

Accountability and effective monitoring [of innovation] is a must to ensure that investment yields a desirable rate of return.

Rajah Rasiah and V.G.R. Chandran

Dr Kastoori Karupanan demonstrates the Digital Autopsy at a mortuary in Kuala Lumpur Hospital. This forensic application creates a three-dimensional image that enables a virtual body to be viewed and dissected in high definition.

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Rajah Rasiah and V.G.R. Chandran

INTRODUCTION

Stable economic growth but challenges lie ahead

The Malaysian economy grew by 4.1% per year on average between 2002 and 2013, pausing only briefly in 2009 at the height of the global financial crisis (Figure 26.1). The rapid return to positive growth in 2010 can be at least partly attributed to the two stimulus packages adopted by the government in November 2008 and March 2009.

Malaysia was an early convert to globalization. Since the launch of export-oriented industrialization in 1971, multinational corporations have relocated to Malaysia, fuelling a rapid expansion in manufactured exports that has helped turn the country into one of the world's leading exporters of electrical and electronic goods. In 2013 alone, Malaysia accounted for 6.6% of world exports of integrated circuits and other electronic components (WTO, 2014).

Rapid growth and the consequential tightening of the labour market led the Malaysian government to focus from the 1990s onwards on a shift from a labour-intensive economy to an innovation-intensive one. This goal is encapsulated in *The Way Forward* (1991), which fixes a target of achieving high-income status by 2020. Whereas Malaysia has done remarkably well over the past two years in terms

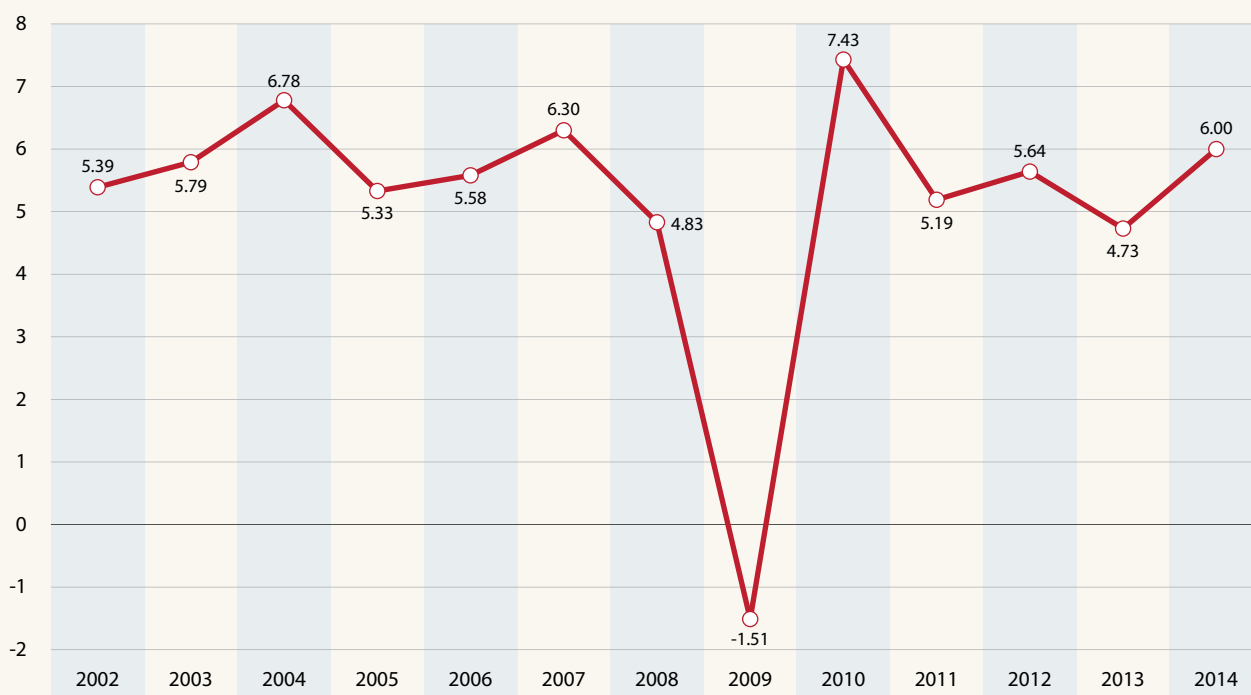
of structural reform, several areas still require attention if the country is to achieve its goal. We shall now examine these areas one by one.

The rapid expansion of exports in electronics from the 1970s onwards has turned Malaysia into a major hub for the production of high-tech goods. Today, Malaysia is highly integrated in global trade, with manufacturing contributing over 60% of its exports. Half of these exports (49%) were destined for the East Asian market¹ in 2010, compared to just 29% in 1980. Over the past 15 years or so, the share of manufacturing in GDP has gradually declined as a natural consequence of the concomitant growth in services as a corollary of greater development. Modern manufacturing and services are deeply intertwined, as high-tech industries often have a massive services component. The development of the services sector is thus not, in itself, a cause for concern.

More worrying is the fact that the shift towards services has neglected the development of high-tech services. Moreover, although the volume of manufacturing has not declined, less value is being added to manufactured goods than before. As a consequence, Malaysia's trade surplus declined from

1. essentially China, Indonesia, Republic of Korea, the Philippines, Singapore, and Thailand

Figure 26.1: GDP growth in Malaysia, 2002–2014 (%)



Source: World Bank's World Development Indicators, June 2015

UNESCO SCIENCE REPORT

144 529 ringgits (MYR) in 2009 to MYR 91 539 in 2013 and Malaysia has been losing ground in high-tech exports. High-tech manufacturing has stagnated in absolute terms in recent years and its share of global added value has slipped from 0.8% in 2007 to 0.6% in 2013. Over the same period, Malaysia's global share of high-tech exports (goods and services) has contracted from 4.6% to 3.5% (WTO, 2014). The contribution of high-tech industries to national GDP has likewise dropped.

Malaysia also needs to reduce its reliance on oil and gas extraction. In 2014, oil and gas contributed nearly 32% of government revenue. Although natural gas represented about 40% of Malaysia's energy consumption in 2008, there have been gas shortages since 2009, owing to the combination of a declining domestic gas supply and rising demand. To compound matters, the sharp drop in global oil prices between July and December 2014 forced the government to cut expenditure in January 2015 to maintain its budget deficit at 3%. A recent budget review indicates that Malaysia will not be able to rely on its natural resources to propel itself towards high-income status by 2020.

Rising inequality is a growing concern in Malaysia, with the disparity between the top 20% income-earners and the bottom 40% widening. The government's Subsidy Rationalization Programme, which had first been rolled out in 2010 with little effect, moved into high gear in 2014 with three consecutive increases in natural gas prices in a single year. The removal of energy subsidies, coupled with the introduction of a general sales tax on consumer goods in April 2015, is expected to increase the cost of living. The four out of ten Malaysians in the lowest income bracket are also increasingly exposed to social and environmental risks. The incidence of dengue increased by 90% in 2013 over the previous year, for instance, with 39 222 recorded cases, in a trend which may be linked to deforestation and/or climate change. The rising crime rate is another concern.

Although Malaysia remains committed to reducing its carbon emissions by 40% by 2020 over 2012 levels, as pledged by the Malaysian prime minister at the climate summit in Warsaw in 2013, it faces growing sustainability challenges. In January 2014, Selangor, the most developed of Malaysia's federated states, experienced water shortages. These were not caused by lack of rainfall – Malaysia lies in the tropics – but by high pollution levels and the drying of reservoirs as a consequence of overuse. Land clearing and deforestation remain major concerns, causing landslides and population displacements. Malaysia is the world's second-biggest producer of palm oil after Indonesia, the two countries contributing about 86% of all palm oil in 2013, according to the World Wildlife Fund's 2013 Palm Oil Buyer's Scoreboard. Since the 1990s, palm oil exports

have represented the third-largest category of Malaysian exports after fossil fuels (petroleum and gas) and electronics. About 58% of Malaysia remained forested in 2010. With the government having committed to preserving at least half of all land as primary forest, Malaysia has little latitude to expand the extent of land already under cultivation. Rather, it will need to focus on improving productivity (Morales, 2010).

Avoiding the middle-income trap

The Najib Razak coalition government came to power in 2009 before being re-elected in 2013. The government estimates that 6% annual growth is necessary to reach high-income status by 2020, which is somewhat higher than the average for the previous decade. A greater focus on innovation will be necessary to reach this goal.

One of the first schemes introduced by the current administration was the Economic Transformation Programme (ETP) in 2010, which contributes to the National Transformation Programme (2009). The ETP laid the foundations for the introduction of the *Tenth Malaysia Plan* (2011–2015) in 2010. The ETP seeks to strengthen industrial competitiveness, raise investment and improve governance, including public-sector efficiency. As much as 92% of this programme is to be financed by the private sector. The programme focuses on 12 growth areas:

- Oil, gas and energy;
- Palm oil and rubber;
- Financial services;
- Tourism;
- Business services;
- Electronics and electrical goods;
- Wholesale and retail;
- Education;
- Health care;
- Communications, content and infrastructure;
- Agriculture; and
- Greater Kuala Lumpur/Kelang Valley.

The programme identifies six Strategic Reform Initiatives to drive competitiveness and create a business-friendly environment: competition, standards and liberalization; public finance reform; public service delivery; narrowing disparities; the government's role in business; and human capital development. The education component of the *Economic Transformation Programme* focuses on four main areas: Islamic finance and business; health sciences; advanced engineering; and hospitality and tourism.

ISSUES IN STI GOVERNANCE

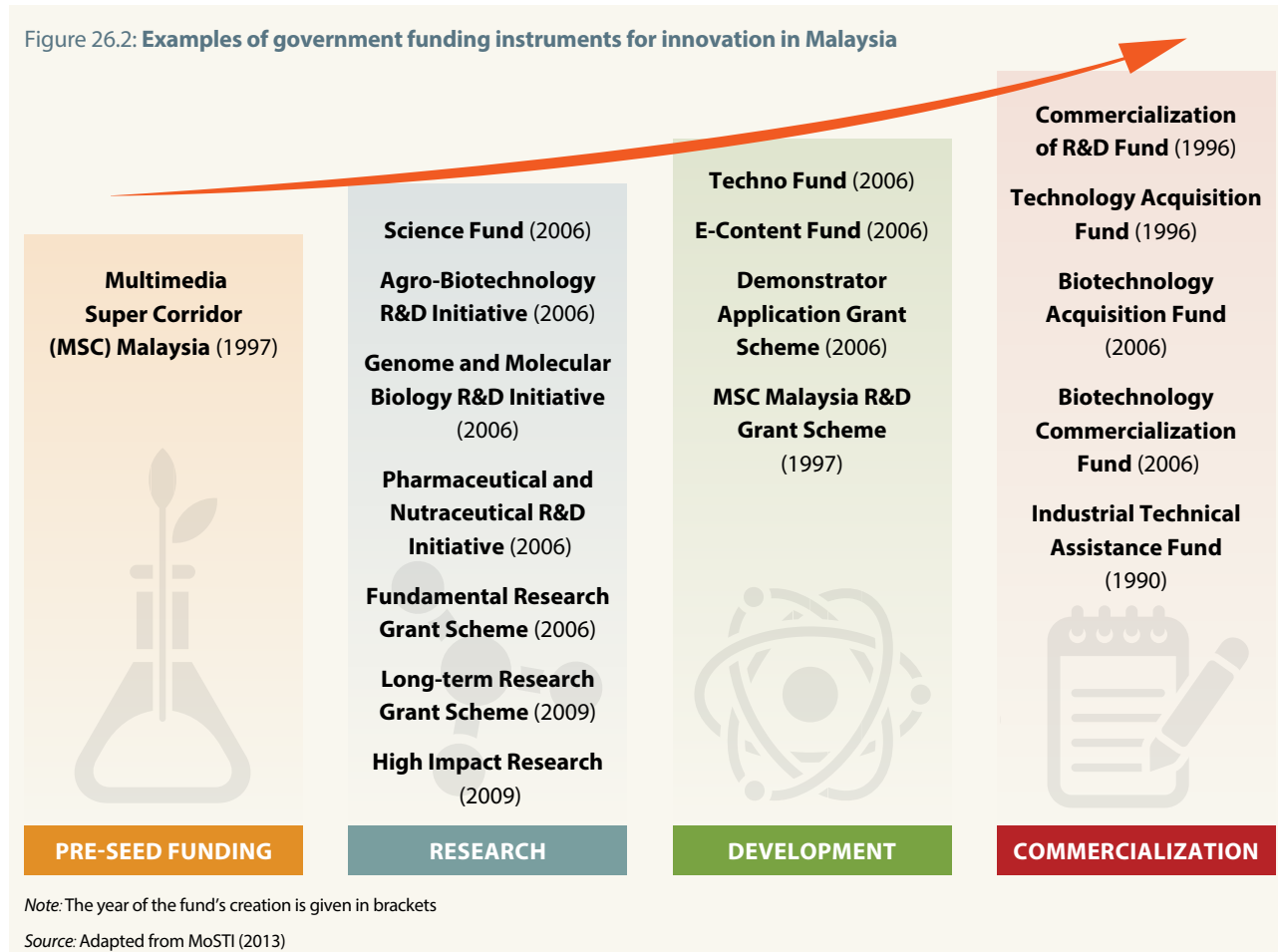
Growing expectations of S&T for inclusive development

Despite significant progress since the 1970s, Malaysia is not yet in the same league as dynamic Asian economies such as the Republic of Korea, with which it is often compared. Governance issues and weak institutional capabilities in STI figure at the top of the list of current shortcomings. In addition, budget deficits have recently started putting pressure on public investment levels, including research and development (R&D). In particular, recurrent crises have pushed the government to shift expenditure towards addressing socio-economic problems.

Innovation for inclusive development has risen in the public policy agenda and is currently being widely discussed in Malaysia, in a context of low farm productivity, increasing health-related problems, natural disasters, environmental problems and even monetary inflation. In 2014, the government launched transdisciplinary research grants with the objective of including societal benefits among the performance criteria at Malaysia’s research universities and providing incentives to promote science in support of poverty alleviation and sustainable development.

Effective inter-agency co-ordination across policy boundaries will obviously be necessary to develop innovative solutions to the problems outlined above. The Ministry of Science, Technology and Innovation (MoSTI) and the Ministry of Education are the principal drivers of Malaysia’s national innovation system. There seems to be some agreement that applied research is the purview of MoSTI, whereas basic research falls under the Ministry of Education, but there is no mechanism for co-ordinating basic and applied research. Also, MoSTI monitors innovation through surveys, the provision of grants and evaluations but it lacks the industrial exposure to co-ordinate industrial grants effectively, a failing which is evident from the absence of an effective performance criterion for some government grant programmes, including the TechnoFund (Figure 26.2). It is important that a body closer to industry, such as the Ministry of International Trade and Industry (MoITI) or its sub-organ, the Malaysian Industrial Development Authority (MIDA), be entrusted with this role. Accountability and effective monitoring is a must to ensure that investment yields a desirable rate of return.

Despite the long-standing role of government in funding R&D programmes, there is currently no systematic approach to R&D programme appraisal and monitoring. Remedying this



oversight would require introducing a legal framework and engaging the stakeholders in the early stages of designing performance monitoring and assessment criteria. Indeed, an independent monitoring body could provide greater accountability and transparency over the disbursement and collection of R&D funds and reduce duplication.

There has been some recognition of the need to co-ordinate STI better, in particular as concerns research and commercialization of the results. For example, the National Science Research Council presented a proposal in 2014 to establish a central independent agency to co-ordinate R&D. The agency's mandate would incorporate technology foresight, among other tasks, as well the monitoring, evaluation and management of R&D.

Many issues have resurfaced in current policy

The government's focus on STI dates back to the launch of the *First Science and Technology Policy* in 1986. This was followed by an *Action Plan for Industrial Technology Development* in 1991 to stimulate the development of strategic and knowledge-intensive industries, as well as by the creation of intermediary organizations such as training centres, universities and research laboratories to propel this development. It is the *Second Science and Technology Policy* (2002–2010), however, which is considered the first comprehensive formal national policy with specific strategies and action plans to set the STI agenda.

The current *Third National Science and Technology Policy* (2013–2020) emphasizes the generation and utilization of knowledge; talent development; energizing innovation in industry; and improving the governance framework for STI to support innovation. Nevertheless, many of the issues targeted in the first two policies have resurfaced in the third policy, implying that the objectives fixed in the previous policies have not been achieved; these issues include the diffusion of technology, the private sector's contribution to R&D and innovation, commercialization, monitoring and evaluation.

Without business R&D, 2020 target will not be reached

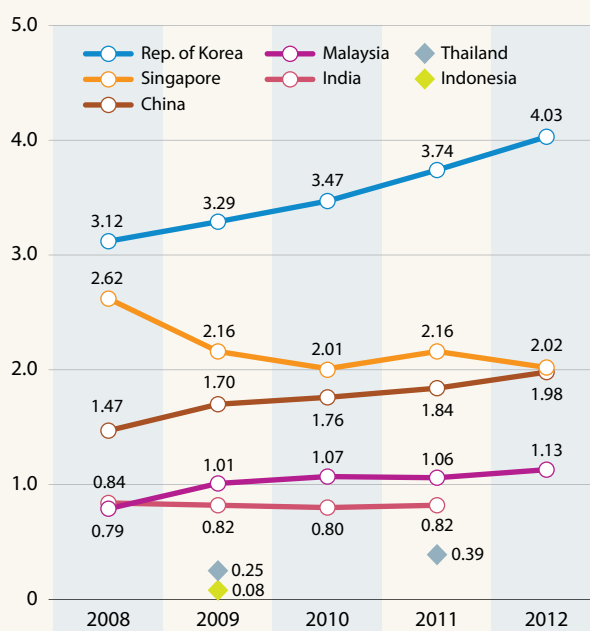
Without a doubt, R&D is contributing far more to the country's development than even a decade ago. Between 2008 and 2012, gross domestic expenditure on R&D (GERD) rose from 0.79% to 1.13% of GDP (Figure 26.3). This is all the more remarkable in that GDP grew steadily over the same period. Despite this progress, Malaysia still lags behind Singapore or the Republic of Korea for this indicator; the gap is particularly wide when it comes to business expenditure on R&D (BERD). In 2012, Malaysia's BERD/GDP ratio stood at 0.73%, compared to 1.2% in Singapore and 3.1% in the Republic of Korea. Malaysia is targeting a 2.0% GERD/GDP ratio by 2020; whether or not it reaches this target will depend largely upon the dynamism of the business enterprise sector.

While private sector participation in R&D has risen considerably since 2005, in particular, its share is still quite low in comparison with dynamic Asian economies. For example, between 2006 and 2011, a total of 25 423 ICT patents were filed in the USA by Koreans, compared to a meagre 273 by Malaysians (Rasiah *et al.*, 2015a, 2015b).

R&D spillovers have not been significant, despite the strong presence of multinational corporations in Malaysia. This is due to the lack of a critical mass of R&D infrastructure, especially as concerns human capital and laboratories specializing in frontier R&D at research universities and government-owned institutions (OECD, 2013; Rasiah, 2014).

The involvement of multinational corporations in frontier R&D is still limited in Malaysia, so pro-active measures will be required to develop this activity (Rasiah *et al.*, 2015a). R&D conducted by both national and foreign firms is largely confined to product proliferation and problem-solving. For example, in the ICT industry, no firm is engaged in R&D targeted at miniaturizing ICT nodes or in expanding wafer diameters. Innovative activity tends to be limited to the transfer and diffusion of technology through intra-industry trade, particularly in the country's free trade zones. This constant focus on production-type operations will only be able to contribute to incremental innovation (Rasiah, 2010). In 2012, a group of multinationals established a platform to promote collaborative R&D; although this is a step in the right direction, it is too early at this stage to assess its success (Box 26.1).

Figure 26.3: GERD/GDP ratio in Malaysia, 2008–2012
Other countries are given for comparison



Source: UNESCO Institute for Statistics, May 2015

Box 26.1: A multinational platform to drive innovation in electrical goods and electronics

To address the shortcomings of the local innovation ecosystem, a group of multinational corporations have created their own platform for Collaborative Research in Engineering, Science and Technology (CREST). Established in 2012, this trilateral partnership involving industry, academia and the government strives to satisfy the research needs of electrical and electronics industries, which employ nearly 5 000 research scientists and engineers.

This platform was initiated by ten leading electrical and electronic companies: Advanced Micro Devices, Agilent Technologies, Altera, Avago Technologies, Clarion, Intel, Motorola Solutions, National Instruments, OSRAM and Silterra. These companies generate close to MYR 25 billion (*circa* US\$ 6.9 billion) in annual revenue and spend nearly MYR 1.4 billion on R&D. Government grants have been utilized extensively by these multinational firms since 2005 (Rasiah *et al*, 2015a).

The Northern Corridor Implementation Authority, Khazanah Nasional, University of Malaya and University of Science Malaysia work closely with CREST. Besides R&D, the focus is on talent development, the ultimate aim being to help the industry add greater value to its products.

Source: www.crest.my

The current gaps in knowledge, capability and financing also make it harder for small and medium-sized enterprises (SMEs) to undertake R&D. Most of the SMEs that work as subcontractors for multinational firms have remained confined to the role of original equipment manufacturers. This prevents them from participating in original design and original brand manufacturing. SMEs thus need greater support in accessing the requisite knowledge, capability and financing. One key strategy is to connect SMEs to the incubation facilities in the country's science and technology parks.

Losing ground in high-tech exports

While discovery and patenting are crucial for Malaysia's export-oriented competitiveness and growth strategy, there still seems to be little return on investment in R&D (Chandran and Wong, 2011). Although patent applications with the Malaysian patent office have increased steadily over the years (7 205 in 2013), they lag far behind those of competitors such as the Republic of Korea (204 589 in 2013), according to the World Intellectual Property Organization. Moreover, domestic applications seem to be of lower quality in Malaysia, with a cumulative grants-to-application ratio of 18% between 1989 and 2014, against 53% for foreign applicants over the same period. In addition, academic or public research organizations in Malaysia appear to have a limited ability to translate research into intellectual property rights. The Malaysian Institute of Micro-electronic Systems (MIMOS),² Malaysia's forefront public R&D institute, which was corporatized in 1992, contributed 45–50% of Malaysia's patents filed in 2010 (Figures 26.4 and 26.5) but the low citations that have emerged from those patents suggest that the commercialization rate is low.

Of some concern is that Malaysia's global share of high-tech density has declined over the years and that the contribution of high-tech industries to manufacturing exports has dropped considerably since 2000 (Table 26.1).

Table 26.1: Intensity of high-tech industries in Malaysia, 2000, 2010 and 2012

Other countries are given for comparison

	World share, 2000 (%)	World share, 2010 (%)	World share, 2012 (%)	Share of manufacturing exports, 2000 (%)	Share of manufacturing exports, 2010 (%)	Share of manufacturing exports, 2012 (%)
Malaysia	4.05	3.33	3.08	59.57	44.52	43.72
Thailand	1.49	1.92	1.70	33.36	24.02	20.54
Indonesia	0.50	0.32	0.25	16.37	9.78	7.30
India	0.18	0.57	0.62	6.26	7.18	6.63
Korea, Rep.	4.68	6.83	6.10	35.07	29.47	26.17
Brazil	0.52	0.46	0.44	18.73	11.21	10.49
Japan	11.10	6.86	6.20	28.69	17.97	17.41
Singapore	6.37	7.14	6.44	62.79	49.91	45.29
China	3.59	22.82	25.41	18.98	27.51	26.27
United States	17.01	8.18	7.48	33.79	19.93	17.83
European Union	33.82	32.31	32.00	21.40	15.37	15.47

Source: World Bank's World Development Indicators, April 2015

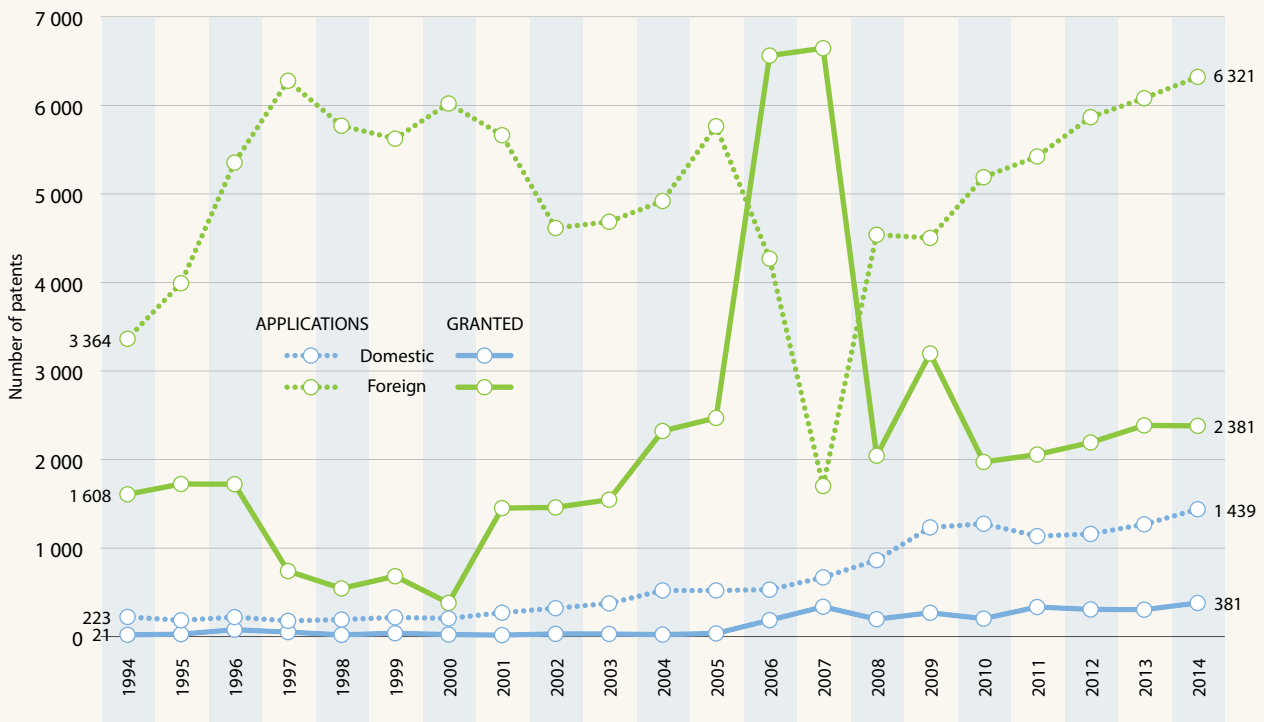
A need to increase the rate of return on R&D

As argued by Thiruchelvam *et al.* (2011), there is still little return on investment in R&D, despite the added emphasis on pre-commercialization and commercialization in the *Ninth Malaysia Plan* (2006–2010). This low commercialization rate can largely be attributed to a lack of university–industry collaboration, rigidities in research organizations and problems with co-ordinating policies. Universities seem to confine the commercialization of their research results to specific areas, such as health and ICTs.

In 2010, the government established the Malaysian Innovation Agency to spur the commercialization of research.

2. This institute was attached to the Office of the Prime Minister until its corporatization.

Figure 26.4: Patent applications and granted patents in Malaysia, 1994–2014

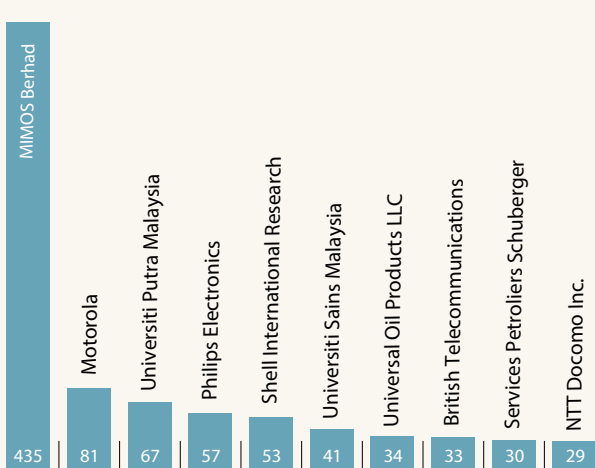


Note: The data for 2014 are for January–November.
 Source: Malaysian Patent Office, March 2014

The Malaysian Technology Development Corporation has also made a concerted effort to help companies translate commercialization grants into viable products. On the whole, however, the results have not been encouraging. Success in commercialization has been limited to a handful of organizations, namely, the Malaysian Palm Oil Board (Box 26.2), Rubber Research Institute of Malaysia, Universiti Putra Malaysia and Universiti Sains Malaysia.

Five years after its inception, the Malaysian Innovation Agency has made a limited impact on commercialization thus far, owing to the unclear delineation of its role in relation to MoSTI and its limited resources. Nevertheless, there is some evidence to suggest that the agency is beginning to play a catalytic role in driving commercialization and an innovative culture, especially as regards innovation beyond the hardware industry, which is where firms³ offering services, such as airline services, are active. The agency still needs to strengthen its ties with other agencies and ministries, however, to ensure the effective implementation of government strategies and plans. Some consolidation of the various agencies and ministries involved in STI would also be desirable, in order to facilitate effective collective action while preserving competition within the system.

Figure 26.5: Top patent assignees in Malaysia, 2010



Source: Compiled from PCT database

The numerous science and technology parks in Malaysia benefit from government incentives designed to stimulate commercialization. These include the Long Research Grants Scheme, Fundamental Research Grants Scheme, the TechnoFund and E-science Fund (Figure 26.2). Although the first two grant schemes focus largely on basic research,

3. A survey by the Malaysian Science and Technology Information Centre in 2012 found that the great majority of firms reporting product innovation had recourse to in-house R&D – 82% in manufacturing and 80% in services – whereas most of the remainder (17% and 15% respectively) conducted R&D jointly with other firms (MASTIC, 2012).

applicants are also encouraged to commercialize their findings. The TechnoFund and E-science Fund, on the other hand, focus exclusively on commercialization. There is a serious need to assess their role and success rate in promoting commercialization. There is also a need to strengthen institutional capabilities in technoparks and to ensure that these public goods effectively target the commercialization of knowledge, with a minimum rate of failure in translating these grants into products and services worth commercializing, which is known as a minimum dissipation of rents (Rasiah *et al.*, 2015a). Most multinational corporations established in Malaysia specialize in ICTs and are located in the Kulim High Tech Park (Kedah) and Penang (Table 26.2).

In 2005, MoSTI extended the research grants it had been offering to domestic firms since 1992 to multinationals (Rasiah *et al.*, 2015b). As a consequence, the number of patents filed in the USA by foreign firms specializing in integrated circuits rose from 39 over the 2000–2005 period to 270 over 2006–2011. As in Singapore, the focus of these research grants is on both basic and applied research (Figure 26.2). However, whereas, in the case of Singapore, university–industry linkages and science parks have largely determined the success of such schemes, these relays are still evolving in Malaysia (Subramoniam and Rasiah, forthcoming).

Box 26.2: The Malaysian palm oil industry

The oil palm industry contributes to R&D through a cess fund managed by the Malaysian Palm Oil Board (Figure 26.6). This entity derives its funding mainly from the cess (or tax) imposed on the industry for every tonne of palm oil and palm kernel oil produced. In addition, the Malaysian Palm Oil Board receives budget allocations from the government to fund development projects and for research projects approved by the Long-term Research Grants scheme. Through the cess, the palm oil industry thus contributes strongly to funding the research grants provided by the Malaysian Palm

Oil Board; these grants amounted to MYR 2.04 billion (circa US\$ 565 million) over the 2000–2010 period.

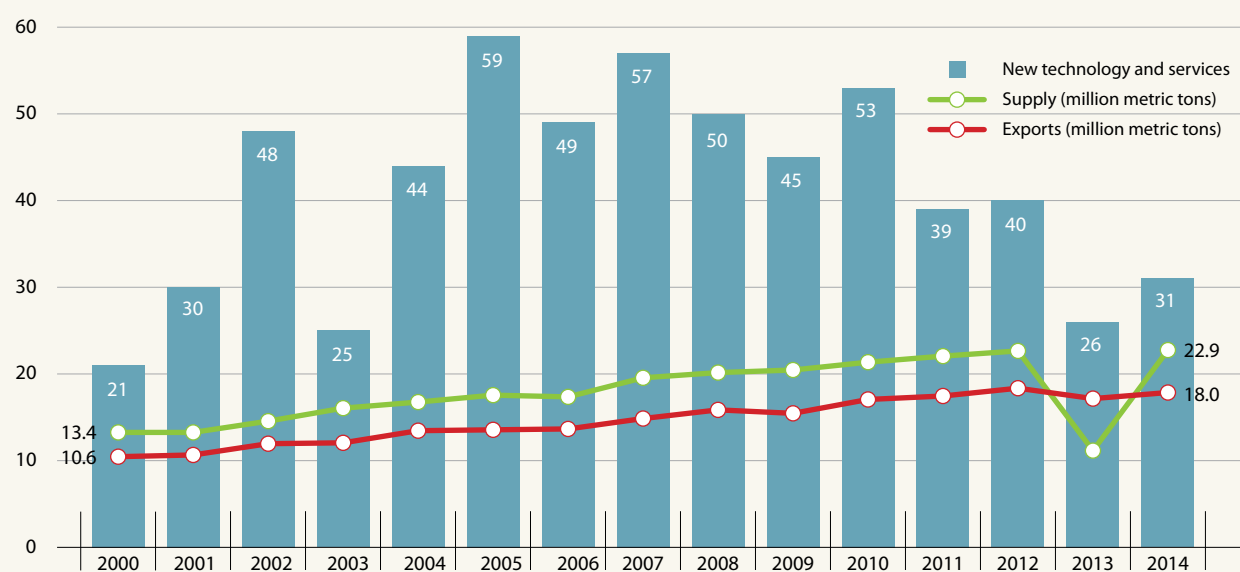
The Malaysian Palm Oil Board publishes several journals, including the *Journal of Oil Palm Research*, and oversees the Tropical Peat Research Institute, which conducts research into the effects of planting palm oil on peat land and on the transformation of peat into a greenhouse gas once it reaches the atmosphere.

The Malaysian Palm Oil Board supports innovation in areas such as biodiesel and alternate uses for palm biomass

and organic waste. Its research into biomass has led to the development of wood and paper products, fertilizers, bio-energy sources, polyethylene sheeting for use in vehicles and other products made of palm biomass. Between 2013 and 2014, the Malaysian Palm Oil Board recorded a rise in the number of new technologies commercialized from 16 to 20.

The Malaysian Palm Oil Board resulted from the merger of the Palm Oil Research Institute of Malaysia and the Palm Oil Registration and Licensing Authority in 2000 by act of parliament.

Figure 26.6: Key indicators for Malaysia’s oil palm industry, 2000–2014



Source: Malaysian Palm Oil Board (2015); United Nations’ Comtrade database

Source: www.mpob.gov.my

Table 26.2: Semiconductor firms in Penang and Kedah with R&D and/or chip design, 2014

	Origin	Year	Structure	Main activity	Upgrading
Advanced Micro Devices	USA	1972	Integrated device manufacturing	Assembly and testing	Has in-house R&D to support assembly and testing
Altera	USA	1994	Integrated device manufacturing	Design centre	Has in-house R&D to support design
Avago Technology	Singapore	1995	Integrated device manufacturing	Assembly and testing	Has in-house R&D to support assembly and testing of analogue, mixed-signal and opto-electronic components
Fairchild	USA	1971	Integrated device manufacturing	Assembly and testing	Started as national Semiconductor; has in-house R&D to support assembly and testing
Globetronics	Malaysia	1991	Fabless	Die sawing, sorting, plating and assembly of LEDs	Has R&D to support production
Infineon	Germany	2005	Integrated device manufacturing	Wafer fabrication	Engaged in '8' powerchip fabrication; has in-house R&D to support wafer fabrication
Intel	USA	1972	Integrated device manufacturing	Assembly and testing	Has in-house R&D to support assembly and testing
Intel	USA	1991	Integrated device manufacturing	Design centre	Integrated circuit design; site was previously used by Intel Technology from 1979 onwards; Has in-house support R&D
Marvell Technology	USA	2006	Fabless	Design centre	Has in-house support R&D
Osram	Germany	1972	Integrated device manufacturing	Wafer fabrication	Established first as Litronix in 1972; acquired by Siemens Litronix in 1981; changed to Osram Opto-electronics in 1992; upgraded from assembly and testing to include wafer fabrication in 2005; has in-house support R&D
Renesas Semiconductor Design	Japan	2008	Integrated device manufacturing	Design centre	Specializes in design; has in-house support R&D
Renesas Semiconductor Malaysia	Japan	1972	Integrated device manufacturing	Assembly and testing	Upgraded to include R&D support since 1980 and has expanded R&D since 2005
Silterra	Malaysia	1995	Foundry	Wafer fabrication	Founded as Wafer Technology Malaysia but renamed Silterra in 1999; has in-house R&D to support wafer fabrication

Note: Fabless refers to the design and sale of hardware devices and semiconductor chips while outsourcing the fabrication of these devices to a semiconductor foundry.

Source: Rasiah *et al.* (2015a)

University reform has boosted productivity

In 2006, the government introduced a *Higher Education Strategic Plan Beyond 2020* which established five research universities over the next three years and raised government funding for higher education. For more than a decade, public expenditure on higher education has accounted for about one-third of the education budget (Thiruchelvam *et al.*, 2011). Malaysia spends more on higher education than any of its Southeast Asian neighbours but the level of commitment had slipped somewhat between 2003 and 2007 from 2.6% to 1.4% of GDP. The government has since restored higher education spending to earlier levels, as it accounted for 2.2% of GDP in 2011 (see Figure 27.5).

The meteoric rise in scientific publications since 2009 (Figure 26.7) is a direct consequence of the government’s decision to promote excellence at the five research universities, namely: Universiti Malaya, Universiti Sains Malaysia, Universiti Kebangsaan Malaysia, Universiti Putra Malaysia and Universiti Teknologi Malaysia. In 2006, the government decided to provide grants for university research. Between 2008 and 2009, these five universities received an increase of about 71% in government funding (UIS, 2014).

Along with this targeted R&D funding, key performance indicators were changed for the teaching staff, such as by making the publication record of staff an important criterion for promotion. In parallel, the Ministry of Higher Education (MoHE) designed and implemented a performance measurement and reporting system for universities in 2009, which were also entitled to conduct self-assessments and self-monitoring.

One spin-off from the increase in R&D funding by MoHE was that the share of basic research rose from 11% of GERD in 2006 to 34% in 2012. The bulk of the budget still goes towards applied research, which represented 50% of GERD in 2012. Between 2008 and 2011, the lion’s share of scientific publications focused on engineering (30.3%), followed by biological sciences (15.6%), chemistry (13.4%), medical sciences (12.0%) and physics (8.7%).

At the same time, Malaysia still has some way to go to improve the impact of its scientific production. At 0.8 citations per paper in 2010, Malaysia trails the OECD (1.08) and G20 (1.02) averages, as well as neighbours such as Singapore, the Republic of Korea or Thailand (see Figure 27.8). It is close to the bottom of the league in Southeast Asia and Oceania for the citation rate and share of its scientific production among the 10% most cited papers between 2008 and 2012 (Figure 27.8).

Although more objective performance measures have been introduced into the university system to assess the outcome of research funding and its impact on socio-economic and sustainable development, a similar system is still missing for public research institutes. In 2013, the government launched an outcome-based approach to assessing public investment in R&D

which includes funding for projects on sustainability and ethical issues. The University of Malaya Research Grant, among others, has since absorbed this criterion by including humanities and ethics, social and behavioural sciences and sustainability sciences among its priority areas for research funding.

TRENDS IN HUMAN RESOURCES

Strong growth in researcher intensity

The number of full-time equivalent (FTE) researchers in Malaysia tripled between 2008 and 2012 from 16 345 to 52 052, resulting in a researcher intensity of 1 780 per million population in 2012 (Figure 26.8). Although this intensity is well above the global average, it cannot match that of the Republic of Korea or Singapore.

The government is eager to develop endogenous research capabilities in order to reduce the country’s reliance on industrial research undertaken by foreign multinational companies. The *Higher Education Strategic Plan Beyond 2020* fixed the target of producing 100 000 PhD-holders by 2020, as well as increasing the participation rate in tertiary education from the current 40% to 50%. The 100 000 PhD-holders are to be trained locally, overseas and through split programmes with foreign universities (UIS, 2014). As part of this effort, the government has allocated MYR 500 million (*circa* US\$ 160 million) to financing graduate students, a measure which helped to double enrolment in PhD programmes between 2007 and 2010 (Table 26.3).

Table 26.3: **University enrolment in Malaysia, 2007 and 2010**

	Total enrolment ('000s) 2007	Private (%) 2007	Total enrolment ('000s) 2010	Private (%) 2010
Bachelor's degree	389	36	495	45
Master's degree	35	13	64	22
PhD	11	9	22	18

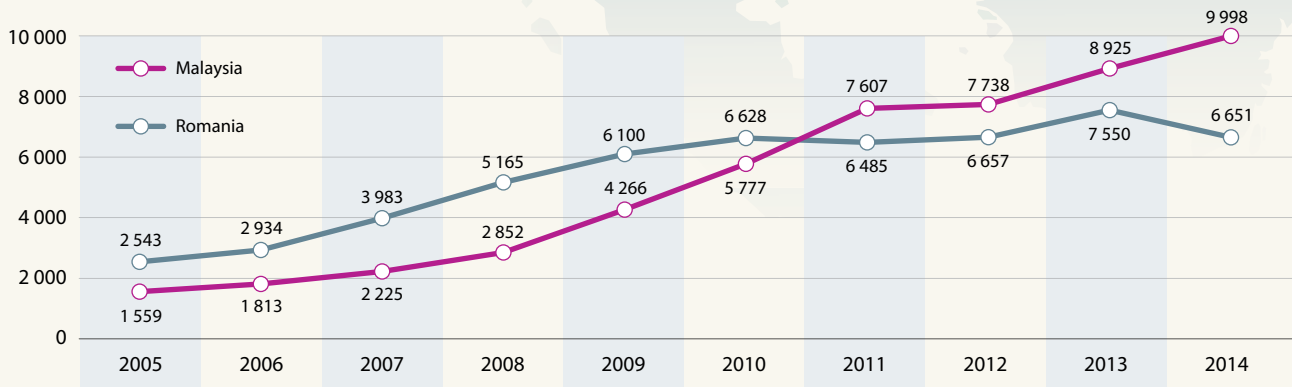
Source: UIS (2014)

Singapore snaps up much of the diaspora

Despite the rise in tertiary students since 2007, brain drain remains a worry. Singapore alone absorbs 57% of the diaspora, the remainder opting for Australia, Brunei, the UK and USA. There is evidence to show that the skilled diaspora is now three times bigger than two decades ago, a factor which has reduced the human resource pool – and, no doubt, slowed progress in STI. In order to address this issue, the government has launched Talent Corp and a targeted Returning Expert Programme (MoSTI, 2009). Although 2 500 returnees have been approved for the incentive scheme since 2011, the programme is yet to make a big impact.

Figure 26.7: Scientific publication trends in Malaysia, 2005–2014

Malaysian publications have grown rapidly since 2005, overtaking those of similarly populated Romania



0.83

Average citation rate for Malaysian publications, 2008–2012; the OECD average is 1.08; the G20 average is 1.02

8.4%

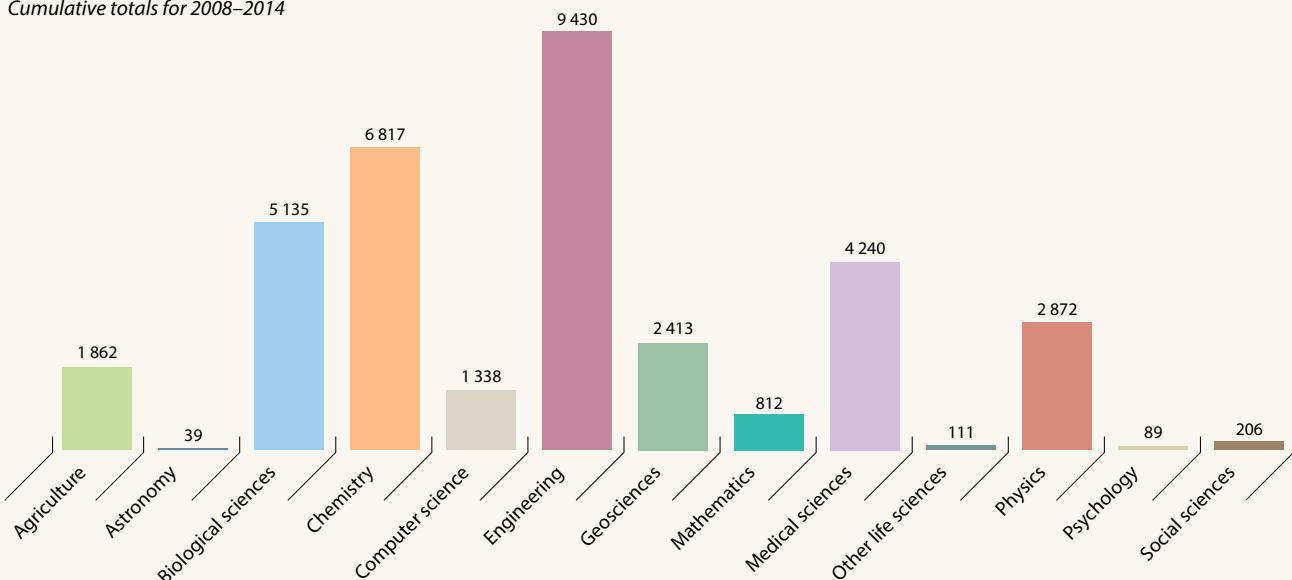
Share of Malaysian papers among 10% most-cited, 2008–2012; the OECD average is 11.1%; the G20 average is 10.2%

46.4%

Share of Malaysian papers with foreign co-authors 2008–2014; the OECD average is 29.4%; the G20 average is 24.6%

Nearly half of Malaysian publications are in engineering or chemistry

Cumulative totals for 2008–2014



Note: The total by field excludes unclassified publications (11 799) between 2008 and 2014.

Malaysia's key scientific partner countries span four continents

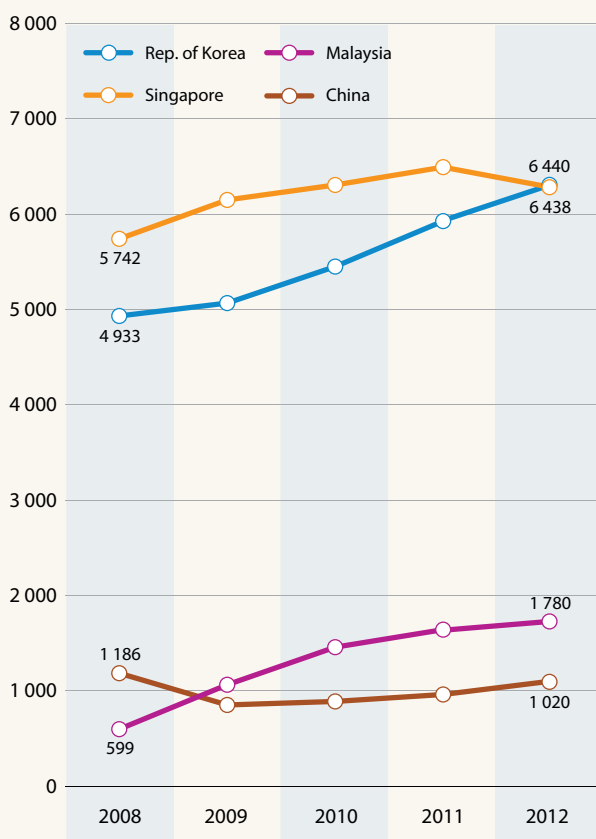
Main foreign partners, 2008–2014 (number of papers)

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Malaysia	UK (3 076)	India (2 611)	Australia (2 425)	Iran (2 402)	USA (2 308)

Source: Thomson Reuters' Web of Science, Science Citation Index Expanded; data treatment by Science-Metrix

Figure 26.8: Researchers (FTE) per million population in Malaysia, 2008–2012

Other countries are given for comparison



Source: UNESCO Institute for Statistics, May 2015

Strong growth in private and foreign students

Meanwhile, private universities are increasingly absorbing more undergraduate students than their public counterparts. Between 2007 and 2010, the share of students enrolled in a bachelor's programme at a private university rose from 37% to 45%. This is a consequence of the five leading research universities' growing focus on graduate education since 2009, accompanied by more competitive intake requirements, as well as the preference of some students for private universities where the use of English as a medium of communication is more common. Of note is that a much larger proportion of academic staff hold a master's or doctoral degree at public institutions (84%) than at private ones (52%) [UIS, 2014].

The government is increasing the number of international schools at primary and secondary levels to accommodate the needs of returnees and earn foreign exchange from non-Malaysian pupils. The target outlined in the *Economic Transformation Programme* (2010) is for there to be 87 international schools by 2020. Although there were 81 such schools by 2012, most of these establishments have small rolls: there were a total of 33 688 pupils in 2012, less than

half the government target of 75 000 pupils by 2020. To close the gap, the government has embarked on an international promotional campaign.

In 2005, Malaysia adopted the target⁴ of becoming the sixth-largest global destination for international university students by 2020. Between 2007 and 2012, the number of international students almost doubled to more than 56 000, the target being to attract 200 000 by 2020. Among member states of the Association of Southeast Asian Nations (ASEAN), Indonesian students were most numerous, followed by Thais. By 2012, Malaysia was one of the top ten destinations for Arab students; the upheaval caused by the Arab Spring has incited a growing number of Egyptians and Libyans to try their luck in Malaysia but there has also been a sharp rise in the number of Iraqis and Saudis. Particularly strong growth has also been observed among Nigerian and Iranian students (Figure 26.9).

Concerns about the declining quality of education

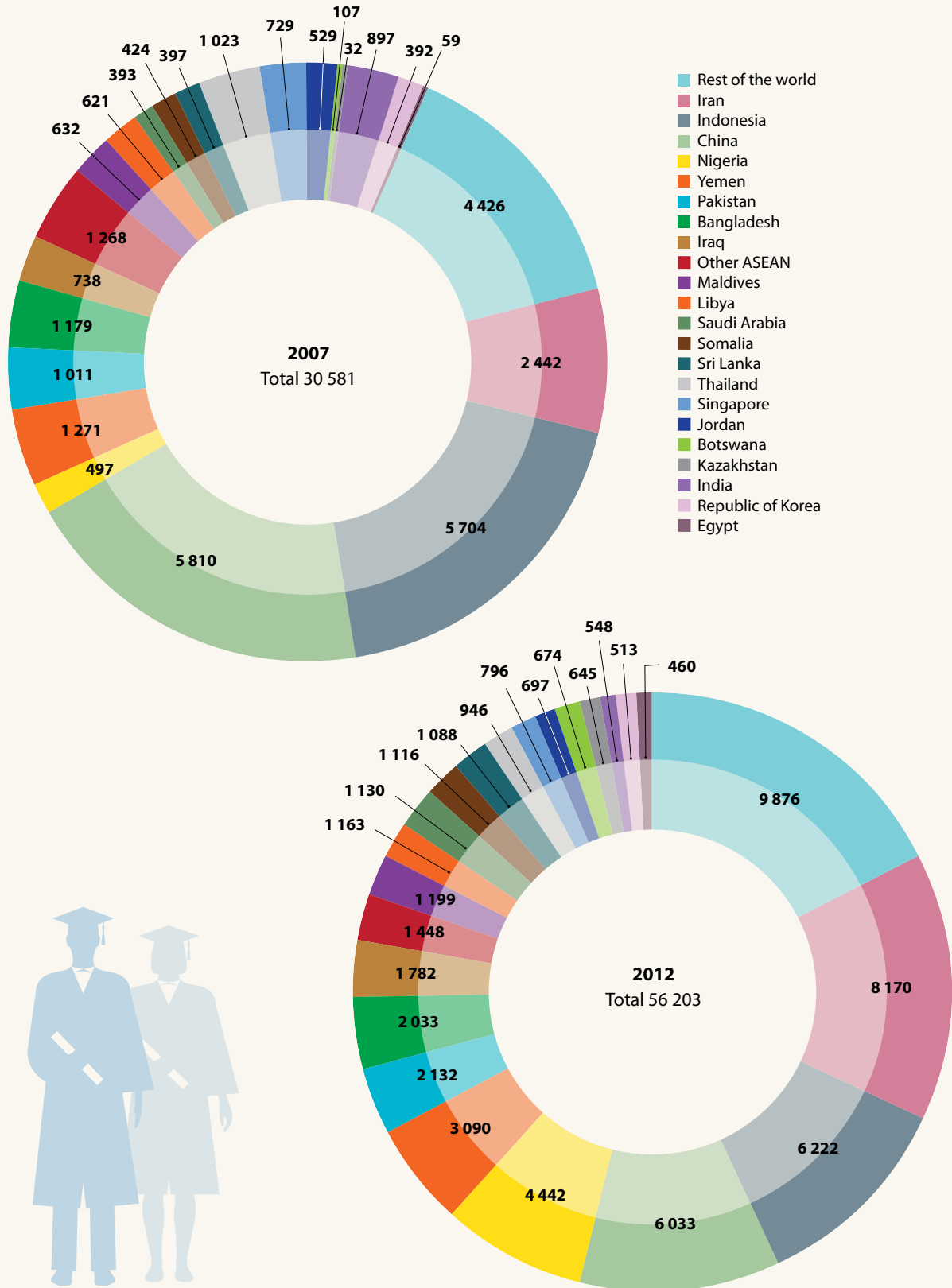
The ratio between university students enrolled in fields related to science, technology, engineering and mathematics (STEM) and those enrolled in non-STEM disciplines has grown since 2000 from 25:75 to 42:58 (2013) and may soon reach the government's target of 60:40. There is evidence, however, that the quality of education has declined in recent years, including the quality of teaching. The results of the Programme for International Student Assessment (PISA) in 2012 show that Malaysian 15 year-olds perform below average in mathematics and scientific literacy. Indeed, Malaysia's score has declined significantly in some fields, with only one out of 100 Malaysian 15 year-olds being able to solve complex problems, in comparison to one out of five in Singapore, the Republic of Korea and Japan. In 2012, Malaysians also scored lower in knowledge acquisition (29.1) and utilization of knowledge (29.3) than teenagers in Singapore (62.0 and 55.4 respectively) or the average for all PISA participants (45.5 and 46.4 respectively).

A number of the education reforms implemented since 1996 have faced resistance from teachers. The most recent national education blueprint (2013–2025), adopted in 2012, aims to provide equal access to quality education, develop proficiency in the English and Malay languages and to transform teaching into a profession of choice. In particular, it seeks to leverage ICTs to scale up quality learning across Malaysia and improve the delivery capabilities of the Ministry of Education through partnerships with the private sector, in addition to raising transparency and accountability. A central goal will be to promote a learning environment that promotes creativity, risk-taking and problem-solving by both teachers and their pupils (OECD, 2013). As it takes time for education reforms to deliver results, consistent monitoring of these reforms will be the key to their success.

4. See: <http://monitor.icef.com/2012/05/malaysia-aims-to-be-sixth-largest-education-exporter-by-2020>

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Figure 26.9: **Number of degree-seeking international students in Malaysia, 2007 and 2012**
By country of origin



Source: UNESCO Institute for Statistics, June 2015

TRENDS IN INTERNATIONAL CO-OPERATION

A Malaysian centre for South–South co-operation

When *ASEAN Vision 2020* was adopted in 1997, its stated goal was for the region to be technologically competitive by 2020. Although the focus of ASEAN has always been on the creation of a single market along the lines of the European model, leaders have long acknowledged that successful economic integration will hinge on how well member states manage to assimilate science and technology. The ASEAN Committee on Science and Technology was established in 1978, just eleven years after ASEAN was founded by⁵ Indonesia, Malaysia, the Philippines, Singapore and Thailand. Since 1978, a series of action plans have been developed to foster co-operation among member states, in order to create a more even playing field in STI. These action plans cover nine programme areas: food science and technology; biotechnology; meteorology and geophysics; marine science and technology; non-conventional energy research; micro-electronics and information technology; materials science and technology; space technology and applications; and S&T infrastructure and the development of resources. Once the ASEAN Economic Community comes into effect in late 2015, the planned removal of restrictions to the cross-border movement of people and services should spur co-operation in science and technology and enhance the role of the ASEAN University Network (see Chapter 27).

In 2008, the Malaysian government established the International Centre for South–South Cooperation in Science, Technology and Innovation, under the auspices of UNESCO. The centre focuses on institution-building in countries of the South. Most recently, it ran a training course on the maintenance of infrastructure from 10 March to 2 April 2015, in collaboration with the Malaysian Highway Authority, Construction Industry Development Board, the Institution of Engineers Malaysia and the Master Builders Association Malaysia.

As far as bilateral co-operation is concerned, the Malaysian Industry–Government Group for High Technology (MIGHT) and the British government established the Newton-Ungku Omar Fund in 2015, which is being endowed with £ 4 million annually for the next five years by each government. In 2014, MIGHT also signed an agreement with Asian Energy Investment Pte Ltd, based in Japan, to create a fund management company called Putra Eco Ventures which would invest in efficient and renewable energy assets and businesses. Potential targets for funding are smart-grid and energy-saving technologies, as well as smart buildings.

5. Brunei Darussalam joined in 1984, Viet Nam in 1995, Lao PDR and Myanmar in 1997 and Cambodia in 1999.

CONCLUSION

To become an Asian Tiger, Malaysia will need endogenous research

Malaysia's chances of emulating the success of the 'Asian Tigers' and reaching its goal of becoming a high-income country by 2020 will depend upon how well it succeeds in stimulating the commercialization of technology and innovation. Foreign multinational firms are generally engaged in more sophisticated R&D than national firms. However, even the R&D conducted by foreign firms tends to be confined to product proliferation and problem-solving, rather than pushing back the international technology frontier.

R&D is conducted predominantly in large-scale enterprises in the electronics, automotive and chemical industries, where it mainly involves process and product improvements. SMEs make little contribution to R&D, even though they make up 97% of all private firms.

Even the foreign multinationals which dominate private sector R&D are heavily dependent on their parent and subsidiary firms based outside Malaysia for personnel, owing to the lack of qualified human capital and research universities within Malaysia to call upon.

The weak collaboration between the principal actors of innovation, namely universities, firms and research institutions, is another shortcoming of the national innovation system. It will be critical to nurture the research capabilities of universities and their ties with domestic firms, in order to foster innovation and improve the commercialization rate of intellectual property. Although applied research has expanded at Malaysian universities in recent years following a government drive to promote research excellence, this trend has yet to translate into sufficient numbers of patent applications. Similarly, the low absorptive capacity of domestic firms has made technological upgrading difficult. Intermediary organizations will play an important role in bridging this gap by facilitating effective knowledge transfer.

The following measures would help to remedy some of these problems:

- The role of public research organizations would be strengthened by training a greater number of researchers and technicians and ensuring that the Long-term Research Grant Scheme and E-science Fund effectively target the production of industry-related innovation. There is also a need to correct market failures that have stifled the expansion of vocational and technical education in the country.
- Collaboration between public research institutes, universities and industry should be strengthened through long-term plans, including in-depth technology foresight

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exercises targeting specific sectors. In this context, there should be an attempt to integrate basic research with commercialization.

- Public research institutes and universities should be encouraged to act as facilitators in improving the local industrial R&D landscape, by providing domestic firms with critical knowledge and know-how through consulting services and other means. The success of the Malaysian Palm Oil Board in transferring know-how and knowledge can serve as a model in this respect.

In addition, in order to overcome shortages in human capital, the government should:

- encourage Malaysians to pursue tertiary education at the world's leading research-based universities, especially those abroad that have a reputation for undertaking frontier R&D, such as in semiconductors at Stanford University (USA) or in molecular biology at the University of Cambridge (UK); one way of doing this is to offer bonded scholarships to students who gain admission to prestigious universities renowned for exposing students to frontier R&D;
- assist national universities in upgrading the qualifications of their academic personnel, so that tenure is given only on the basis of proven participation in world-class research and publications. There is a need for better linkages between universities and industrial firms, in order to make academic research more relevant to the needs of industry;
- promote stronger scientific links between Malaysian universities and proven international experts in key research areas and facilitate two-way 'brain circulation';
- turn science and technology parks into a major launch pad for new innovative start-ups by encouraging universities to set up technology transfer offices and encouraging parks to become the nodes linking universities with industry; this will require evaluating candidate universities and firms seeking incubation facilities prior to granting them space in science and technology parks, as well as regular reviews to assess the progress made by start-up companies.

KEY TARGETS FOR MALAYSIA

- Attain high-income economy status by 2020;
- Raise the GERD/GDP ratio to 2% by 2020;
- Raise the participation rate in higher education from 40% to 50% by 2020;
- Produce 100 000 PhD-holders by 2020;
- Raise the share of science, technology and mathematics students at university level to 60% of the total by 2020;
- Develop 87 international primary and secondary schools by 2020 with a roll of 75 000 pupils;
- Increase the number of international students to 200 000 by 2020 to make Malaysia the world's sixth-largest destination;
- Reduce carbon emissions by 40% by 2020 over 2012 levels;
- Preserve at least 50% of land as primary forest, as compared to 58% in 2010.

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