promote bilateral aid to developing countries in Asia, the plan is best remembered for sponsoring thousands of Asian students to study in tertiary institutions, with the UK and Australia among the most popular destinations. Today the effects of the scheme permeate the most senior levels of business, academia and policymaking in Malaysia—with many interviewees fondly recalling their student days in countries like the UK, despite the weather there.

266 Scopus database, Elsevier, retrieved 2 August 2010. This number excludes conference papers.

267 Data provided by Elsevier. The UK produced 37,000 co-authored papers in 2007; Evidence Ltd (2009). *International comparative performance of the UK research base*. Department for Business, Innovation and Skills: London, UK.

268 Prime Minister's Initiative 2 Connect. *PMI2 Connect: year one higher education partnership fund results 2007–08*. British Council: London, UK.

269 The founding member countries of the Colombo Plan included Australia, Canada, Ceylon (now Sri Lanka), India, New Zealand, Pakistan and the UK. They were later joined by Burma, Cambodia, Indonesia, Japan, Laos, the Philippines, the USA, Vietnam and Thailand.

Today there are almost 12,500 Malaysians studying in the UK, a third of whom are enrolled in postgraduate programmes.[270] With universities such as Nottingham, Southampton and Newcastle establishing branch campuses in Malaysia, the opportunities for stronger institutional linkages, student exchanges and 'sandwich' years also continue to grow.[271]

7.3 Looking down

A similar story can be told of Australia, which is the number one study destination for Malaysians, attracting over 20,000 students to both universities and vocational training institutions in 2010.[272] Scholarships from the Malaysian Government for public university academics to pursue PhDs overseas have also prompted significant growth, especially in the fields of science and engineering.[273] The Australian Government believes that their attractiveness as a study destination is partly due to the success of the Colombo Plan, with an estimated 250,000 alumni boasting an Australian qualification.[274] Such benefits are now being reflected in co-authored publications. In 2000, papers co-authored between Malaysia and Australia totalled just 40; in 2009 they reached 259, an increase of 548% with the most common areas of collaboration being medicine, engineering and computer sciences, followed by physics and astronomy.[275]

7.4 Other collaborators

7.4.1 Malaysia and the European Union

Beyond the UK, Malaysia's collaborative relations in Europe are minor. Germany ranks 10th among Malaysia's co-authored publications with 237 articles from 2004 to 2008, followed by France in 14th position with 148 papers, and the Netherlands in 17th with just 119.[276] Despite significant increases in the amount of European Commission funding available, Malaysia has been considered a 'strikingly marginal beneficiary' of EU-funded regional cooperation programmes in the region—with just one project underway in 2000. After a concerted push from the European side, the number of projects has now increased to 19 in 2005, but issues of limited awareness and perceived bureaucracy remain significant deterrents.

270 Education Market Intelligence (2009). *Malaysia market information*. British Council: London, UK.

271 Lewis L (2008). *Newcastle University to open in Malaysia* (17 November). The Times: London, UK.

272 Australian Government (2010). *Monthly summary of international student enrolment data—Australia—YTD May 2010*. Department of Education, Employment and Workplace Relations: Canberra, Australia.

273 Australian Government (2007). *Market data snapshot no. 21* (June). Australian Education International: Canberra, Australia.

274 Australian Government (2007). *Market data snapshot no. 21* (June). Australian Education International: Canberra, Australia.

275 Scopus database, Elsevier, retrieved 2 August 2010.

276 Scopus database, Elsevier, retrieved 28 July 2010.

In March 2010, the European Union announced that RM2.5 million would be provided to the University of Nottingham–Malaysia, to increase awareness and collaboration through EU research frameworks. According to the Vice President of Research, Professor Sayed Azam-Ali, this centre will bring together university and industry partners from across Malaysia and will also leverage EU-related teaching materials and expertise.

7.4.2 A global champion for food security

On a somewhat larger scale, the University of Nottingham–Malaysia was also successful in its bid to secure a new international organisation dedicated to neglected and underutilised crops and related food security research. With over half of humanity's food derived from rice, wheat and maize, 'Crops for the Future' aims to explore other important but typically overlooked sources of nutrition, food, animal feed and other resources. Aimed at being a 'single global champion' for such research, this is an exciting opportunity for Malaysia not only to advance its research capacity in food security and biodiversity, but also to become a facilitator of collaborations around the world.

7.4.3 Malaysia and the region

Due largely to the huge disparities in scientific capacity across South East Asia, Malaysia's collaboration with its neighbours is still quite limited, with Indonesia, Singapore and Thailand the most favoured partners. Indonesia, in particular, has moved from co-authoring just three papers in 1996 to becoming the sixth most prominent Malaysian collaborator, surpassing Singapore and China, with 136 papers in 2009.[277] Perhaps not surprisingly, it is India and Japan, those far more advanced in STI capacity, that feature more prominently in Malaysia's collaborative networks—ranking second and fifth respectively in 2009.[278]

Malaysia's geographical position and its unique cultural diversity is certainly an advantage in terms of collaborations with the emerging superpowers of China and India. With China's average annual growth rate of scientific output at 17% between 1997 and 2007 (compared to the US 0.7%[279]), and India producing 51,283 papers in 2009 alone,[280] a more concerted and aggressive strategy of scientific engagement and exchange between Malaysia and these superpowers would seem opportune.

277 Data provided by Elsevier.

278 Scopus database, Elsevier, retrieved 28 July 2010.

279 Chemistry World (2010). *US science lead slips* (25 January). Royal Society of Chemistry: London, UK.

280 Scopus database, Elsevier, retrieved 28 July 2010.

7.5 South–South collaboration

Dato Lee Yee Cheong talks so quickly and passionately about his latest role that it can be difficult to get a word in. A former engineering and industry leader in Malaysia and beyond, Dato Lee now acts as chairman of the International Science, Technology and Innovation Centre for South–South Cooperation (ISTIC). Established in 2008, operating under the auspices of UNESCO and largely funded by the Malaysian Government,[281] ISTIC aims to be an international platform for countries of the G77 and the OIC to collaborate in STI.

'ISTIC is important,' Lee explains, 'because developing countries need to have confidence in themselves and we must not be dominated or overshadowed by the likes of China, India and Brazil. It's not about philanthropy or aid; future markets are all based in the South so ISTIC is about investing now, building relationships now so that developing countries can benefit from each other in the future.' Focused on STI policy for development, capacity building and collaborative initiatives that leverage existing networks, ISTIC concentrates on areas such as water, energy, health, agriculture and biodiversity.[282] Importantly, ISTIC is symbolic of broader ambitions to become a hub for knowledge sharing among poorer countries.

The UN Development Programme has also recognised Malaysia's potential, listing the sharing of successful development strategies as a key focus area in partnership with the Malaysian Government. Malaysia will share its expertise in relation to oil and gas as well as providing training and skilled personnel to assist in fostering private sector development.[283] As one of the only countries to reach seven out of eight Millennium Development Goals (with the exception of the HIV target), Malaysia's experience is now shared as an example of best practice for other developing countries.

7.6 A role model in the Islamic world?

Such leadership and knowledge sharing is also particularly important across the Islamic world. The OIC's 57 member states include 22 of the world's 50 least-developed countries, and so greater dialogue about the relationship between science, innovation and development is much needed. Building on Malaysia's involvement with the UN to share best practice, similar initiatives and training could take place amongst the least developed OIC countries; Malaysia would be well placed to facilitate these exchanges.

281 The Malaysian Government provided an initial input of US$10 million for construction and set-up costs, and provides an annual donation of $1.2 million. See Sawahel W (2007). *Malaysia to lead South–South collaboration*. SciDev.net.

282 ISTIC programs. ISTIC: Kuala Lumpur, Malaysia.

283 Government of Malaysia & UNDP (2007). *Country Programme Action Plan between the Government of Malaysia and the UNDP 2008–2012*. UNDP: Kuala Lumpur, Malaysia.

Malaysia demonstrated such leadership during its chairmanship of the OIC between 2003 and 2007. Charged with reinvigorating the OIC, Malaysia proposed a number of ambitious policies, including the settlement of the Israeli–Arab conflict, the promotion of a moderate and progressive approach to Islam (called Islam Hadhari[284]), and increased economic cooperation among Muslim countries.[285] These initiatives were ultimately unsuccessful, but Malaysia's constructive ambition for STI collaboration across the OIC remains a source of inspiration today.

As highlighted in Chapter 5, many believe that Malaysia could play a key role in assisting other Islamic countries to foster STI. Vision 1441H highlights 'fostering collaboration in STI' among OIC countries as part of its quest to inspire Islamic countries to become more proficient in 'the acquisition, generation, distribution and exploitation of knowledge'.[286] In this context, it is useful for Malaysia to look to other OIC member states who are investing in similar scientific areas for potential collaboration. Nanotechnology, for example, as highlighted in Chapter 4, is a newer priority for Malaysia and is an area where countries like Iran and Turkey are also gaining traction. Building networks and forums for the exchange of information and ideas, particularly at this early stage, could prove highly valuable.

Vision 1441H also suggests that OIC countries should spend 1.2% of their GDP on research and development. It says that by 2015, 30% of students in OIC countries should have the opportunity to go to university, and encourages scholarships and exchanges, particularly among OIC member states. While only seven years into this ambitious 17-year strategy, the majority of countries will fall well short of such lofty aims and senior Malaysians have expressed disappointment about the lack of commitment among OIC States.

7.7 Where next?

Malaysia has rich networks to draw from. The Commonwealth connection links it to 54 countries; the OIC links it to 56 other states; membership of bodies such as ASEAN and APEC connect it to its region; and its unique cultural diversity opens enviable doors in East Asia. In terms of a framework from which to build collaborative networks, these are strong credentials. Initiatives such as ISTIC and 'Crops for the Future' demonstrate an increasing desire to tap into global research more effectively. The increase in co-authored papers in a relatively short period of time is also positive and should be further encouraged.

284 Islam Hadhari or 'Civilizational Islam' is a theory of government based on the principles of Islam which focuses on efforts to improve the quality of life through knowledge and human development. This broad concept was originally mooted by Malaysia's fifth Prime Minister, Tun Abdullah Ahmad Badawi.

285 Sinanovic E (2010). *Malaysia, the Organisation of the Islamic Conference (OIC), and limits of Muslim cooperation*. Paper presented at the annual meeting of the Midwest Political Science Association 67th Annual National Conference: Chicago, IL, USA.

286 Organisation of the Islamic Conference (October 2003). *Vision 1441: Kuala Lumpur Declaration on Science and Technology for socio-economic well-being of the Ummah*. Organisation of the Islamic Conference: Kuala Lumpur, Malaysia.

Ch'ien Lee, Royal Society SEARRP

Much more needs to be done, however, if Malaysian scientists are to meet international standards. Collaboration is still some way off becoming embedded in the research culture of Malaysian scientists, and the links established through initiatives such as the Colombo Plan could be better used. The next chapter considers what policy levers might be available to secure a more prominent place for Malaysia in international networks of science and innovation.

8 Prognosis

Getting the right mix for a robust, productive yet flexible STI system is complicated. There are many choices, yet with a limited budget it may be difficult to strike the right balance. In Malaysia there has been much experimenting with various policies and initiatives, but now is the time to refine and perfect the model. This is likely to mean a more holistic, integrated system which is entrepreneurial and empowered to adapt swiftly to new ideas and opportunities.

This report has identified some of the key elements of Malaysia's innovation system, how they are currently being combined, and how they might be improved. In this chapter, we review our main findings and offer some concluding reflections on the strengths and weaknesses of Malaysian science and innovation.

8.1 The argument reinstated

Firstly, we have tried to capture Malaysia's longstanding ambition to become a knowledge-based economy by 2020. We looked at the evolving national emphasis, from rubber and tin to palm oil, combined with the greater prioritisation of ICT, then biotechnology, pharmaceuticals and other high-tech industries in more recent years. To achieve Vision 2020, the challenge now is to consolidate and focus investment through all the layers of the STI system to ensure success.

Secondly, identifying the defining characteristics and strengths of Malaysia has been a key priority. Biodiversity is one such strength, as is a rich cultural mix of Malay, Indian, Chinese and other indigenous ethnic groups which are a source of national pride and powerful networks. With a Muslim majority and many other religious groups, and a large English-speaking population, such networks can criss-cross the globe with relative ease, reaching emerging areas as well as the more established ones.

Thirdly, we have sought to identify gaps or tensions within the current framework that require attention, whether that is the tension between the shortage of workers educated above secondary school and the limited number of highly skilled jobs as identified in the NEM, or the lack of technology transfer and exchange between MNCs and local businesses, as well as the apparent disconnect between government and industry which is slowly being addressed. Understanding the variations in STI capacity across the country is also important, with the larger centres of Kuala Lumpur, Selangor and Penang far outstripping the poorer states in terms of R&D budgets. Such challenges are not unique to Malaysia, yet it is critical to acknowledge these limitations in order to address them.

Fourthly, we have profiled the key individuals and institutions that have shaped and inspired Malaysia's STI ambitions. Such individuals stem from policy communities as well as business, academia and beyond. They, and others like them, will be critical to perfecting Malaysia's innovation model.

Throughout this study, a number of strengths and weaknesses of Malaysia's STI system have been identified. Below is a summary of these findings.

8.2 Strengths and weaknesses of Malaysian science, technology and innovation

8.2.1 Strengths

8.2.1.1 A coherent vision

When announcing the Tenth Malaysia Plan to the parliament in June 2010, Prime Minister Najib reflected on Malaysia's development journey thus far—built upon two Malaya Plans, nine Malaysia Plans, three Outline Perspective Plans, as well as Vision 2020. Such strategies, combined with the NEM, provide a clear framework for Malaysia—with detailed plans, targeted sectors, and a reasonably honest assessment of impediments and obstacles to growth. While their implementation requires improvement, they provide a comprehensive and encouraging overview of the country's strategic STI priorities.

8.2.1.2 Economic and political stability

Malaysia has shown strong economic growth for most of the last decade (with the exception of 2009 where Malaysia was hampered by the global economic downturn).[287,288] Despite recent electoral shocks, Malaysia also offers a stable political system compared to the recent violence in Thailand or the perturbing acts of terrorism in Indonesia. Such credentials make Malaysia a stable country in which to invest, trade and collaborate.

8.2.1.3 Strong investment in people

From the 1970s onwards, Malaysia has invested heavily in human capital. The government focused on primary and secondary levels before embarking upon a comprehensive transformation of higher education to satisfy increased demand and to stimulate economic growth. As a result, numbers of PhDs and researchers are now significantly improving. While there are clear frustrations, overcoming obstacles to talent development is a clear priority of the Najib Government.

8.2.1.4 Global leadership credentials

Malaysia has proved itself as a world leader in the industries of rubber, tin and more recently palm oil, with growing expertise in halal-related sectors and in Islamic finance. These leadership credentials bode well for Malaysia's potential in other targeted sectors such as biotechnology, and agricultural and medical research. Malaysia's emergence as a global scientific player is some way off, but the foundations and experience are now in place.

287 Average growth of over 5% for 2000–2008, World Development Indicators: Washington, DC, USA.

288 2009 growth of –1.7%. IMF World Economic Outlook (2010). IMF 2010: Washington DC, USA. Available online at: http://www.imf.org/external/pubs/ft/weo/2010/01/pdf/text.pdf, accessed 4 February 2011.

8.2.1.5 Emerging leaders within industry

While technology transfer from MNCs to local businesses has been weak, companies such as Petronas and other emerging local talents have demonstrated Malaysia's capacity to nurture entrepreneurial and high-value industries. Commodity research organisations like MPOB are also strong examples of industry working well with research communities to develop stronger economic sectors which can be applied in other areas.

8.2.1.6 Capacity to leverage its rich biodiversity

Malaysia's rich environment is one of the country's great strengths. Previously the poor cousin to economic development, sustainability is slowly becoming embedded in Malaysian society. Understanding, valuing and appreciating Malaysia's biodiversity holds much potential for ground-breaking research if harnessed appropriately.

8.2.2 Weaknesses

8.2.2.1 Putting plans into action

Excellent at developing strategies, yet weak in implementation—this was a common theme across our research. Malaysia's excessive bureaucracy, coupled with poor monitoring, ill-equipped or unprepared middle management and weak implementation strategies, means that Malaysia often fails to deliver. Compounded by a seemingly endless raft of 'announcements' which distract from completing those initiatives already underway, policy development can seem reactive rather than strategic. Weak integration between government departments and agencies was also identified as a weakness, as well as funding reallocation part way through implementation.

8.2.2.2 Converting education investment into skilled jobs

As acknowledged in the NEM, Malaysia has thus far failed to convert its significant investment in education into more highly skilled jobs for the country. Such talent shortfalls are a clear impediment to economic growth. The World Bank has highlighted the issue of secondary education under-preparing students for tertiary education. Meanwhile, industry and academics complain that students today lack the entrepreneurial and innovative flare required for scientific discovery and high-quality research.

8.2.2.3 Protectionist perceptions

Despite a growing recognition that autonomy is critical for fostering a strong research base and higher education system, the controlling hand of government still looms large over much of the STI landscape. This can stifle innovation and creativity within the research community and hinders the capacity to leverage opportunities for collaboration and exchange, both domestically and abroad. This extends to broader questions around the lack of entrepreneurial spirit in Malaysia, potentially stifled in rote-based learning environments.

8.2.2.4 The middle-income trap

Decades of FDI investment have disappointingly resulted in little or no transfer to local businesses and the capacity among Malaysia's SMEs to become more dynamic and innovative appears questionable. Genuine examples of innovative and entrepreneurial Malaysian companies are rare. As other 'cheaper' countries take over the low-cost manufacturing base, Malaysia is struggling to find a way out of its current middle-income trap through alternative sources of growth. Similarly, the national STI agenda is centrally driven and focused mainly on a handful of targeted cities with limited opportunities and resources to foster greater ownership of the innovation agenda across the country.

8.2.2.5 Mixed messages

Despite substantial funding being directed towards research and entrepreneurial programmes, Malaysia suffers from an overwhelming array of government departments, agencies, sub-agencies and other groups offering multiple programmes and schemes, in similar or crowded policy spaces. Periodic shifts on substantial policy questions, such as the language of instruction in science and maths, have sent confusing messages both domestically and internationally, and undermine Malaysia's contribution to scientific knowledge and collaborative networks.

8.2.2.6 Sustainability in the shadows of palm oil

Across Malaysia, the distinctly shaped palm oil tree is easy to spot and it is everywhere. While Malaysians will argue that these plantations have largely replaced the rubber that was there previously rather than pristine forest, there are external perceptions that environmental sustainability lies in the shadows of the dominating palm oil sector and of economic growth more generally. Government moves to embed sustainability policies and practices into the broader national framework are much welcomed. Yet real appreciation of climate change and sustainable practices across industry and domestic life is still at a nascent level and warrants far greater attention. Within the education system, there are encouraging initiatives such as the United Nations scheme to promote Education for Sustainable Development and emerging 'sustainability science', but more needs to be done to embed sustainability into education.

8.3 Recommendations for Malaysia

8.3.1 Consolidating and streamlining

With so many ministries, agencies, schemes, grants and initiatives within Malaysia's STI system, there is an urgent need for consolidation and streamlining to ensure maximum impact and value for money. This could include the fostering of greater integration between departments, through the re-establishment of a high-level cross-departmental committee and secondments, as well as a rationalisation of schemes and incentives for R&D and technology development. The Office of the Science Adviser, with advice from the new National Science and Research Council, may be best placed to take up this agenda given the cross-departmental oversight of this office.

New initiatives must not overshadow the delivery of existing policies. STI requires a stable, long-term policy framework—with confidence that the government's commitments will be adequately funded and achievable. Equally, understanding and managing all the different components needed to design a holistic STI system is complicated. Further investments in STI policy training focused on effective integration of policy would be strategic, particularly to deepen understanding within government.

Stronger mechanisms for monitoring and implementation are also critical, as well as encouraging the analysis of perceived policy shortcomings or failures. A specific agency such as an Audit Commission could be tasked with overseeing this monitoring and implementation, using annual reporting structures and other mechanisms to ensure greater accountability and ownership within the relevant ministry or agencies.

8.3.2 More empowerment of education institutions

Following decades of impressive investment, Malaysia now needs to focus on revitalisation and empowerment across the whole education structure. Starting at primary and secondary school levels, more initiatives to revitalise science and mathematics education are urgently needed. Malaysia needs to identify qualified specialist teachers who are committed, well trained and well supported if they are to inspire future generations to consider STI careers. This should become an urgent priority of the MOE and MOHE collectively. A comprehensive review of the entire education system which considers how best to encourage critical thinking as well as increasing the uptake of science, technology, engineering and mathematics (STEM subjects) would also be valuable. Such a review would need buy-in from MOSTI, MOHE, MOE, the newly established National Science and Research Council, and the Office of the Science Adviser to ensure cross-government ownership.

At tertiary level, worldwide experience suggests that competition drives excellence. Therefore, in Malaysia, more autonomy and academic freedom is required across all educational institutions, not just a select few. This should empower the student, academic and broader research community as is attempted by the APEX initiatives. Universities should also be encouraged to closely link research and teaching, to inspire more enquiry-driven teaching mechanisms rather than rote-learning models. To foster greater competition, results-based funding which is linked to a university's performance as well as international standards could be one model to pursue. Enabling greater autonomy should be a priority of MOHE, working with universities to develop more flexible yet robust models for accountability. Similarly, greater attention needs to be placed on vocational training as an urgent priority. Targeted schemes, such as the 'VET' programme in Australia which enables secondary students to include vocational training in their final studies, could be useful models to consider.[289]

The system of post-doctoral research assistants is not well established in Malaysia and should urgently be considered. Many scientists go straight from their PhD to a university position where they have a heavy teaching load and need experienced assistance in order to do research. A post-doctoral scheme which enables early career scientists to strengthen their experience of research and teaching as part of their career development would be valuable.

8.3.3 Establish a clear independent strategy for the National Science and Research Council

Much improvement and consolidation in Malaysia's research agenda have been seen in recent years. The announcement of the intention to create a National Science and Research Council is also encouraging. This council must be independent from the government with a set funding allocation which is protected from diversion to other projects or government priorities. This body should define and develop national research priorities, using eminent Malaysian scientists to shape and promote Malaysia's research agenda and drawing expertise from industry, academia and government. High-level advice should be sought from internationally renowned scientists and policy experts. This council might also oversee regular but coordinated technology foresight exercises which would enable Malaysia to focus on its strengths and further prioritise its STI investments.

289 Victorian Curriculum and Assessment Authority: East Melbourne, Victoria, Australia.

8.3.4 Engaging local players across the country to drive the national agenda

Technology foresight exercises are also useful for discovering where strengths and capacity lie throughout the country, as well as recognising where there are duplications. There is no point in each state developing its own biotechnology hub and, as the BioValley example demonstrates, clusters of excellence rarely emerge from nothing. National strategies need to be more tailored to suit the individual characteristics of each state. More localised plans should be developed in partnership between national and state governments as well as engaging other key players in academia and industry to develop a sense of shared ownership and commitment. Such plans need clear and achievable targets, which are monitored. STI policy training at state level would also be useful.

8.3.5 Creating a thriving business environment at every level

Malaysia needs to develop a more adaptive and flexible environment if innovative capacity is to grow in the business sector. For the MNCs, Malaysia needs to stand out from competitors with an aggressive yet sophisticated strategy to target business R&D which complements the country's research strengths. Meanwhile, a new culture of creativity and competition needs to thrive among indigenous businesses, particularly SMEs. This might be achieved through further R&D tax incentives, more favourable procurement mechanisms, as well as through facilitating exposure to broader trade markets.

Ensuring an adequate skills supply is also fundamental. Further mechanisms to drive university and industry collaboration are needed, such as mandatory industry placements as part of university courses. Establishing valued advisory networks around key sectors, with academic, government and industry representation, could also be useful in ensuring more crossover and understanding. The MPOB is a good role model here for other sectors.

8.3.6 Becoming a leader among biodiversity countries

Malaysia is blessed with a distinct natural landscape. It should reach out to countries with similar levels of biodiversity and natural resources such as Australia, Indonesia and Brazil in order to share best practices, and to promote scientific collaborations and commercial partnerships. There is great potential to leverage Malaysia's biodiversity for drug discoveries. Drug development is difficult and expensive, yet rich biodiversity can open many research avenues. Malaysia could establish an International Council for Biodiversity, bringing together mega-diverse countries to share their knowledge and best practice, which could in turn help Malaysia to discover new, more rewarding areas of research emphasis. This Council could be more inclusive than the existing Like-Minded Mega Diverse Countries Council, established in 2002, which includes 12 of the 17 mega-diverse countries. In addition to providing an opportunity for countries to share information, it would also serve as an active platform to articulate and advance biodiversity issues at both national and international levels.

Closer to home, initiatives to increase public awareness of the value of Malaysia's biodiversity—from an environmental, scientific and also economic perspective would be valuable. Prime Minister Najib has already highlighted the need for Malaysia to lead in providing environmentally -sustainable eco-tourism. The establishment of a world class Centre of Excellence in Biodiversity, which focuses on research as well as effective public engagement, could play a key role in this regard.

8.3.7 Embedding international benchmarks into scientific structures

If Malaysia is to compete and benchmark against international best practice, international collaboration needs to be far more deeply embedded into the systems and structures of research funding within universities, research institutes and in private R&D centres. Making collaboration a prerequisite of popular research funding could be considered. Similarly, establishing a Malaysian-led collaborative research fund similar to the successful UK 'Connect' initiative would enable Malaysian scientists to deepen their global scientific networks, and promote stronger international links. This independent research council, suggested above, could also be responsible for embedding international benchmarks within research frameworks.

8.4 Recommendations for international collaborators

Overshadowed by other Asian 'tigers', Malaysia will take some time before it emerges as a global scientific leader. However, the global research community would be well advised to start building relationships and networks now—particularly in sustainability-focused research where Malaysia's rich biodiversity provides a rare window. Malaysia could also be a strong partner within international development or capacity-building initiatives focused on STI, especially within tri-party structures where shared practices and experience could be helpful.

8.5 Recommendations for the Islamic world

During its chairmanship of the OIC, Malaysia displayed ambition for Islamic world countries. As one of the more advanced economies among the 57 member states, Malaysia is both a role model and a champion for knowledge-based development. Working closely with the OIC, Malaysia could help other OIC nations to develop robust national development strategies with a particular focus on science and technology. This would include an emphasis on the development of indigenous innovation as well as building capacity through collaboration and exchange. As a country with rich oil and gas deposits, Malaysia is also well placed to share its experience in balancing natural resources with a more knowledge-based future.

List of acronyms

APEC	Asia–Pacific Economic Cooperation
APEX	Accelerated Programme for Excellence
ASEAN	Association of South East Asian Nations
ASM	Akademi Sains Malaysia (Academy of Sciences Malaysia)
BEM	Board of Engineers Malaysia
BM	Bahasa Melayu (Bahasa Malaysia language)
BN	Barisan Nasional
CARIF	Cancer Research Initiatives Foundation
CEO	Chief Executive Officer
COMSTECH	OIC Standing Committee on Scientific and Technological Cooperation
CSR	Corporate Social Responsibility
CTFS	Center for Tropical Forest Science
CTRM	Composites Technology Research Malaysia, Sdn Bhd
DOA	Department of Agriculture
EPU	Economic Planning Unit
EU	European Union
FDI	Foreign Direct Investment
FRIM	Forest Research Institute Malaysia
FTZ	Free Trade Zone
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GHG	Greenhouse Gas
GLC	Government Linked Company
GNI	Gross National Income
GRI	Government Research Institute
HC	Head Count
IBS	Institute of Bioscience
ICT	Information and Communication Technology
IHL	Institute of Higher Learning
IMD	International Institute for Management Development (Switzerland)
IMR	Institute of Medical Research

IPCC	Intergovernmental Panel on Climate Change
IRPA	Intensification of Research in Priority Areas
ISECO	The Islamic Educational, Scientific and Cultural Organization
ISTIC	International Science, Technology and Innovation Centre for South–South Cooperation
KL	Kuala Lumpur
KLIA	Kuala Lumpur International Airport
MASTIC	Malaysian Science and Technology Information Centre
MEGTW	Ministry of Energy, Green Technology and Water
MIDA	Malaysian Investment Development Authority
MIGHT	Malaysian Industry–Government Group for High Technology
MIMOS	Malaysian Institute of Microelectronic Systems
MIT	Massachusetts Institute of Technology
MITI	Ministry of International Trade and Industry
MNC	Multinational Corporation
MNRE	Ministry of Natural Resources and Environment
MOA	Ministry of Agriculture and Agro-based Industry
MOE	Ministry of Education
MOH	Ministry of Health
MOHE	Ministry of Higher Education
MOSTI	Ministry of Science, Technology and Innovation
MPC	Malaysia Productivity Corporation
MPIC	Ministry of Plantation Industries and Commodities
MPOB	Malaysian Palm Oil Board
MPOC	Malaysian Palm Oil Council
MSC	Multimedia Super Corridor
MTDC	Malaysian Technology Development Corporation
NCSRD	National Council for Scientific Research and Development
NEM	New Economic Model
NEP	New Economic Policy
NGO	Non-Governmental Organisation
NIC	National Innovation Council
NSRC	National Science and Research Council
NSTP	National Science and Technology Policy

OIC	Organisation of the Islamic Conference
OPEC	Organisation of the Petroleum Exporting Countries
PDT	Photodynamic Therapy
PIA	Promotion of Investment Act
PPP	Purchasing Power Parity
PSDC	Penang Skill Development Centre
R&D	Research and Development
RM	Malaysian Ringgit (currency)
RRI	Rubber Research Institute
RSPO	Roundtable on Sustainable Palm Oil
SAFE	Stability of Altered Forest Ecosystem
SCORE	Sarawak Corridor of Renewable Energy
SEARRP	South East Asia Rainforest Research Project
SESRIC	The Statistical, Economic & Social Research & Training Centre for Islamic Countries
SME	Small and Medium Enterprise
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
TPM	Technology Park Malaysia
UKM	Universiti Kebangsaan Malaysia (National University of Malaysia)
UM	Universiti Malaya (University of Malaya)
UMNO	United Malays National Organisation
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNIK	Unit Inovasi Khas
UniKL	Universiti Kuala Lumpur
UoN	University of Nottingham (Malaysia campus)
UPM	Universiti Putra Malaysia (Putra University, Malaysia)
USM	Universiti Sains Malaysia (Science University of Malaysia)
USPTO	United States Patent and Trademark Office
UTM	Universiti Teknologi Malaysia (Technological University of Malaysia)
VC	Venture Capital

A note on the data

Expenditure on research and development (R&D) is used throughout this report as a proxy for spending on science. Gross expenditure on research and development (GERD) as collated by UNESCO includes investment by government and business enterprise, funding from overseas sources, and 'other' sources, which can include funding by private foundations and charities. Unless otherwise stated, where changes in expenditure over time are discussed in the report, the figures used are based on constant prices and purchasing power parity as calculated by UNESCO.

When we refer to 'papers' or 'publications' in the report, this refers to peer-reviewed articles which have appeared in international journals. This data has been drawn, unless otherwise noted, from Elsevier's Scopus database. It is inevitable that numbers may be skewed by a single year, by individuals or by individual institutions.

The data given is the best that is readily available at the time of publication. There may be issues with self-reporting or a difference of definition. Where possible, attempts at further clarification have been made. Any further errors or omissions are the responsibility of the authors.

Currency may be presented in either US dollars or Malaysian ringgit, depending on what is most appropriate.

Using the rate applied on 5 January 2011, US$1.00 = RM3.06850 (http://www.xe.com).

Appendix 1.

The Atlas of Islamic-World Science and Innovation

This country case study is the first to be published as part of the Atlas of Islamic-World Science and Innovation project.

This exciting project aims to explore the changing landscape of science and innovation across a diverse selection of countries with large Muslim populations in the Middle East, Africa and Asia. Looking in detail at up to 15 economically and geographically diverse countries, including Malaysia, Egypt, Iran, Jordan, Qatar, Pakistan, Nigeria, Senegal and Azerbaijan, the project charts the delicate interplay between science, innovation, culture and politics. The project also aims to explore and promote new opportunities for partnership and exchange.

The Atlas is a unique partnership between organisations from across the Islamic world, Europe and internationally. Jointly managed by the Royal Society and SESRIC (the lead statistical agency of the OIC), the project is overseen by a Joint Management Team of all the project partners, which is chaired by Professor Ihsanoglu, Secretary-General of the OIC. Project partners include the British Council, the International Development Research Centre of Canada, the Islamic Development Bank, Nature, COMSTECH (the OIC's Standing Committee on Scientific and Technological Cooperation), the Qatar Foundation and the Islamic Educational, Scientific and Cultural Organisation. In March 2007, the project was endorsed by all the Kings and Heads of State of the OIC in Dakar, Senegal, reflecting the importance of this project to senior figures across the Islamic world.

Each country case study consists of an independent and authoritative assessment of how capabilities are changing, and an analysis of the opportunities for and barriers to further progress. It does not aspire to be a comprehensive analysis of every sector, but will map key trends and consider the role of international best practices at the country level.

Every report is jointly authored by an experienced international analyst of national science and innovation systems and an in-country researcher, ideally placed in a recognised or emerging centre of excellence within the country of focus. By working closely with national research partners, national governments, universities and other stakeholders throughout the process, the hope is that the findings will be taken forward and used by the countries to strengthen their innovation systems. By bringing together such a wide range of stakeholders, the aim is to identify new opportunities for collaboration and partnership between scientists, policy makers, the private sector and the non-government sector in the Islamic world and elsewhere.

Malaysia marks the beginning. At the time of publication, research is under way in Pakistan, Jordan, Qatar and Egypt. Several country studies will be released throughout 2011 and 2012.

At the conclusion of this project, an agenda-setting overview report will be produced. This report will highlight commonalities and differences between the countries, and draw wider conclusions about the prospects for science and innovation across the Islamic world, and closer collaboration with the rest of the world. It will be launched at a two-day international conference, scheduled to be held in Qatar in 2012.

For more information about the Atlas of Islamic-World Science and Innovation project, please see either http://www.aiwsi.org or http://www.royalsociety.org/aiwsi or email info@aiwsi.org or aiwsi@royalsociety.org.

Appendix 2.

List of organisations interviewed

Academy of Sciences Malaysia (ASM)
Agro-Biotechnology Institute
British Council Malaysia
British High Commission, Kuala Lumpur
British Malaysia Society
Cancer Research Initiatives Foundation (CARIF)
Danum Valley Conservation and Field Centre
Department of Islamic Development Malaysia
Eco-Nova
Economic Planning Unit (EPU)
ETI Tech Sdn Bhd
Forest Research Institute Malaysia (FRIM)
Global Diversity Foundation
HSBC
Ingress Technologies Sdn Bhd
Institut Kimia Malaysia (IKM)
Institute for Medical Research (IMR)
Institute of Pharmaceuticals and Nutraceuticals (IPHARM)
Institute of Strategic and International Studies Malaysia (ISIS)
International Institute of Advanced Islamic Studies (IAIS)
International Islamic University Malaysia (IIUM)
International Science, Technology and Innovation Centre for South–South Cooperation (ISTIC)
Japan International Cooperation Agency (JICA)
Khazanah Nasional Berhad
Kulim Technology Park Corporation Sdn Bhd
M.E.P.S. Concept Holding Sdn Bhd
Mahsa University College
Malaysia Think Tank, London
Malaysia University of Science and Technology (MUST)
Malaysian Biotechnology Corporation (BiotechCorp)
Malaysian Genome Institute
Malaysian Industry–Government Group for High Technology (MIGHT)
Malaysian Invention and Design Society

Malaysian Investment Development Authority (MIDA)
Malaysian Nuclear Agency
Malaysian Palm Oil Council (MPOC)
Malaysian Science and Technology Information Centre (MASTIC)
Malaysian Technology Development Corporation Sdn Bhd (MTDC)
Ministry of Science, Technology and Innovation (MOSTI)
Multimedia Development Corporation (MDeC)
National Space Agency (ANGKASA)
Palm Oil Industrial Cluster Sabah Sdn Bhd
Petronas
PriceWaterhouseCoopers Malaysia
Proforest
Proton (Perusahaan Otomobil Nasional Sdn Bhd)
Penang Skills Development Centre (PSDC)
Sabah Biodiversity Centre
Sabah State Economic Planning Unit
Sarawak Biodiversity Centre
Sarawak Forestry Department
Sarawak Timber Industry Development Corporation
School of Oriental and African Studies (SOAS)
Science and Technology Unit, Sabah Chief Minister's Department
Shell
Sime Darby Group
Socio-Economic & Environmental Research Institute (SERI), Penang
Technology Park Malaysia (TPM)
Telekom Malaysia Berhad (TM)
Tenaga Nasional Berhad (TNB)
TM Research and Development Sdn Bhd
Universiti Kebangsaan Malaysia (UKM)
Universiti Kuala Lumpur (UniKL)
Universiti Malaya (UM)
Universiti Malaysia Sabah (UMS)
Universiti Malaysia Sarawak (UNIMAS)
Universiti Putra Malaysia (UPM)
Universiti Sains Malaysia (USM)
Universiti Teknologi Malaysia (UTM)
Universiti Tunku Abdul Rahman (UTAR)

University of Cambridge
Wildlife Conservation Society, Sarawak
Yayasan Sabah (Sabah Foundation)
Zetta Consultants

Individuals

Professor Emeritus Dato' Dr Zakri Abdul Hamid
Dato' Henry Barlow
Dato' Lee Yee Cheong
Dr Saw Leng Guan (Forest Research Institute, Malaysia)
Royal Professor Ungku Abdul Aziz Ungku Abdul Hamid
Professor Lai-Meng Looi (Department of Pathology, UM)
Tan Sri Datuk Dr Haji Omar Bin Abdul Rahman
Datin Paduka Hajah Dr Sharifah Mazlina Syed Abd Kadi
Dr Ravigadevi Sambanthamutra (ABBBC, MPOB)
Datuk Dr Tengku Mohd Azzman Shariffadeen Tengku Ibrahim
Professor Fatimah Yusoff (IBS, UPM)
Associate Professor Dr Robiah Yunus (Universiti Putra Malaysia)
Professor Dr Asma Ismail
Professor Farida Shah
Dr Benoit Goossens (Danau Girang Field Centre)
Professor R.N.Z.A Rahman (Institute of Biosciences)

Appendix 3.

Malaysian titles

Malaysia has a complex hierarchy of titles. These can be both hereditary and non-hereditary and can be conferred at both the Federal (national) and State (regional) level. The brief descriptions below outline the selection of titles found in this report.

Royal titles

Tengku/Tunku and Ungku are hereditary royal titles roughly equivalent to Prince or Princess, reserved for members of the royal families.

Federal titles

- Tun—the highest non-royal title, limited to 35 local living holders any one time.
- Tan Sri—the second highest title, limited to 75 living holders at any one time.
- Datuk (or Datin Paduka for women)—is limited to up to 400 living recipients at any one time. Some heads of states may also confer the title Datuk.

State titles

These can be granted by the Ruler or Governor of each state. They are honorary and non-hereditary.

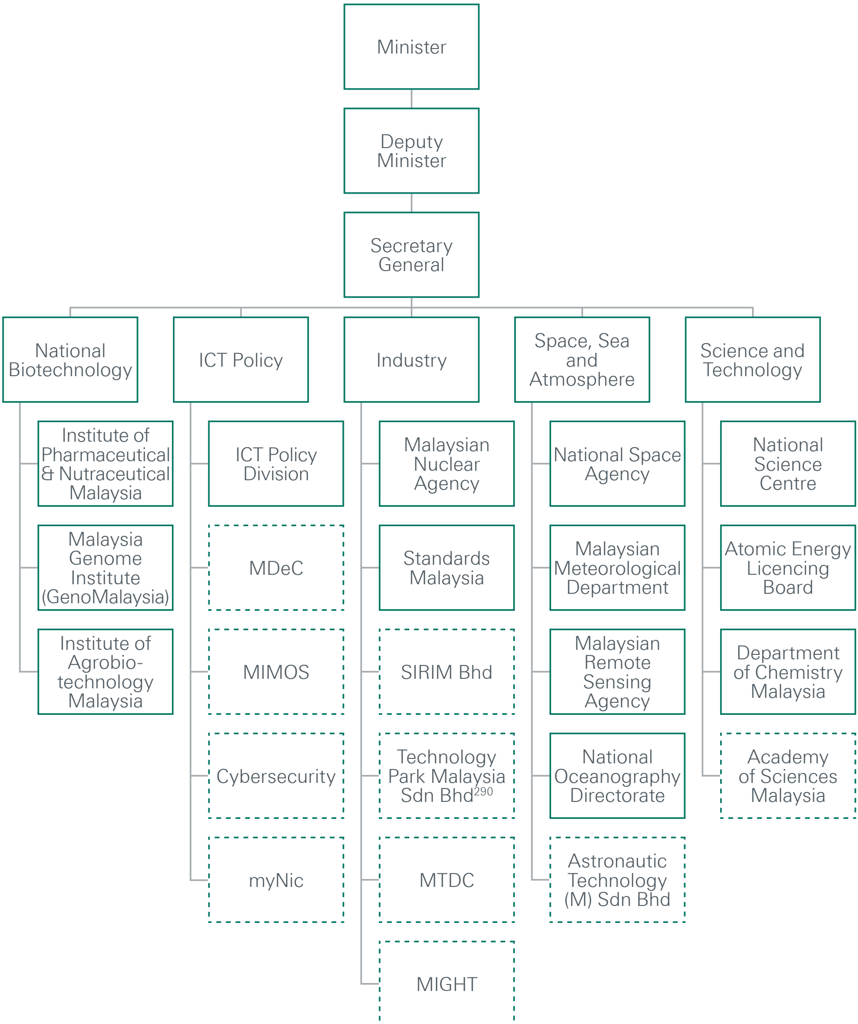
- Dato' Sri, Dato' Seri or Datuk Seri is the highest state title, below Tun and equivalent to Tan Sri.
- Dato' is the most common highly regarded title in Malaysia.

Appendix 4.

Additional information on MOSTI

Organisational chart of MOSTI and its sub-departments

(Government Linked Companies/NGO/Statutory Bodies)



290 Sdn Bhd is the Malay equivalent of private limited company

Key grant schemes offered by MOSTI (as referred to in Chapter 1: Mapping)

Pre-seed

- Multimedia Super Corridor Malaysia Technopreneur Pre-Seed Fund Programme

  This scheme is aimed at entrepreneurs involved with high technology. Only individuals can apply, and not existing companies. The programme offers up to RM150k of conditional funding to develop viable business plans into commercially focused ICT projects with a prototype, and to produce detailed business plans suitable for venture funding and commercialisation.

- Malaysia's National SME Development Council provides policy direction across 16 Ministries (including MOSTI) and 75 Agencies.

Research stage

- ScienceFund

  The ScienceFund is a research grant for R&D projects in strategic basic and applied sciences, focusing on five main clusters: ICT; Biotechnology; Industry; Sea to Space; and Science and Technology Core. The ScienceFund has a ceiling of RM500,000 per period of research (a maximum of 18 months for the ICT cluster, and 24 months for all others).

- R&D initiative funds for:

  - Genomics and molecular biology

    This fund of RM100 million provides grants of up to RM5 million for the generation of intellectual properties and technologies for application in modern bio-manufacturing of high-value products such as biocatalysts, fine chemicals and diagnostics.

  - Agro-biotechnology

    A fund of RM80 million provides grants of up to RM2.5 million for agro-biotechnology projects leading to modernisation and transformation of the agricultural sector.

  - Pharmaceutical and nutraceuticals

    A fund of RM90 million provides grants of up to RM5 million for the development of proof of concept products.

Research & development stage

- Strategic Thrust Areas in Research (STAR) program

  The aim of this programme is to encourage multinational technology leaders to set up R&D facilities in the MSC. The funds available are 50% of the total project cost or RM7.5 million, whichever is lower. Applicants are expected to undertake cutting-edge R&D, and to employ and train a workforce of at least 90% Malaysian knowledge workers.

Development

- TechnoFund (for innovative technologies)

  There are two types of funding available under this scheme. The pre-commercialisation fund is available for the development of commercial-ready prototypes. Companies can also apply for a second fund, for intellectual property acquisition. Applications must be for one of four technology clusters: Agriculture, Biotechnology, ICT and Industry.

- InnoFund

  The Enterprise Innovation Fund aims to assist individuals/sole proprietors, micro- and small businesses to develop or improve products, processes or services with elements of innovation for commercialisation. The Community Innovation Fund aims to help community groups to convert knowledge into products, processes or services that improve the quality of life of communities.

- Technology Development (for patenting, commercialisation, technology transfer).

- Strategic Funding for ICT.

Commercialisation

- Commercialisation of R&D Fund

  This fund aims to accelerate the commercialisation of R&D products by providing funding for market survey and research or product/process design and development; standards and regulatory compliance and intellectual property protection; and demonstration of technology. The fund can provide up to 50% of eligible costs or RM50,000, whichever is lower.

- Technology Acquisition Fund

  This fund provides up to RM2 million for the acquisition of foreign technologies.

- The Malaysia Commercialisation Assistance Programme

  The programme for emerging and established life sciences and agricultural biotechnology companies began accepting applications in 2010. This programme was designed to provide training and assistance to companies for commercialising technologies, products or services.

Appendix 5.

Relevant data on the status of science and research in Malaysia

Indicator	1996	1998
GERD - Total	549196.083	1127000
GERD - financed by Abroad %	...	3.691215617
GERD - financed by Abroad	...	41600
GERD - financed by Business enterprise %	...	61.42857143
GERD - financed by Business enterprise	...	692300
GERD - financed by Government %	...	31.81898846
GERD - financed by Government	...	358600
GERD - financed by Higher education %	...	3.238686779
GERD - financed by Higher education	...	36500
GERD - performed by Business enterprise %	...	66.20230701
GERD - performed by Business enterprise	...	746100
GERD - performed by Government %	...	21.94321207
GERD - performed by Government	...	247300
GERD - performed by Higher education %	...	11.85448092
GERD - performed by Higher education	...	133600
GERD as a percentage of GDP	0.216446459	0.397891581
GERD in '000 PPP$	379422.7032	712891.7813
GERD per capita (in PPP$)	17.96027689	32.08854458
Researchers (FTE) - % Female	26.87434002	27.40046838
Researchers (FTE) - Business enterprise	...	...
Researchers (FTE) - Female	509	936
Researchers (FTE) - Government	...	...
Researchers (FTE) - Higher education	...	...
Researchers (FTE) - Total	1894	3416
Researchers (HC) - % Female	...	...
Researchers (HC) - Business enterprise	...	...
Researchers (HC) - Female	...	...
Researchers (HC) - Government	...	...
Researchers (HC) - Higher education	...	...
Researchers (HC) - Total	...	6249
Researchers per million inhabitants (FTE)	89.65400371	153.7603198
Researchers per million inhabitants (HC)	...	281.2787583
Total R&D personnel (FTE) - % Female	...	27.61418269
Total R&D personnel (FTE) - Business enterprise	...	...
Total R&D personnel (FTE) - Female	...	1838
Total R&D personnel (FTE) - Government	...	...
Total R&D personnel (FTE) - Higher education	...	...
Total R&D personnel (FTE) - Total	4437	6656
Total R&D personnel (HC) - % Female	...	...
Total R&D personnel (HC) - Business enterprise	...	...
Total R&D personnel (HC) - Female	...	...
Total R&D personnel (HC) - Government	...	...
Total R&D personnel (HC) - Higher education	...	...
Total R&D personnel (HC) - Total	...	12127

Malaysian Science and Technology Indicators (monetary values in '000 MYR)
Data obtained from: 1996-2006: UNESCO (www.uis.unesco.org)
2008: Malaysian Science and Technology Indicators Report 2010 (MOSTI) Pre publicaiton copy with provisional data

2000	2002	2004	2006	2008
1671500	2500600	2843800	3646700	1738800
...	11.5012397	0.369224277	0.194696575	0.1
...	287600	10500	7100	1738.8
...	51.4516516	71.23215416	84.73140099	30.7
...	1286600	2025700	3089900	534600
...	32.14028633	21.49940221	4.960649354	24.8
...	803700	611400	180900	431300
...	4.910821403	6.899219354	9.682726849	44.5
...	122800	196200	353100	772900
57.90607239	65.308326	71.50643505	84.90964434	...
967900	1633100	2033500	3096400	...
24.97756506	20.27913301	10.440256	5.196479008	...
417500	507100	296900	189500	...
17.11636255	14.41254099	18.05330895	9.893876656	...
286100	360400	513400	360800	...
0.487012494	0.691491695	0.599897052	0.636916975	0.24
1045027.536	1615384.248	1661347.414	2085039.491	...
44.9018142	66.61390977	65.99510389	79.90266742	...
31.83870466	34.24619254	37.10383204	38.75163756	...
...	2767	4104.3	3529.3	378
2045	2451	4700.87	3756.7	...
...	1203	2130.81	1068.2	1566
...	3187	6434.38	5096.8	16097
6423	7157	12669.5	9694.3	18042
...	...	35.83492118	37.65312024	42.4
...	...	5940	4160	563
...	...	8275	7162	...
...	...	4347	2709	3650
...	...	12805	12152	19701
15022	17790	23092	19021	22843
275.9777542	295.1345805	503.2812292	371.5039605	...
645.451942	733.609639	917.302983	728.9207918	...
30.41749503	33.1842326	36.15684367	38.08941696	41.1
...	4267	6127.2	5627.8	47.1
3060	3561	6467.23	5110	...
...	2652	4021.31	2350	3009
...	3812	7738.04	5438	16840
10060	10731	17886.6	13415.8	20320
...	...	34.0315657	37.1197332	...
...	...	8737	7025	709
...	...	10544	9127	11662
...	...	7437	4556	5899
...	...	14809	13007	21797
23262	24937	30983	24588	28405

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Malaysia has long had the target of becoming a knowledge-based economy by 2020. Creating a vibrant environment for science and innovation is seen as the best way for the country to escape the middle-income trap. The last few decades have seen record levels of investment in education and research. Shining new labs and special zones for technology and entrepreneurship reflect the government's ambitions, yet challenges such as a shortage of talent and bloated bureaucracy seem to hinder progress. Looking across all the different elements within Malaysia's science and innovation system, is the current blend of initiatives and strategies the right model for a more innovative Malaysia?

This report provides a comprehensive snapshot of the key aspects of Malaysia's science and innovation system, looking at the recent history and future prospects. It suggests how Malaysia might overcome some barriers to innovation, from consolidating and streamlining existing government policies to becoming a leader amongst other bio-diverse countries. Whilst often overshadowed by other rising Asian powers, this study argues that the international research community would be well advised to look to Malaysia for future collaborations.

Malaysia is the first country study to be released as part of the Atlas of Islamic-World Science and Innovation. Bringing together partners from across the Islamic world, Europe and North America, the Atlas project is exploring the changing landscape of science and innovation across a diverse selection of countries with large Muslim populations. Further details of the project are provided within.

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