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Academy of Sciences Malaysia

SCIENCE OUTLOOK

action towards vision

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MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATION

AKADEMI SAINS MALAYSIA

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Academy of Sciences Malaysia
Level 20, West Wing, MATRADE Tower
Jalan Sultan Haji Ahmad Shah
off Jalan Tuanku Abdul Halim
50480 Kuala Lumpur, Malaysia
Phone: + 603.6203.0633
Fax: + 603.6203.0634
www.akademisains.gov.my

As Malaysia prepares itself towards 2020, there is a need to better understand and harness Malaysia's STI capabilities, capacity and potential to devise a more realistic and pragmatic implementation strategy, as well as an approach for socio-economic transformation and inclusive growth. The Science Outlook signifies a new beginning in an effort to bring Malaysia's STI development to the next level.

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FOREWORD BY THE HONOURABLE MINISTER OF SCIENCE, TECHNOLOGY AND INNOVATION

I would like to commend the Academy of Sciences Malaysia (ASM) which serves as a national STI Think Tank, for the exemplary and timely effort in producing the Science Outlook 2015: Action towards Vision. This report provides a much needed independent review, evidence-based analysis and insights on the STI landscape in Malaysia based on the strategic thrusts of the current National Policy on Science, Technology and Innovation (NPSTI), 2013-2020 as well as the way forward.

As the ministry mandated to lead the National Science, Technology and Innovation (STI) Agenda of the nation, the Ministry of Science, Technology and Innovation (MOSTI) has a major responsibility to ensure an enabling ecosystem for STI to thrive. The key building blocks or strategic thrusts are effective governance, robust research, development & commercialization (R,D&C), competent STI talent, invigorated industries, STI encultured society as well as strategic international alliances.

The Government is committed to facilitating requisite infrastructure, institutional framework, collaborative platforms and incentives to drive STI for socio-economic transformation. However, it is necessary to first analyse our current position, capacity and capabilities to determine how resources and investments should be deployed towards realising envisioned outcomes.

In this context, the Science Outlook 2015 would certainly serve as a useful reference.

STI cannot be considered in isolation as it cuts across economic sectors, ministries and knowledge domains. The Science Outlook 2015 advocates transformative thinking, integrated planning and inclusive implementation of the national STI agenda and this resonates well with MOSTI's goals. I hope the Science Outlook 2015 will spur and catalyze action to effectively leverage STI towards boosting national productivity and competitiveness. The findings, gap analysis, incisive perspectives, benchmarking as well as way forward prescriptions highlighted in the report will serve as a useful reference not just for the policy makers, but also for other stakeholders such as the scientific community, economists and industry practitioners.

I consider the Science Outlook 2015 by ASM, a strategic document that offers timely insights into the Malaysian STI landscape and the way forward.

STI CUTS ACROSS ECONOMIC SECTORS, MINISTRIES AND KNOWLEDGE DOMAINS

Datuk Seri Panglima Madius Tangau

FOREWORD BY ASM PRESIDENT

The Academy of Sciences Malaysia (ASM) in fulfilling its role as a "Thought Leader" in the science, technology and innovation (STI) arena is committed to relentlessly champion STI advancement and excellence for national development and global competitiveness. ASM translates this mission into action by undertaking strategic STI studies and delivering programmes that mobilise a wide spectrum of expertise not only within the Academy but also its network of prominent international partners and linkages. Our efforts are bolstered by an immense sense of responsibility and urgency to see STI being effectively harnessed for wealth creation and societal well-being.

As a STI Think Tank, ASM strives to provide the best scientific advice that is independent, credible, relevant and timely in nature. This is made possible through the cultivation of a robust ideation process that explores creative avenues, different perspectives and varied expertise. This has resulted in scientific advice that takes into account multi-sectorial feedback, a futuristic outlook and approaches that transcend conventional discipline boundaries.

One of the flagship initiatives that ASM embarked on last year is to produce a biennial Science Outlook report. Therefore, ASM is pleased to publish Malaysia's first Science Outlook that presents an independent review of key trends in science, technology and innovation in Malaysia. The Science Outlook is aimed at providing evidence-based insights and new perspectives on the Malaysian STI landscape. It is hoped that this Science Outlook will be a useful reference for informed decision-making. As you go through the Science Outlook Report, you may find that the issues highlighted are 'nothing new'. However, this time around, ASM has endeavoured to present the issues with supporting data and evidence along with recommendations to address them effectively. If requisite action is not taken with a sense of urgency, the same issues will keep coming up again and again until something is done differently to successfully address them. Hence, the tagline of this inaugural Science Outlook Report is, "Action towards Vision".

From the very beginning of the STI agenda in the national policy framework to the current National Policy on Science, Technology and Innovation (2013-2020) (NPSTI), we have come far. Over the years, we have identified and built formidable STI networks locally, regionally and globally, with the intention of strategically positioning Malaysia in STI, encouraging cross-pollination between industry and academia as well as leveraging on a common pool of ideas, talents and resources.

Among the visible outcomes of our endeavours include improved Research and Development (R&D) and technological capabilities as well as greater public awareness and understanding on the role and relevance of science for society.

However, even with robust policy frameworks, government support and private sector participation, the implementation of policy measures seems to be fragmented and eclectic with multiple agencies and institutions competing to get their voices heard. Such disparities have proved to be counterproductive, especially in meeting the singular objective of fully harnessing our STI potential and contributing positively to national development. Even when setting STI targets for policy making and planning, it is of utmost importance to evaluate and analyse our current position, capacity and capabilities to objectively consider whether they are practical and achievable towards realising envisioned outcomes.

The vision to transform Malaysia into a STI -powered, high-income economy, calls for commitment to integrate STI in development policies and national plans towards sustainable, people centered solutions. When it comes to issues concerning low capacity for innovation, fewer investments in technology, poor orientation towards Science, Technology, Engineering and Mathematics (STEM) education and low private sector participation in R&D for commercialisation there is a need like never before, for the execution of integrated, strategic interventions in the spirit of national interest.

We need to revisit our implementation strategies, and support ideas or solutions that will help us appreciate and harness the role of STI for national development. To achieve this vision, we need to mobilise action by bringing together all the proponents of STI and advocate a unified strategy, direction and destination. I am confident that this Science Outlook will provide the necessary impetus and motivation to look at STI with a new pair of lenses.

I would like to take this opportunity to congratulate and thank all members of the Science Outlook Steering Committee, under the able leadership of Professor Datuk Dr Halimaton Hamdan FASc, as well as other ASM Fellows and Associates who contributed through the various Working Groups as well as all those who were involved in one way or another for concerted effort in publishing this inaugural Science Outlook. ASM hopes the Science Outlook can be institutionalised and published every two years with the purpose of reporting real-time progress on the adoption and implementation of various STI policies, programmes and platforms, as defined under the current policy framework.

On behalf of the Academy of Sciences Malaysia, I would also like to sincerely thank all government ministries, agencies, institutions of higher learning, research institutes as well as industry and corporate entities who have participated in providing input or data for the Science Outlook. ASM looks forward to constructive feedback from the various stakeholders and partner organisations. I hope this Science Outlook will facilitate the harnessing of STI for national development and global competitiveness.

ACTION TOWARDS VISION: HARNESSING OUR STI POTENTIAL

Tan Sri Datuk Dr Ahmad Tajuddin Ali FASc

PREFACE BY THE CHAIRPERSON

In carrying out its function as a science, technology and innovation (STI) Think Tank, the Academy of Sciences Malaysia (ASM) has published its first Science Outlook that provides an independent review of key trends in science, technology and innovation in Malaysia. This inaugural edition of the Science Outlook has focused on the National Policy on Science, Technology and Innovation (NPSTI, 2013-2020) and its six pillars namely: (i) Transforming STI governance, (ii) Advancing scientific and social research, development and commercialisation, (iii) Developing, harnessing and intensifying talent, (iv) Energising industries, (v) STI enculturation as well as (vi) Enhancing strategic international alliance.

The philosophy of the Science Outlook is to evaluate where we are in STI, benchmark ourselves with other countries that are advancing well in STI, identify the gaps, consider future implications and recommend the way forward to realise our aspirations. The Science Outlook study process was carried out by a Steering Committee and six Working Groups that involved a wide array of experts and analysts as well as four international reviewers. Eighty-one national policies were analysed and hundred ninety four references were looked up in the process of the study. Analysis of historical and secondary data as well as primary data obtained through surveys and interviews was carried out. In addition, a benchmarking of best practices and analysis of various models of selected countries around the world was carried out. This facilitated the charting of outcomes at various stages of STI development as well as identification of the gaps vis-à-vis the set policy targets. The views and opinions presented in this Science Outlook are substantiated with verified facts, figures, primary as well as secondary research findings, case studies and inferences drawn by economists and statisticians. In a nutshell, the Science Outlook presents an independent analysis and consolidated report on key STI trends and development in Malaysia in the context of the NPSTI pillars for evidence-based, informed decision making.

On behalf of ASM, I would like to acknowledge the support of various subject experts, industry practitioners, scientists and statisticians, researchers and writers, for their tireless efforts in making this Science Outlook possible. This document highlights pertinent areas that need to be effectively addressed concerning Malaysian STI policies, capabilities, initiatives, opportunities and aspirations by various stakeholders such as policy makers, government officials, academics, industry leaders, international partners and the general public.

It is hoped that this Science Outlook initiative would catalyse the transformation of STI for wealth creation and societal well-being.

IMPACTFUL SCIENCE, TECHNOLOGY AND INNOVATION (STI) FOR WEALTH CREATION AND SOCIETAL WELL-BEING

Professor Datuk Dr Halimaton Hamdan FASc

CONDUCT OF THE STUDY

Malaysia's first Science Outlook has been anchored by ASM, under the auspices of MOSTI. The objective is to conduct a study or review of Malaysian STI landscape and to test our preparedness to achieve STI targets as the country aspires to emerge as a developed economy.

Six working groups, dedicated to six areas of STI, were formed, with a mix of representations from the industry, government, academia and professional circles. The working groups deliberated many discussions to identify and define the scope of their respective chapters, making it relevant and supported by evidence-based research or information.

196 References

14 Steering committee members

4 International reviewers

6 Working groups

STI Governance (**13 members**)
RDC (**11 members**)
STI Talent (**6 members**)
Energising Industries (**6 members**)
STI Enculturation (**10 members**)
Strategic International Alliance (**5 members**)

AIM, CARIF, COMPASS ROSE, DOSM, EPU, IDEAS, IIUM, IKIM, ILMIA, INSTITUTE ENGINEERING MALAYSIA, MASTIC, MIGHT, MOE, MOSTI, MPC, MSA, MSPK – NSRC, NSC, PARLIAMENT, PEMANDU, PERDANA UNIVERSITY, PETROSAINS, SMECORP, STANDARDS MALAYSIA, TINDAKAN STRATEGI, UKM, UM, UMK, UNITEN, UPM, YSN-ASM

22 Analysts

3 Data Analysts

5 Writers

1 Chief Editor

73 organisations and **14** individuals participated in the Surveys, Industry STI Perception Audits, Focus Group Discussions, Media Engagement Exercises, & Face-to-Face Conversations

8 individuals conducted Surveys, Industry STI Perception Audits, Focus Group Discussions, Media Engagement Exercises, & Face-to-Face Conversations

28 organisations provided key information & data

The project is a result of a comprehensive stock-taking and engagement exercise, involving multiple stakeholders – from policy makers to regulatory authorities, from industry players to associations, from thought leaders to subject matter experts, from proponents of STI agenda to its beneficiaries.

In the absence of a centralised repository on STI performance, issues, challenges and opportunities, it is important to reach out to various sources of information to include facts and figures, views and perspectives, past records, current trends and future prospects. The key objective has been to understand where we stand as a nation in terms of STI capabilities, capacity and aspirations.

Towards establishing this and for undertaking this scientific project, ASM adopted a three-pronged approach for data collection and analysis:

1) Exploring national archives and knowledge centres to verify and establish various performance indicators in STI space;
2) Engaging with ministries, agencies, media, academicians, researchers, scientists, industry players, entrepreneurs, economists amongst others to secure quantitative and qualitative data on STI initiatives, programmes, policies and the overall ecosystem; and
3) Analysing local and global trends and best practices to address the gaps and arrive at recommendations.

Such an extensive exercise was followed by inputs from international peers and subject matter experts for greater credence.

Various members of the working groups assumed distinctive roles, guiding the process of conducting primary or secondary research / data collection, diagnostic analysis, benchmarking, inclusions and omissions, etc. Each working was assigned a writer, who reported to the Chief Editor, responsible for documenting the evidences, information and interpretations under active direction and supervision of the working groups.

ASM undertook the responsibility to have a bird's eye view of the overall project efforts, to include multiple stakeholder engagement in the form of qualitative audits. The exercise involved qualitative in depth interviews or interactions with private sector industry players, the media, researchers, policy makers etc. The following methodologies were used to conduct baseline studies and to derive rich insights for individual chapters:

1 Face-to-Face Conversations with Ministries, Regulatory Authorities, Agencies, Associations and Apex Institutions

were organised to get an insider commentary on everything that drives STI policies, the measures taken to address some of the gaps and challenges, the outcomes and future expectations on STI development. Some of the key stakeholders include the Ministry of Science, Technology and Innovation (MOSTI), Ministry of Education (MOE), Malaysian Productivity Council, Malaysian Rubber Product Manufacturers Association, National Instruments Academy and Innovation Nucleus (NI-AIN), Halal Industry Development Corporation, Malaysian Palm Oil Council, National Innovation Agency Malaysia (AIM), SME Corp Malaysia (SME Corp) amongst others. It was important to identify perceptual or reality gaps between governing bodies, policy makers and implementers, and the beneficiaries or participation of various STI programmes and platforms. This approach helped to identify challenges between public and private institutions in meeting the common agenda of STI implementation.

2 An Industry STI Perception Audit

was conducted using 'Purposive Sampling' technique involving one-to-one in-depth interviews with senior management, i.e. CEOs and leaders driving businesses and companies. In traditional research terms, this qualitative approach may not lend itself to quantifiable results or generalisability to the entire population as with mass surveys. However, the methodology provided rich insights and data relevant for further analysis. The companies were selected from various National Key Economic Areas (NKEA) or priority sectors of the economy. Through this approach, the working group has been able to establish STI trends for review and analysis.

3 A Media Engagement Exercise

was conducted to gain an outside perspective on the subject of STI and its practical implications on society and economy at large. All mainstream and language print, and electronic media were interviewed to get a balanced view. The exercise also helped to establish the relevance of Science for Society and Society for Science.

4 One Consultative Lab

was organised to review the Science Outlook and seek feedback from Young Scientists Network (YSN) Malaysia. More than 40 young scientists participated in the discussions during the YSN-ASM Colloquium 2014 and the feedback was incorporated to substantiate the key findings of the Science Outlook.

In addition, due diligence was undertaken to identify various primary and secondary data sources to include national resources and international reports. National resources included databases of reputable institutions such as Bank Negara Malaysia, MATRADE, Department of Statistics Malaysia, Malaysian Investment Development Authority (MIDA), MOSTI, ASM's Mega Science Framework Study for Sustained National Development or the Mega Science Agenda: Malaysia 2050 amongst others. The international reports included the Global Competitiveness Reports from World Economic Forum, Global Innovation Index, IMD World Competitiveness Yearbook 2013 and other relevant reports published by OECD amongst others. References and citations from credible and institutionalised reports helped to support various inferences and for establishing correlations between various determinants and drivers of STI success.

In analysing and interpreting the data and information, ASM maintained its evidence-based approach and worked closely with statisticians, scientists and economists to substantiate various findings.

1. For very specialised and scientific areas such as the Research, Development and Commercialisation (R,D&C), a holistic approach by way of the Innovation Systems Framework was used to diagnose the performance, which included assessment of key players and factors within the innovation system, including existing institutional arrangements, and R,D&C programmes established by the Government [Figure (a)]. Such assessments included analysing national achievements, active players and effective programmes in R,D&C. Furthermore, anecdotal

evidence and qualitative analysis (with case studies) have been included to substantiate the findings presented in this chapter.

2. Various statistical and regression analysis models were also drawn to simulate scenarios favourable to STI Development. The overall engagement exercise undertaken for the purpose of this report relied on the interviewer's notes, observations, analysis, and even omissions, in establishing trends, which were verified by the participating companies, experts, policy makers, regulators, relevant ministries, industry opinion-makers and entrepreneurs amongst others.

   - Why Qualitative and Perception Audits? With 98.5% of the industry establishments categorised as SMEs (SME Corp Malaysia Annual Report 2013), who have had a poor orientation or response towards online surveys, a more personal and one-to-one approach was considered more practical and yielding. In the past, the Royal Society[1] of UK in undertaking research in Malaysia had questioned the reliability and accessibility of quantitative surveys, owing to extremely poor response rate and poor quality of data.

   - How were these interviews or engagement exercises conducted? Supported by cue-sheets and pre-determined line of questioning or themes, the interviews were verbally conducted in "discussion-mode or style"; without any physical aid of a questionnaire. The themes included STI Awareness, Industry Readiness, Cost Effectiveness, SWOT, Communications & Engagement, International Alliance and Research Mobility, STI Governance & Mobility, Way Forward Recommendations etc. The interview duration varied from one to two hours per company respondent and considering the quality of time spent in probing and deliberating to elicit relevant information and / or data, a trend started emerging (with repetitive responses) after the first 20 interviews. No new information was registered or recorded after the first 20-22 interviews.

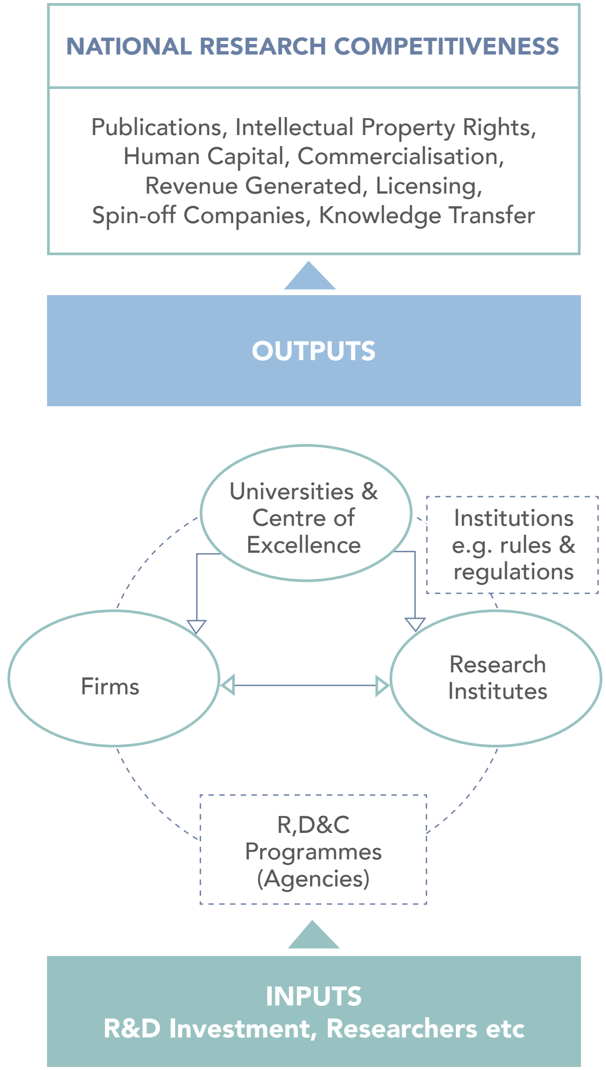

Figure (a). Framework for assessing the inputs and performance of R,D&C.
Source: Modified based on framework established by Chandran et al. (2012)

* Source: MOE, NSRC, MOSTI, MASTIC, MYIPO and DOSM
** Some data were also obtained from individual firms and their respective annual reports, researchers' surveys and datasets from ScienceSnap (2014).

[1] A Fellowship of the world's most eminent scientists and the oldest scientific academy in continuous existence.

ADVISORY & WORKING GROUPS

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Dr Ahmad Ibrahim FASc
Former Chief Executive Officer, ASM

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Director Malaysian Foresight Institute, MIGHT

Professor Dr Yang Farina Abdul Aziz FASc
Head, Centre for Water Research & Analysis (ALIR) UKM

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Director, Academic Development Management Division, Higher Education Department, MOE

Datuk Fadilah Baharin FASc
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Associate Professor Dr Noor Azlan Mohd Noor
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Fraunhofer Institute for Production Systems and Design Technology (IPK)

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UM

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UKM

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Director, Scientific Foundations of Medicine
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UPM

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UMK

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Malaysia Institute of Integrity

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MPC

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Fellow
ASM

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National Institute of Labour Market Information and Analysis
ILMIA

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Director, Methodology and Research Division
DOSM

Energising Industries Working Group

Datuk Fadilah Baharin FASc
Chairperson

Rizal Kamaruzzaman
Executive Director
Tindakan Strategi Sdn. Bhd.

Rohana Ramly
Former Deputy CEO (Coordination & Development)
SME Corp Malaysia

Czarif Chai Abdullah
Deputy Director (Business Development Division)
SMECorp Malaysia

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Fellow
ASM

Ir Choo Kok Beng FASc
Institute Engineering Malaysia

STI Enculturation Working Group

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ASM

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UNITEN

Associate Professor Dr Abhimanyu Veerakumarasivam
Director, Scientific Foundations of Medicine
PERDANA

Associate Professor Dr Noor Azlan Mohd Noor
Department of Sociology & Anthropology
IIUM

Tuan Haji Anis Yusal Yusoff
Principal Fellow, Institute of Ethnic Studies (KITA)
UKM

Kamaruhzaman Mat Zin
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MASTIC

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NSC

Tengku Nasariah Tg. Syed Ibrahim
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PETROSAINS

Wee Hui Bieh
Malaysian Scientific Association (MSA)

Strategic International Alliance Working Group

Rizal Kamaruzzaman
Chairperson

Datuk Fadilah Baharin FASc
Director General
Department of Standards Malaysia

Professor Dr Yang Farina Abdul Aziz FASc
Head, Centre for Water Research & Analysis (ALIR)
UKM

Datuk Mazlan Othman FASc
Fellow
ASM

Associate Professor Dr Zainovia Lockman
School of Materials & Mineral Resources Engineering
USM

Subject Matter Expert

STI Governance

Associate Professor Dr Shahir Shamsir
Deputy Director, UTM RMC

R,D&C

Associate Professor
Dr VGR Chandran Govindaraju
Department of Development Studies,
Faculty of Economics and Administration
UM

STI Talent, Energising Industries & Strategic International Alliance

Professor Dr Jamal Othman
Professor & Consulting Economist, UKM

Editorial Team

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Analyst (Europe)

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Acronyms

ABI	Agro-Biotechnology Institute
ACSB	Asia Council for Small Business
AEC	ASEAN Economic Community
AES	Automated Enforcement System
AFAS	ASEAN Framework Agreement on Services
AGE	Acute Gastroenteritis
AIM	Agensi Innovasi Malaysia
AJFTA	ASEAN & Japan Free Trade Agreement
AKFTA	ASEAN & Korea Free Trade Agreement
AMED	Asia Middle East Dialogue
AMS	ASEAN Member States
ANGKASA	National Space Agency
APEC	Asia Pacific Economic Cooperation
APSS	Advanced Passenger Screening System
ASEAN	Association of Southeast Asian Nations
ASEM	Asia Europe Meeting
ASM	Academy of Sciences Malaysia
ASTI	Association of Science, Technology and Innovation
BCF	Biotechnology Commercialisation Fund
BCG	Biotechnology Commercialisation Grant
BERD	Business Expenditure on R&D
BFM	Business FM
BK	Brain Korea Programme
BNM	Bank Negara Malaysia (Central Bank)
BTP	Bioeconomy Transformation Programme
CIF	Community Innovation Fund
CIF	Community InnoFund
COE	Centre of Excellence
COMCEC	Standing Committee for Economic and Commercial Cooperation of the Organisation of the Islamic Cooperation
COSEPUP	Committee on Science, Engineering Public Policy and
COST	Community of Science and Technology
CPC	Central Product Classification
CRDF	Commercialisation of R&D Fund
CREST	Collaborative Research in Engineering, Science & Technology
CSR	Corporate Social Responsibility
CTBTO	Preparatory Commission for the CTBT Organization
DOA	Department of Agriculture
D8	Developing Eight
DAGS	Demonstrator Application Grant Scheme
DDI	Direct Domestic Investment
E&E	Electrical and Electronics
EARTM	East Asia SME Round Table Meeting
EC	European Commission
EIF	Enterprise InnoFund
EIU	Economist Intelligence Unit
EMBRAER	Empresa Brasileira de Aeronáutica
EPPs	Entry Point Projects
EPU	Economic Planning Unit
ERIA	Economic Research Institute for ASEAN and East Asia
ERT	European Roundtable of Industrialists
ETP	Economic Transformation Programme
EU	European Union
FACS	Federation of Asian Chemical Societies
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FEALAC	Far East Asia Latin America Cooperation
FIT Act	Federal Act of 4 October 1991 on the Federal Institutes of Technology
FPC	Fiscal Policy Committee
FTA	Free Trade Agreement
FRI	Forest Research Institute
GATS	General Agreement on Trade in Services
G2G	Government-to-Government
G77	Group of Seventy Seven
GCI	Global Competitive Index
GERD	Gross Expenditure on R&D
G2B	(Government to Business)
GLC	Government-Linked Company
GNI	Gross National Income
GPS	Global positioning system
GRIs	Government Research Institutes
GDP	Gross Domestic Product
GTAP	Global Trade Analysis Project
GTP	Government Transformation Programme
HCRST	Human Capital Roadmap for Science and Technology 2012 – 2020
HIPs	High Impact Programmes
HRDF	Human Resource Development Fund
HSE	Health, Safety and Environment
IBSE	Inquiry Based Science Education
IAEA	International Atomic Energy Agency
ICAO	International Civil Aviation Organization
ICONedu	Online Education Content Creation Grant
ICONity	Online Social and Community Content Creation Grant
ICSB	International Council for Small Business
ICT	Information and Communications Technology
IFNM	Institute of Pharmaceuticals & Nutraceuticals Malaysia
IGS	Industry Research & Development Grant Scheme
IHL	Institutions of higher learning
ILMIA	Institute of Labour Market Information and Analysis
IMASE	International Muslim Association of Scientists and Engineers

IMR	Institute for Medical Research
IOR-ARC	Indian Ocean Rim Association for Regional Cooperation
IPCP	Intellectual Property Commercialisation Policy
IP	Intellectual property
IPO	Initial public offering
ISBC	International Small Business Congress
ISIC	International Standard Industrial Classification of All Economic Activities
ITRI	Industrial Technology Research Institute
JKPDA	Jawatankuasa Pelaburan Dana Awam
JMEPA	Economic Partnership Training Program under the Economic Partnership Agreement Malaysia-Japan
JPA	Jabatan Perkhidmatan Awam
KBSM	Kurikulum Bersepadu Sekolah Menengah
KBSR	Kurikulum Bersepadu Sekolah Rendah
KPI	Key performance indicator
K-SME	Knowledge-based Small and Medium Enterprise
LEP	Look East Policy
LHC	Large Hadron Collider
LIH	Low Income Household
LINC	Leaders in Industry University Programme
MACRI	Malaysian Association of Creativity & Innovation
MaGIC	Malaysian Global Innovation and Creativity Centre
MARDI	Malaysian Agriculture Research and Development Institution
MASTIC	Malaysian Science and Technology Information Centre
MBC	Malaysian Biotechnology Corporation
MCY 2014	MOSTI Commercialisation Year 2014
MDTCC	Ministry of Domestic Trade, Cooperative and Consumerism
MEB	Malaysia Education Blueprint 2013-2025
MESITA	Malaysia Electricity Supply Trust Account
MGS	MSC R&D Grant Scheme
MGS Pre-Seed	Multimedia Super Corridor Pre-Seed Fund
MGTC	Malaysian Green Technology Corporation
MIDA	Malaysian Industry Development Authority
MIGHT	Malaysian Industry-Government Group for High Technology
MIST	Mexico, Indonesia, South Korea, Turkey
MITC	Melaka International Trade Centre
MITI	Ministry of Trade and Industry
MNC	Multinational corporation
MOE	Ministry of Education
MOF	Ministry of Finance
MOHR	Ministry of Human Resources
MOSTE	Ministry of Science, Technology and Environment
MOSTI	Ministry of Science, Technology & Innovation
MOUs	Memorandums of Understanding
MP	Malaysia Plan
MPOB	Malaysian Palm Oil Board
MRA	Mutual Recognition Agreement
MSC	Malaysian Super Corridor
MTDC	Malaysian Technology Development Corporation
MTN	MIGHT Technology Nurturing
MyIPO	Intellectual Property Corporation of Malaysia
MYRA	Malaysia Research Assessment
NAM	Non-Aligned Movement
NAP	National Agricultural Policy
NCII	National Corporate Innovation Index
NEAC	National Economic Advisory Council
NEM	New Economic Model
NERS	National Enforcement and Registration System
NGO	Non-Government Organisation
NKEA	National Key Economic Area
NKRA	National Key Results Area
NOD	National Oceanography Directorate
NPSTI	National Policy on Science, Technology and Innovation Policy (2013-2020)
NSC	National Science Challenge
NSRC	National Science Research Council
NSTP	National Science and Technology Policy 1986-1989
NSTP2	The Second National Science and Technology Policy and Plan of Action (2002 – 2010)
NSU	National Strategic Unit
NTIS	National S&T Information Service
NTP	National Transformation Programme
NTU	Nanyang Technology University
NUS	National University of Singapore
OECD	Organisation of Economic Co-Operation and Development
OIC	Organisation of Islamic Conference
OPCW	Organisation for the Prohibition of Chemical Weapons
PEKA	Assessments of Science Process Skills (Penilaian Kemahiran Amall)
PETRONAS	Petroliam Nasional Berhad
PISA	Programme for International Student Assessment
PISF	Penang International Science Fair
PMR	Lower Secondary Assessment (Penilaian Menengah Rendah)
PPSMI	Teaching of Science and Mathematics in English
PRIs	Public Research Institutes
PSC	Penang Science Cluster
PSN	National Science Centre (Pusat Sains Negara)
PT3	Form Three Assessment (Pentaksiran Tingkatan Tiga)
RCCPS	Redeemable Convertible Cumulative Preference Shares
RCPS	Redeemable Convertible Preference Shares
R&D	Research and development
R,D&C	Research, Development and Commercialisation
RE	Rare Earth
RECSAM	The Regional Centre for Education in Science and Mathematics
REP	Returning Expert Programme
RFID	Radio Frequency Identification Technology
RSE	Researcher, Scientist and Engineer
RTA	Revealed Technology Advantage
RU	Research university
S2A	Science to Action
S4I	Science for Industry
S&E	Science and Engineering
S&T	Science and Technology
SBTC	Skill-biased technical change
SFM	Sustainable Forest Management
SGI2012	Year of Science and the National Innovation Movement 2012

SIRIM	Malaysian Institute of Microelectronic Systems
SME	Small and Medium Enterprise
SMS	Short messaging service
SSD	Solid-state drive
STAR	Scholarship Talent Attraction and Retention
STEM	Science, Technology, Engineering and Mathematics
STEPAN	Science and Technology Policy Asian Network
STI	Science, Technology and Innovation
STI Act	Science, Technology and Innovation Act
TAF	Technology Acquisition Fund
TalentCorp	Talent Corporation Malaysia Berhad
TAPS	Talent Acceleration in Public Service
TECHNOFUND	Pre-Commercialisation Fund
TIMSS	Trends in International Mathematics and Science Study
TLO	Technology Licensing Officer
TM	Telekom Malaysia
TNB	Tenaga Nasional Berhad
TTO	Technology Transfer Officer
TVET	Technical and Vocational Education and Training
UK	United Kingdom
UM	University of Malaya
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNIDO	United Nations Industrial Development Organisation
UNOOSA	United Nations Office for Outer Space Affairs
UPM	University Putra Malaysia
UPSR	Primary School Achievement Test (Ujian Pencapaian Sekolah Rendah)
US	United States
USAINS	USM's institute for research in molecular medicine
USM	Universiti Sains Malaysia
WEF	World Economic Forum
WTO	World Trade Organization
YIM	Yayasan Inovasi Malaysia
YSN	Young Scientists Network

INTRODUCTION

1.0 Background And Rationale

The Malaysian government endorsed the National Policy on Science, Technology & Innovation (NPSTI) 2013-2020 to bring forth a vision of building a scientifically advanced and progressive society led by innovation. However, like other developing economies, Malaysia has its own set of cultural, political and socio-economic barriers which hinder the promotion of Science and Technology (S&T) across various levels of policy and decision-making process, including industry and society.

It is commendable that the Government has successfully sustained the interest, commitment and political will to develop and build national S&T capabilities and capacities since 1986. Some of the more significant achievements include the establishment of the National Innovation Model, development of knowledge-based industries and an ever-increasing appetite for meaningful Research and Development (R&D). Nevertheless, S&T advocates and institutions continue to face challenges, especially in their efforts to measure the impact of our forward-looking policies and their implementation. Some of the core issues include:

- Incoherent approach (across multiple implementation bodies, agencies and institutions) in the development of our home-grown capabilities in Science, Technology & Innovation (STI);
- Low levels of policy outreach or awareness, despite the many promotional exercises (especially amongst the younger / future generations of researchers, academicians, scientists, policy makers and regulators); and
- Non-availability of credible and up to date data to ratify, reflecting the gaps and recommendations towards effective implementation of S&T programmes and policies.

- Stocktaking
- Study key trends and challenges
- Data gathering
- International reviewers

- Identify indicators
- Benchmarking
- Evaluation
- Analysis

- Way forward
- Towards evidence-based informed decision making
- Future implications
- Recommendations

Figure (a). The philosophy of Science Outlook

In the process of producing this strategic document, the above issues were encountered more than once. Sufficient facts and trends have since been documented, which reinforce the critical need to revisit the national S&T needs, capabilities, resources and priorities and determine a new philosophy of positive change for progress. This calls for the following to be realised:

- An integrated approach to S&T policy formulation and implementation: This in turn will satisfy the original intent of the Government to foster strong and resilient partnerships, connectivity and interdependence across all sectors of the economy and society;
- A robust, centralised, national information diffusion mechanism for S&T awareness and enculturation: This in turn will allow for better understanding of S&T targets and garner support from critical stakeholders towards meeting common objectives; and
- Scientific evidence to measure and rationalise past, current and future investments in S&T: This in turn will help determine the criteria not only for measuring the success of implementation but also how to sustain policy measures and investments to progressively meet the national S&T agenda.

As a country aiming to be one of the top 10 most competitive economies globally, our development pillars must be built on strong scientific fundamentals. The **Science Outlook: Action towards Vision** is an independent effort to review the STI landscape in Malaysia with NPSTI (2013-2020) and its six pillars as its basis. Figure (a) illustrates the philosophy of Science Outlook which addresses our current position in the STI landscape, the gaps identified, and our recommended "Action towards Vision".

The process included a stocktaking exercise to study key trends and challenges in STI, data gathering and international peer review. This was followed by a thorough evaluation and gap analysis on various indicators of STI development. Our ultimate objective has been to establish an evidence-based approach to STI decision making, with measurable ways to forward recommendations.

We are hopeful that the information and recommendations presented in this document will serve as a baseline study (to be undertaken once every two years) and will support other STI-related studies. Moving forward, the Science Outlook will evolve to support evidence-based policy formulation.

In conclusion, it is pertinent to note that the need for appropriate governance initiatives resonate throughout this document. This is because resolution of governance issues lies at the bedrock of STI development in the country. The studies undertaken for the Science Outlook have surfaced the following key challenges that need to be addressed on a comprehensive and broad-based basis:

- STI development is a uniquely people -centric endeavour. It does not share the development norms of many other programmes where physical infrastructure drives social change. STI development needs people who are more than simply aware of STI – it requires them to embrace, grow, feed and nourish it.
- The need for STI is to be treated not just as another programme in a vast list of government initiatives, but a value-system that is embraced by all sections of the society. This means that STI must be seen as a national imperative.
- This further means that its current status as a ministerial mandate needs to expanded by creating institutional mechanisms that can breach sectorial, administrative and political barriers:
  - To higher-level organs of political and legislative leadership; and
  - Research, Development and Commercialisation (R,D&C) generation and civil society as a whole

2.0 But, What's New?

The evaluation of individual institutional roles in doing this would, therefore, need to take into account these challenges, which are at the heart of the STI development process in the country. The Science Outlook: Action Towards Vision emphasises on a very practical approach, well grounded in reality, evidenced through research, feedback, global trends and best practices.

- Most of the issues discussed in the Science Outlook may be familiar areas and some of them may have been identified as issues decades ago. However, what is new is the evidence provided; which not only validates the findings but also supports the future course of action.
- Back in the 1960s, Malaysia and South Korea shared the same socio-economic status and yet, the STI Ecosystem evolved far greater in South Korea than in our country. We may have reached a point of saturation with issues that we already know, with no sustainable action plan towards positive change. Science Outlook may be the first of efforts towards such action and change.
- Science Outlook calls for significant changes (in strategies and approach, in policies, in implementation, and most importantly in measuring the outcomes of STI) towards significant impact towards 2020.

3.0 Do We Have A Robust STI Governance System In Place?

It is important to acknowledge the critical function of governance as a continuous cycle that involves various critical phases across all pillars of the NPSTI such as:

- Evaluation of national and societal needs, including the industrial, socio-economic and political landscape within the context of STI;
- Adoption of various STI policy measures;
- Monitoring of performance or implementation;
- Informing the relevant stakeholders, including the public, about the policy as well as its relevance and impact;
- Enabling stakeholders and the public to contribute or participate in STI policy development, implementation and improvement;
- Bringing together the people, capabilities, forces and authority to deliberate on various issues and gaps;
- Solving the issues identified through course correction and strategic solutions; and
- Evaluation on the effectiveness and sustainability of the solutions to create new benchmarks, targets or policy recommendations to adopt in the near future.

The evaluation phase helps in both initiating the process and closing the loop. During evaluation, the individual functions and contributions of the institutions that currently promote or are involved in driving the country's STI agenda must be reviewed for necessary improvement. The end objective is to create an environment or ecosystem enabled by effective STI Governance.

Recommendations:

- Empower a centralised STI coordination and monitoring body, which will transcend across all ministries, to garner greater stakeholder participation;
- Strengthen STI management cycle with focus on monitoring and evaluation as well as ideation, in keeping with global best practices;
- Establish a Parliamentary Select Committee on STI to build political will and create legislative consensus towards promoting STI agenda; and
- Support the enactment of a Science Act, which will serve as an overarching Master Plan for unified execution strategy.

Stocktaking:

- The vast scope of governance requires objectivity, a fundamental understanding of the STI development and management cycles, and above all, an unbiased critique or review by an independent body at various phases. Countries such as South Korea, Japan and Taiwan, with high economic output, also have a stable STI governance structure. In Malaysia, the missing link between various stages of the cycle or the transition phases from National Science and Technology Policy (NSTP) (1986-1989) to NPSTI (2013-2020) is the "availability of sufficient proof or evidence" in the form of credible data. Without this, it will be extremely difficult to:
  - measure the performance of the STI policies and targets; and
  - develop a strong rationale for future recommendations.
- There has been no sufficient legislative consensus or motivation to correlate STI contributions or its potential with national goals. This could be due to disinterest or lack of STI orientation. According to the Hansard Analysis, 2008-2013, dialogues on STI in parliament have been dominated by development project queries. Furthermore, an absence of formal platform to deliberate on STI issues with expert inputs dissuades meaningful STI strategy formation.
- There is no data available to establish the extent of influence on the part of the STI agenda or policy in STI-related ministries, National Research Institutions, science communities or the public.
- Multiple agencies (400+) promoting or implementing 51 STI-related policies, programmes / agendas may be working in the absence of coordinated planning, without a well-defined monitoring or measurement mechanism.

4.0 Does Public R,D&C Address National Priorities, Challenges And Potential Opportunities?

The Government's aspiration is to position Malaysia amongst the top 10 countries in the Global Competitiveness Index and Global Innovation Index. According to the Global Competitiveness Report (2014-2015), Malaysia's current position is 20th amongst 144 other economies.

Against this backdrop, in the context of our R,D&C capabilities and potential, Malaysia needs coordinated research prioritisation, capacity and strategy to achieve its targets. Some of the components that would contribute to the STI landscape of the country include:

- sustainable investments;
- slow but steady industry participation; and
- cross-pollination / partnerships amongst various R,D&C institutions.

Over the years, multiple ministries and agencies have been allocated R&D funds from the Government, expanding the scope and opening many possibilities for meaningful R,D&C. Such allocations have traditionally been in the areas of Information and Communications Technology (ICT), engineering sciences and natural sciences. These areas contributed significantly in terms of commercialisation returns, publication and patents generation compared to other programmes due to the scale effect.

However, what we lack is a seamless process to transition smoothly from Pre-R&D stage to subsequent stages of R&D, Early Stage Commercialisation and Commercialisation.

Recommendations:

- Empower an existing centralised body to promote seamless R,D&C implementation, management and monitoring to evaluate beyond traditional return on investments (ROIs); and
- Strategise and focus on effective utilisation of GERD for competitiveness.

Stocktaking:

- Malaysia has relatively low R&D investments [RM10.6 billion or 1.13% GERD per Gross Domestic Product (GDP) in 2012] when compared to the average R&D spending in G20 countries, which is 2.04%. Looking at the current GERD per GDP and the targeted 2.0% by 2020, the country needs to achieve an approximate 77% increase in GERD over the next five years. There is no documented evidence on the capacity, resources or strategy that suggests this ambitious target will be met. In addition, research prioritisation is currently practised without organised efforts, monitoring and follow-through. This often results in abandoned projects with no practical outcomes.
- The composition of the R&D pie in Malaysia is skewed towards applied research, with relatively low emphasis on basic or experimental research, unlike other advanced countries such as Singapore and South Korea where experimental research has more traction. Even in applied research, due to the diversification of R&D funding and allocation, the budgets are assigned to many research projects, leaving little room to create enough pool or economies of scale (masses) in specific sectors or fields of research.
- Industry or business sector participation alongside Government Research Institutions (GRIs) and Public Research Institutes (PRIs) is minimal, limiting the opportunities to strengthen the R&D output for its commercial intent and application.

5.0 Are We Well-positioned With Our STI Talent Pool?

Quality human capital or talent is needed to promote Malaysia's growth and position its excellence in the global marketplace. Talent is also unconditional not only in the pursuit of STI targets but also to sustain STI development towards building an efficiency-driven economy.

The decades-old evolution of the education system reflects the Government's commitment to encourage and build home grown STI talent. Science, Technology, Engineering and Mathematics (STEM) talent in the country has been enhanced through the intensification of postgraduate programmes at Institutions of Higher Learning (IHLs), which help promote R&D initiatives and provide a skilled workforce.

Various programmes have been implemented to develop a talent pool, beginning with the Early Childhood Care and Education Policy to meet the diverse needs of the crucial early years of new-borns, up until the age of six. Besides the mainstream education system, the private sector has also positively contributed to the STEM education ecosystem of the country by way of an established private education and Technical and Vocational Education and Training (TVET) system.

Nevertheless, despite many efforts and substantial expenditure on education, there seems to be a decline in interest in Science, contributing to STI talent depletion. A national study, *S&T Human Capital: A Strategic Planning Towards 2020 (2012)*, confirmed that the country will need one million S&T workers by 2020, of which 500,000 will require at least a diploma or university degrees. At the same time, it is projected that a ratio of 70:10,000 research personnel to workforce would be needed.

Hence, the underlying statement is that we do not have enough talent. The question is, how do we reorganise our efforts towards developing, harnessing and intensifying STI talent?

Recommendations:

- Endorsement of a Human Capital Roadmap for S&T 2012–2020 (HCRST) towards systematic planning and development of STI Talent.

  The roadmap covers:
  - a strategic framework that will align human capital development in S&T services and delivery decisions with the New Economic Model (NEM) of Malaysia;
  - S&T human capital goals and priorities the determination of measurable success factors and the identification of concrete outcomes that will drive the development of an actionable roadmap
  - a review of the current status of people, processes, technology and culture to determine their current state and opportunities for measurable and business-aligned outcomes; and
  - delivery of prioritised recommendations and an outlined action plan that will form the basis of a multi-year roadmap to drive measurable results.
- Bridge the gap between policy and reality through review of implementation.
- Strategise effective policy measures to retain STI Talent.

Stocktaking:

- One of the many strategies (which was proven effective in the past) has been to offer incentives in the form of scholarships and grants to students opting for the Science Stream. However, diminishing or low levels of interest in STEM-related studies amongst students suggests that there is little or no documented evidence on the best method for promoting science education in the country.
- At the current rate of student enrolment in STEM studies, both at the higher secondary and tertiary levels, there will not be enough skilled personnel to meet the above projections or to build the envisaged knowledge-driven, value-add economy.
- There are too many gaps along the entire STEM talent chain, from the secondary school level to the R&D level, to successfully meet the requirements of 2020.

6.0 How Engaged Are The Industries In The Existing STI Framework Towards Spearheading Economic Growth Through R&D?

The role of industries is paramount in fostering new economic growth, especially in terms of increased private sector investments and commitment to the STI agenda. Therefore, it is important to build the 'risk' appetite of the industry or entrepreneurs to stimulate greater investments in R&D and accelerate commercialisation thereafter.

The current and future success of STI development will largely depend on the extent and quality of linkages between academia and industry. Indeed, such linkages should be established to enable cross-pollination of STI ideas, programmes, investments, resources and outcomes.

Furthermore, to enhance the level of engagement and participation of industries for STI, it is important to re-evaluate or reinforce the key indicators for measuring the outcomes of communication, funding opportunities and policies that enable industry linkages.

Recommendations:

- Strategise effective implementation of formal and regulated linkages for public-private partnerships. For instance, there is a huge opportunity to strengthen and empower formalised platforms for tripartite (UIG) linkages and avoid overlapping roles.
- Aggressive and continuous dissemination of STI agenda to the industry players and enhance their understanding and involvement. Industry associations (with measurable KPIs) can also play a role in deploying such channels to promote STI objectives as well as to mobilise industry players for active participation in R&D initiatives. Similarly, a national S&T data or information centre (as an enabler) will help create a knowledge repository of the value (in measurable terms) achieved by the industry through various STI investments and initiatives, which in turn may attract more players for collaboration. The centre will be strategic in terms of going beyond collation and documentation of data, to include holistic analysis for future STI development.

Stocktaking:

- The general trend in Malaysia (as in other developing countries) is that the industry is only receptive to research that provides direct solutions to their business and promises ROI.
- Supporting the knowledge -advancement and human capital development objectives of R&D may not be one of the considerations for the industry. The biggest motivation for the industry towards R&D or STI initiatives is the availability of funds or access to public funds, technological innovations with commercial value and fiscal incentives.
- Poor industry awareness on the existing STI policy frameworks, sources and criteria for research funds prevents industry players from contributing to or participating in R&D or STI initiatives. Low awareness is due to lack of sufficient opportunities for communication, limited exposure and engagement.

7.0 Is STI Exciting and Meaningful To The Society?

The NPSTI emphasises the need to strengthen and integrate STI into the mainstream consciousness, across all sectors and at all levels of the national development agenda. It also states that STI should be pervasive and touch the lives of every Malaysian, i.e. create a society with an STI culture or mindset.

"Science beyond Scientists", is a global philosophy that is relevant for Malaysia as it helps to sensitise the society on various aspects of development, while the nation achieves its 2020 milestone of being a developed economy. Its policies and programmes could be even more effective if society can develop a greater understanding of the role of science and participate in scientific endeavours with active interest and not merely a cursory appreciation of technology in their day-to-day lives. There have been some flagship events, programmes and concepts in Malaysia that were successful in not only imparting scientific knowledge, but in enhancing science exploration, innovation and communication amongst the future citizens and professionals of the country.

In addition, Malaysia has many governmental and non-governmental organisations including private sector companies and individuals, who are actively promoting the cause or role of 'science for society' and for national development. A number of science-themed publications, news and documentaries are also released periodically by industry experts, thought leaders, media channels and associations, creating an interest in science and related areas.

To communicate the role of public in creating a science culture, it is important to acknowledge that "Science is Culture". This means that informal learning platforms must exist or be created for achieving civic scientific literacy. If we do not succeed in building such a culture today, our children – the future citizens and proponents of STI – will fail to contribute meaningfully to the STI ecosystem.

Recommendations:

- Strategic long-term STI Enculturation Plan through:
  - Early exposure to science in schools;
  - Popularising science to society;
  - Engaging public using multiple platforms; and
  - Developing Science Enculturation Index.
- Such a plan should define the roles of multiple stakeholders such as the Government, scientists, prosumers, businesses, media, parents and youth, and the society at large, in promoting the cause of science for development.
- The Plan should also clearly define the platforms for public engagement, including the frequency and the content to popularise science amongst non-science communities.

Stocktaking:

- The data suggest that there is a relatively high level of interest in S&T amongst the Malaysian public. However this interest seems to be temporal driven by current issues, and does not translate into corresponding level of scientific literacy. This has resulted in a lack of basic S&T knowledge and skills (MASTIC, 2014b). Thus, we lag in terms of nurturing a scientific culture. We need to have a consistent and robust measure of STI enculturation level to understand where we are.
- The various STI public engagement programmes or initiatives currently in place do not present compelling data or results to determine the contemporary public understanding on their roles in proposing a national STI agenda.
- There are not enough opportunities for the public to participate or engage with the science community on the development of STI policies, programmes, initiatives and institutions.

8.0 Can Malaysia Tap Into Global Opportunities Through Strategic Collaborations In The STI Arena?

The need for enhancing strategic international alliances was neither articulated nor highlighted in the initial S&T frameworks, at least not until the current policy was introduced. The focus (in the past) was primarily centred on building and strengthening national capabilities and capacity for research, technology and innovation. Today, Malaysia remains committed to collaborate, co-create and foster strategic S&T partnerships for socio-economic growth through Memoranda of Understandings (MoUs), agreements and treaties with high-potential partner countries.

According to the Ministry of Foreign Affairs, Malaysia has signed 108 multilateral treaties but only 15.7% or 17 of the treaties are STI-related. To-date, 26 bilateral MoUs have been signed between Malaysia and other countries for cooperation in STI such as the MoU on Science and Technology with Myanmar (2013), Mozambique (2012), Saudi Arabia (2011), the United States (2010) and Russia (2003), as well as the MoU on Marine Science with China (2009). Meanwhile, there are 87 Scientific and Technological Cooperation agreements, all of which are part of an Umbrella Agreement.

Duly, it is important to note that these international alliances may be limited to promoting business and trade, as opposed to facilitating meaningful exchange of knowledge, skills, talent or technology.

Conversely, cross-border partnerships for R&D (driven by universities and research Institutions) may contribute to technology and knowledge-transfer but without any positive economic impact or STI outcomes.

Recommendations:

- Forge and increase STI-focused international alliances to establish Malaysia's leadership and achieve excellence.
- Target strategic partners (ASEAN, BRICS and MIST) and improve image of Malaysia's STI capabilities. Towards this, practical models to facilitate international alliances must be devised which will:
  - create multi-lateral synergies alongside bilateral opportunities through intra-ASEAN collaboration and by tapping the potential in BRICS and MIST economies, with clear interventions to bridge STI professionals inclusive of industry specialists and academicians;
  - establish private sector partnerships with a leading role in driving STI initiatives such as:
    - An investment with clear economic benefits for the stakeholders involved.
    - Corporate social responsibility.
    - Technology transfer programmes (as part of a larger trade deal).
  - institutionalise a Centre of Excellence (an operational model) to increase collaborative and applied research; increase production of human capital; create a sustainable STI culture and develop long-term R&D capability.

Stocktaking:

- Only 15.7% multilateral agreements are STI-related (Ministry of Foreign Affairs) and out of 119 countries, Malaysia has signed 113 STI related bilateral agreements with 88 countries. However, there is no evidence on how various agreements provide benefits related to STI development for Malaysia.
- In other words, the outcomes of the existing MoUs, treaties or alliances are not always published or known, even in the context of STI development (exchange of knowledge and skills, higher trade value, export / import potential, etc.)
- There is no sufficient drive to effectively position STI knowledge, competencies and infrastructure for Malaysia to emerge as a potential partner in the global arena.
- The current agreements are mainly related to the economic, scientific, technical and cultural cooperation between Malaysia and other countries and do not necessarily contribute to the advancement of trade or exchange of STI knowledge, skills, expertise, etc.

9.0 Conclusion

Malaysia has earned a favourable reputation regionally and internationally for staying true to its path making, robust policy frameworks, even as an emerging economy. The NEM and the Economic Transformation Programme (ETP) are testimonies of the nation's willingness as well as its readiness to"change the rules of the game" to become a developed nation. The multiple government ministries and agencies, supported by an equally large number of stakeholder groups, continue to demonstrate their commitment to the greater vision of the country rather than just serving their individual agendas.

Though the cycle of planning and implementation may be seamless, it sometimes lacks cohesiveness. This is particularly relevant to STI in Malaysia and it undermines the potential of the available STI resources as well as negatively affects the outcomes of its development. A lack of a unified approach in meeting the national STI vision or objectives will continue to influence the performance of various STI proponents and the STI development track as a whole, if not corrected. "Turfism" is another issue which exists in various pockets of the industry as well as the Government, preventing meaningful exchange of ideas, smart partnerships, synergy in efforts and overall, achievements in science for the benefit of the economy as well as our society.

The Science Outlook has brought to light the various gaps and issues (at both the micro and macro levels) [Figure (c)], known to the science fraternity but could not be addressed in the absence of a consensual environment or an ecosystem amenable to STI development. The most important question is how can we achieve such unison to accelerate our STI journey and work towards Vision 2020?

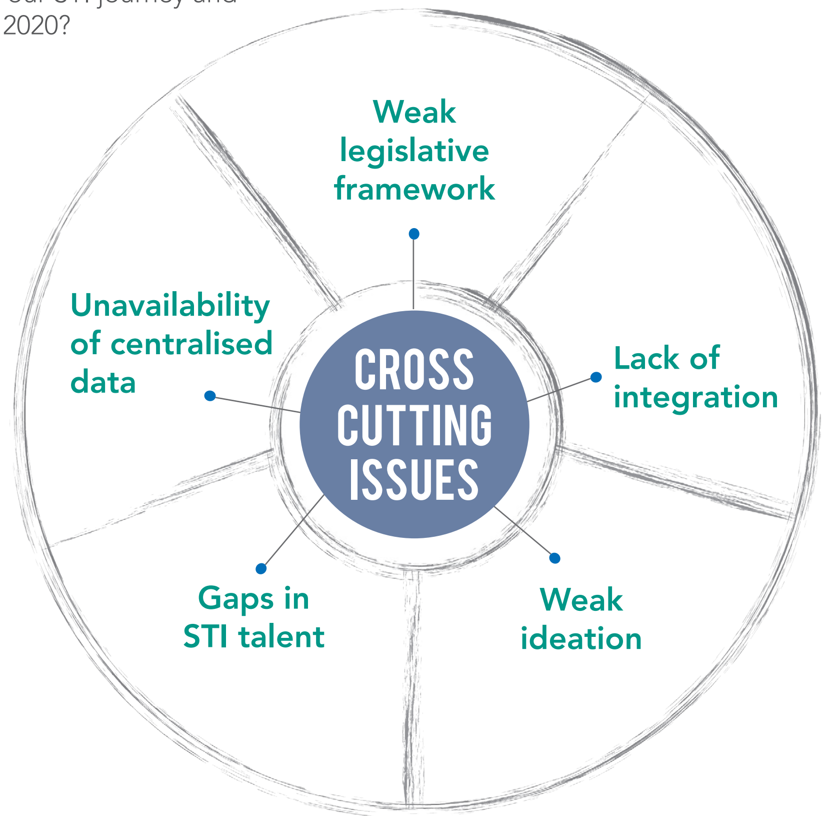


Figure (b). The cross-cutting issues

High Time For Making The Science Act A Reality, With A Science Agenda Setting The Roadmap

While the Government's S2A programme will help mitigate the issue of isolated and uncoordinated implementation of STI policy measures, there is a need to define a common direction by making the proposed Science Act a reality for Malaysia. This Science Act (as evidenced by other STI-enabled, developed countries) can be instrumental in devising STI developmental strategies, with clearly articulated roles and responsibilities for the multiple sectorial bodies involved (governance), and a collaborative approach (investments, talent and resources) with measurable outcomes (data). These can be part of the National Science Agenda, which will identify and launch national STI programmes and initiatives to propagate the role and cause of science, set R&D priorities based on National Key Economic Areas (NKEAs) and create platforms to establish STI linkages with the industry and the science community, both locally and internationally.

We must be aware of the fact that there will always be a risk of losing sight of the big picture if we fail to define (in absolute, measurable terms) an integrated implementation plan. Various sectorial players and custodians of STI development projects must be empowered (in their own right and position) to engage, forge STI alliances within and outside the country and motivate action for an outcome that is meaningful to every Malaysian. Science for all and science for development is our objective as we deliberate action to make the Science Act Malaysia possible towards meeting our vision.

Be The Change, To Change The Future Course Of Action For STI Development

The Science Outlook is the first of what will hopefully be many efforts to acknowledge and accept some of the fallacies, which are present not so much in the system, but in our approach taken thus far towards STI development. All that needs to change is the modus operandi by which the STI planning and implementation cycles are managed. Every stakeholder and institution responsible for furthering the STI agenda must be an agent of change and propagate the value of joining forces, capabilities and even budgets for greater impact.

STI has long been acknowledged as prerequisites for sustainable growth, not only for a developing country but also for a developed economy. Our existing policy frameworks are well planned, as they contain numerous provisions and opportunities for STI development. These (on their own) can serve as a springboard for additional dialogue and discussion regarding the best way forward strategies, with practical value for both stakeholders as well as the nation. The recommendations submitted by the Science Outlook can be the starting point for STI proponents to convene with the industry, the government, regulators and, most important, the Public, to articulate their individual roles in shaping the future STI landscape. Our efforts hereafter will be:

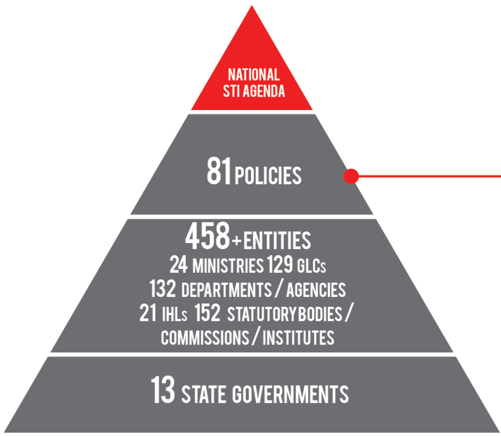
- Involve more stakeholders in drafting the Science Outlook, including government offices as well as the private sector;
- Initiate new efforts to close the gaps (data etc.) identified, through new studies and evidence for the next Science Outlook.

01

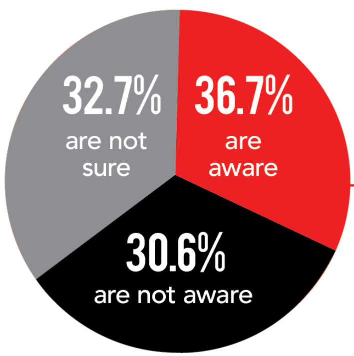
STI Governance

STI GOVERNANCE

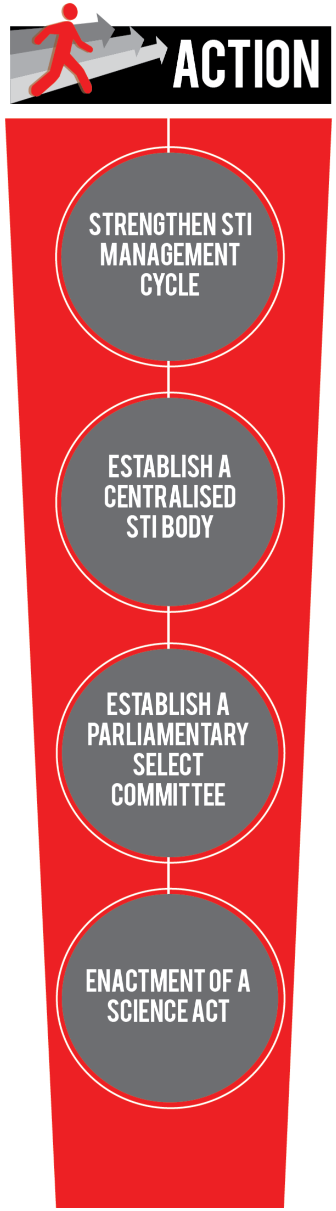
AN OVERARCHING NATIONAL STI AGENDA FOR A UNIFIED EXECUTION STRATEGY



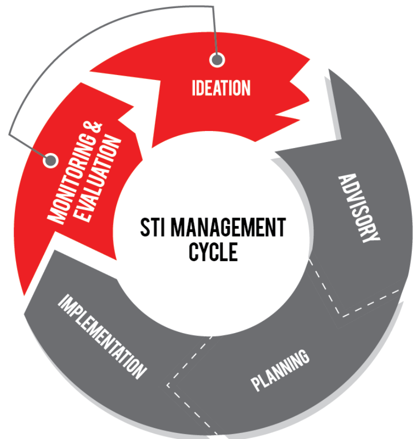
56 OUT OF 81 POLICIES ARE STI RELATED



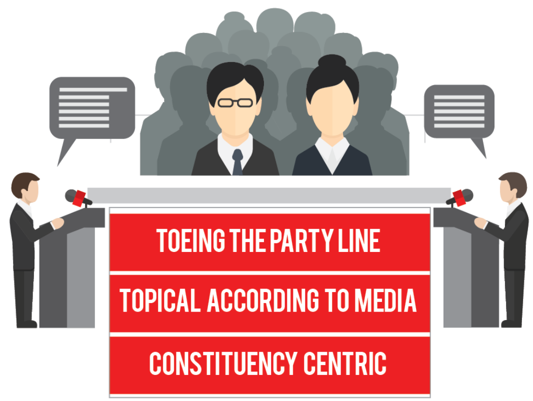
Industry Awareness of STI Policy



WEAK LINKS IN THE STI MANAGEMENT CYCLE



PROBLEMS WITH PARLIAMENTARY DEBATES



Science Outlook 2015

01
STI Governance

Are We Optimising Our Potential, with Clear National STI Agenda, Towards 2020?

Our journey towards 2020 as a rapidly developing country continues, with the Government engaging all fronts to successfully implement the ETP, focusing on the 12 identified priority sectors or National Key Economic Areas (NKEAs), for maximum socio-economic impact. While the STI and its implementation are manifested in various national blueprints such as the NPSTI, Malaysia Education Blueprint 2013-2025 (MEB), SME Masterplan 2012-2020 and the aforementioned ETP, there is no unified approach or execution strategy. This poses a challenge to efficient and effective application of STI solutions for national development. It also underscores the need for a sound governance framework to address complex socio-cultural and fundamental policy measurement issues as we continue in our efforts to make possible an STI-powered economy by 2020.

One of the key milestones in the STI journey was the launch of "Science to Action" or S2A Initiatives by Malaysia's Prime Minister YAB Dato' Sri Mohd. Najib Tun Haji Abdul Razak in 2013, which includes three key components – Science for Industry, Science for Well-Being and Science for Governance. Malaysia aspires to be one of the top 10 countries listed in the Global Competitiveness Index and the Global Innovation Index by 2020 through:

- Strengthening current industries, creating new industries and entrepreneurs through identification of new growth areas and increasing private sector participation in S&T development;
- Improving the quality of public life through the use of S&T. This includes popularisation of science and improvement on the uptake of STEM; and
- Strengthening public services and governance to ensure an eco-system conducive to the development and uptake of S&T.

How easy or arduous a task would it be to achieve significant results in these three areas? How favourable are the multiple stakeholders including the science community, to the idea of contributing to the identified targets and objectives? To answer these questions, it is important to gain a historical perspective on the evolution of science and its associated policies in this country, evaluate where we stand today and identify what are some of the absolute, non-negotiable preconditions to successful execution of Malaysia's STI agenda.

With A STI Roadmap That Dates Back Nearly Three Decades, Do We Have A Robust STI Governance Framework In Place?

Since the very beginning of policy formation, the ultimate aim of national planners has been to build and accelerate the STI capabilities towards establishing Malaysia's competitiveness and leadership not just regionally but also globally. From defining and establishing the relevance of a science policy as well as the importance of R&D way back in 1986, Malaysia progressed to the diffusion stage as early as 1990, with widespread application of technology and development of capabilities to promote industrial development.

By 2002, when the Second National Science and Technology Policy and Plan of Action (2002 – 2010) (NSTP2) was introduced, it focussed on strengthening research and technological capacity alongside promoting commercialisation of R&D and building on STI human capital. Moving forward to the next stage and addressing some of the gaps, the National Innovation Model was launched in 2007 to take a balanced approach between technology-driven and market-driven innovation, recommending a paradigm shift especially in the modus operandi of the various universities, industries and research institutes that undertook R&D.

Efforts to review the previous policy have led to the framing of the current instrument, the NPSTI (Figure 1-1). This policy clearly defines specific goals with an aspiration to create a high income, sustainable and inclusive nation. It is believed that by strengthening and mainstreaming STI at all levels and sectors of the economy, Malaysia will emerge as a scientifically advanced, knowledge-based, innovation-led and globally competitive nation.

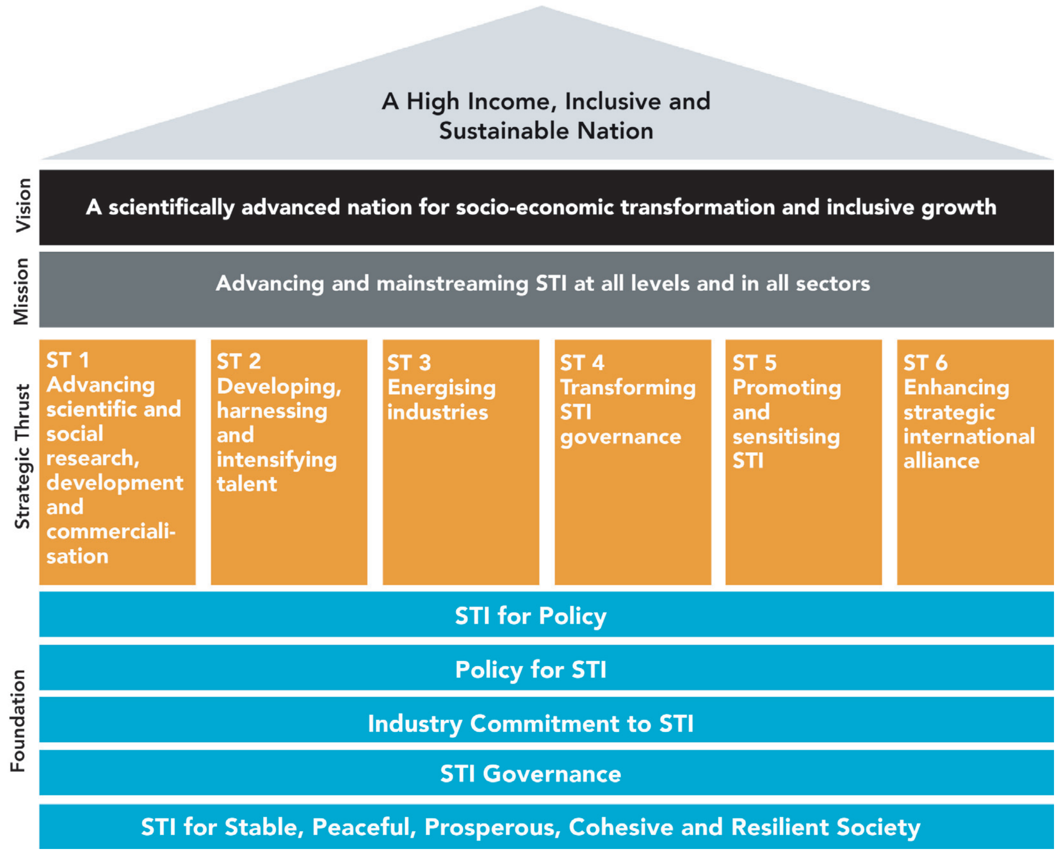


Figure 1-1. National Policy on Science, Technology and Innovation (2013-2020) (NPSTI)
Source: MOSTI 2013

It must be noted that all along, the STI initiatives were well integrated into Malaysia's Five-Year Development Plans (Figure 1-2). Though Malaysia has had an STI policy since the 1980s, most policies prior to the NSTP did not have explicit reference to STI (Further Reading 1-1). A policy is deemed 'explicit' if it covers the use of STI to achieve the objective of the policy; the presence of R&D component in the policy or proposes R&D to achieve policy goals. Alternatively, a policy is deemed 'implicit' when statements regarding STI are vaguely mentioned or referred as a general goal of a policy.

Twenty per cent of pre-1986 policies have STI reference as compared to 91% of governmental policies announced after 1986 (Table 1.1).

This suggests a paradigm shift in policy design that may be attributed to the launch of the first NSTP and the specific chapter dedicated for S&T in the 5th Malaysia Plan (5MP) in 1986. Most policies contain current terms such as "research and development" that were absent in older policies. The post 1986 policies that did not possess any STI references are mostly non-technology in nature such as the First National Tourism Policy (1992 – 2002), the Second National Tourism Policy (2003 – 2010), the National Consumer Policy 2002, the Second National Youth Development Policy 1998 and the Fair Trade Practices Policy 2005. The extent to which STI-related policies have permeated all levels of STI-related ministries and national research institutions is unclear.

Table 1-1. Analysis of STI elements

Description / Policy	**Pre - 1986**	**1986 & beyond**	**Total**
		Number (%)	
Policy with explicit reference to STI	5 (20%)	51 (20%)	56 (69%)
Policy with implicit reference to STI	20 (80%)	5 (9%)	25 (31%)
Total	25	56	81

Note: This analysis covers all policies including the obsolete ones.
Recurring policies and its updates/variation were assessed separately.

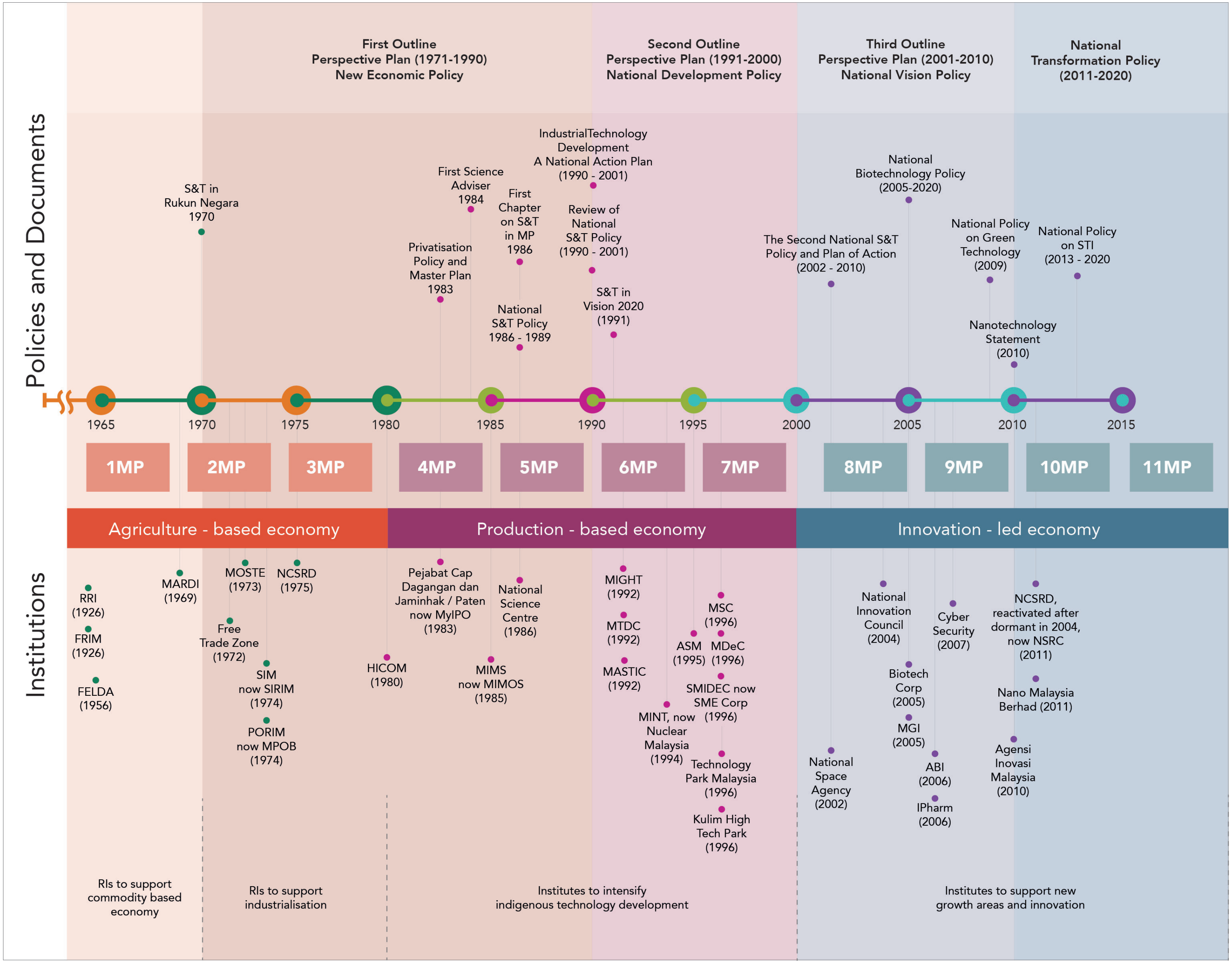


Figure 1-2. Malaysia's STI development and achievements
Note: This figure is derived from Further Reading 1-2

The continuous evolution of the STI policy measures rested on the premise that Malaysia needed a Governance structure that would help focus on a wide spectrum of 'Science' – from education and research to development of technology and deployment of innovation - a system that would help unify the efforts, establish synergies and improve the overall delivery system across multiple ministries and agencies, industry as well as the members of the science community, who continue to drive various STI programmes and initiatives.

The role of governance is critical in actualising the set goals or policy measures into tangible outcomes. It underpins the importance of a sound institutional and regulatory framework that would transcend all ministries, with greater stakeholder' participation, and recognise STI Governance as one of the five foundations and six major thrusts in the current policy.

As a thrust, the policy calls for a reinvigoration of existing governance mechanism of all four players (Quadruple Helix - Government, Academia, Industry and People) in a creative, systemic, open and user-centric innovation environment. Therefore, a linear and top-down approach that was the mainstay of previous policy instruments would no longer be considered relevant, especially without the participation of consumers, customers and citizens. In view of this, a "Science Act" has been proposed and promoted as one of the means to remove the scientific and / or technological divide that exists between policy makers, implementers, collaborative partners and the beneficiaries, alongside some policy amendments, which would enhance the institutional framework and management of various STI components.

Hence, with the proposed Science Act, STI Governance in Malaysia can be best articulated in the context of its two key definitions:

1 Governance for STI is defined as the process that involves actors and the rules that govern their engagement, which shapes the development of STI within national boundary.

2 STI for Governance encompasses scientific and innovative advances to improve the elements of openness, participation, accountability, effectiveness and coherence in decision -making as well as the interactions between STI actors and policies.

In evaluating governance mechanisms, cognisance needs to be taken of the manner in which the prevailing environment affects STI as well as how STI informs policy. The former would relate to the enabling environment for policy implementation while the latter would be an indicator of the extent to which STI has been internalised within government bureaucracy, private sector, and the civil society and its place in the nation's overall national development outlook.

If One Compares Malaysia's Governance Framework with Other STI-Enabled Countries, What Would Be the Key Missing Elements?

1. Lack of Political Will and Legislative Drive to Address STI-related Issues: The past legislative involvement in STI in Malaysia was investigated through Hansard Analysis (Further Reading 1-3), which suggests that though there has been sufficient dialogue with submission of developmental issues, queries and recommendations related to STI, legislative consensus or motivation to map STI contributions or its potential with national goals was missing in principle. Majority of the questions in the legislative were ex-post questions concerned with past actions instead of ex-ante questions which was aimed at influencing future actions, indicating that parliamentarians play a passive role in charting the STI direction of the nation.

There seems to be a positive correlation between the top 11 STI countries in terms of their level of investment in R&D with the existence of well-established STI institutional frameworks. In most countries, STI development is led by the Chief Executive (Prime Minister or President, or in the case of South Korea, by both). Interestingly, in the United Kingdom (UK), there is no specific agency mechanism at political level, but there is a parliamentary select committee on STI to advise the Prime Minister. In Malaysia, the nearest that we have is the Science Advisor to the Prime Minister. The Science Advisor, however, is not part of the political infrastructure.

From an institutional standpoint, STI enculturation in Malaysia currently is more of an individual ministerial function and responsibility without committed involvement of or from institutional stakeholders such as other ministries or state governments, who fail to see their own roles in STI development. A similar situation prevails in Brazil but there also exists formal coordination mechanisms that allow the relevant ministry to reach out to all stakeholders at local levels (Further Reading 1-4). In Malaysia, however, the ministries deal with other ministries, not with the grassroots institutional and social stakeholders that these other ministerial, or state organs, are mandated to consult.

STI needs to be a legislative imperative for a stable development of STI and by law; it should be definite in its agenda, objectives and sustainable outcomes. Truly, only when governed by law or by the proposed Science Act, can the implementation be seamless across various states and sectors, with visible impact on socio-economic development of the country.

In many countries, the legislative will also go beyond their framework to create meaningful discussions on science and related spheres in the public domain. For instance, in the United States (US), the House of Representatives has a Science, Space and Technology Committee with a jurisdiction over all energy research, development, demonstration as well as other projects.

Comparison of legal and administrative structures of top 11 countries (GERD per GDP)

South Korea

4.36% GERD per GDP

Legal Structure

- Science and Technology Promotion Act (Act No. 1864) — Framework Act on Science and Technology

- Act on the Support of Korea Scientific and Technological Intelligence Center (Act No. 2109) – Act on the Establishment, Operation and Support of Government-Funded Science and Technology Research Institutes

Administrative Structure

- The Presidential Advisory Council on Science and Technology advises the President on S&T and ICT policies and development in South Korea.

- The Ministry of Science, ICT and Future Planning and the National Science and Technology Council co-ordinate major ICT policies and projects, develop strategic policies on technological innovation and provide guidelines for future development of the ICT industry.

Israel

3.93% GERD per GDP

Legal Structure

- Law for the Encouragement of Industrial Research & Development –1984

Administrative Structure

- The Ministry of Industry, Trade and Labor establishes (a) the Office of the Chief Scientist to implement the government's policy on supporting and encouraging industrial R&D, and (b) the Investment Promotion

- Centre to promote foreign and local investment in domestic Innovation and Technology industry.

- The Ministry of Science, Technology and Space identifies the research areas in Innovation and Technology that are of national priority, and develops human capital through investing in higher education and science and technology.

Finland

3.55% GERD per GDP

Legal Structure

- Government Decree on the Science and Technology Policy Council of Finland 1043/2008

Administrative Structure

- Advisory body includes the Government (Prime Minister as Chair, Minister of Education and Science and the Minister of Economic Affairs as vice-chairs, and seven other ministers), science and industry members.

- Quite influential due to high-level representation.

Sweden

3.41% GERD per GDP

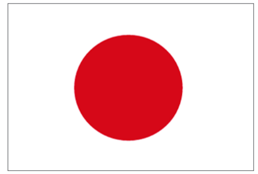
Legal Structure

- The Research and Innovation Bill (2012/13:30)

Administrative Structure

- Sweden's governance system is well geared to a high level of commitment to science and research. Advisory body consists of academic and industrial stakeholders in private capacity.

- Advise the Education Minister who acts as chair.



Japan

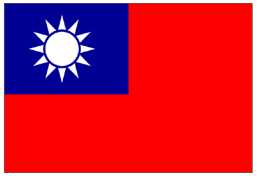
3.35% GERD per GDP

Legal Structure

- Science and Technology Basic Law 1995

Administrative Structure

- National S&T Council chaired by Prime Minister. Three different agencies to implement R&D.



Taiwan

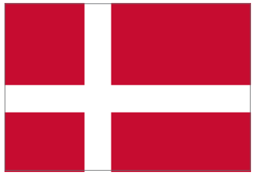
3.06% GERD per GDP

Legal Structure

- Fundamental Science and Technology Act (2001- 2004)

Administrative Structure

- Responsibilities for the promotion of scientific and technological development are delegated among various government agencies: under the Office of the President is the Academia Sinica, and under the Executive Yuan are the Science and Technology Advisory Group, National Science Council, Ministry of Education, Department of Health, Environmental Protection Administration, Ministry of Economic Affairs, Council of Agriculture, Ministry of Transportation and Communications, Atomic Energy Council, Ministry of the Interior, Council of Labour Affairs, Public Construction Commission, Council for Cultural Affairs, and Ministry of National Defence.



Denmark

2.98% GERD per GDP

Legal Structure

- Consolidated Act on the Danish National Research Foundation 2008

Administrative Structure

- Danish Council for Research Policy as advisory body. Members in private capacity from industry and academia. Reports to both Minister and the Parliament. Central in debates on system reform. Secretariat run by Ministry.

Germany

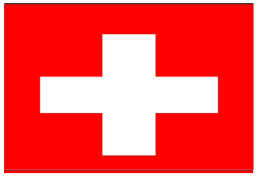
2.98% GERD per GDP

Legal Structure

- Academic Freedom Law (*Wissenschaftsfreiheitsgesetz*)

Administrative Structure

- At the federal level, the Federal Ministry of Education and Research (BMBF) is responsible for research policy while Federal Ministry of Economics & Technology (BMWi) is in charge of innovation and technology policies, and some areas of R&D policy.
- At state level (*Bundesländer*), the science and education ministry and the economics ministry are responsible for science policy. The German Science Council (*Wissenschaftsrat*) is an advisory body to the federal government and its state governments. The council also makes recommendations to higher education institutions. The advisory board *Forschungsunion Wissenschaft–Wirtschaft* (Research Union Science–Industry) was set up by BMBF in 2006 and has 23 experts from the science field and industry. The Commission of Experts for Research and Innovation (*Expertenkommission Forschung und Innovation* – EFI) is an advisory body set up in March 2007, with six international experts. It advises the federal government on scientific issues and provides annual reports on research, innovation and technological productivity.
- Parliamentary activities in the research policy fields are handled by the Committee for Education, Research and Technology Assessment, advised by the Office of Technology Assessment at the German Bundestag.



Switzerland

2.87% GERD per GDP (2008)

Legal Structure

- Federal Act of 4 October 1991 on the Federal Institutes of Technology (FIT Act)

Administrative Structure

- Political responsibilities for research and higher education are divided between the central state (Confederation) and the regional authorities (the Cantons).

Austria

2.84% GERD per GDP

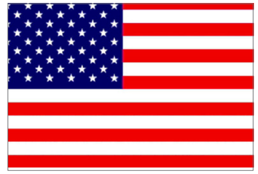
Legal Structure

- Research Funding Act 1967 (Forschungsförderungsgesetz)

- Research Organisation Act, (Forschungsorganisationsgesetz) Federal Law Gazette No. 341/1981

Administrative Structure

- There are two formal bodies for science policy advice: the Austrian Council for Research and Technology Development and the Austrian Science Board (both established by law).
  - The Federal Ministry of Science, Research and Economy is responsible for tertiary education and for basic research in Austria (now also covering all tasks headed by the former Ministry of Science).
  - The Federal Ministry of Transport, Innovation and Technology manages the largest public budget in applied research.
  - The Federal Ministry of Finance is responsible for the allocation of financial resources to the other ministries.



USA

2.79% GERD per GDP

Legal Structure

- Law Enforcement Science and Technology Act of 2000

- Frontiers in Innovation, Research, Science, and Technology Act of 2014

Administrative Structure

- STI advisory groups at Presidential, judicial and legislative levels.

- National Academy of Science is a major think tank.

Sources: Arellano Law Foundation 1997; Attorney-General's Chamber Singapore 2002; Australian Government ComLaw 2014; Bartzokas 2007, Cabinet Office Government of Japan 2011; Court & Sutcliffe 2005; Cunningham 2007; Deok 2004; ERAWATCH; Finlex Data Bank 2008; Ministry of Education and Research Sweden 2012; Ministry of Economy Israel 2005; Ministry of Economy, Trade and Industry Japan 2010; National People's Congress Taiwan 1993; OECD 2010; OECD.StatExtracts 2014; The Federal Authorities Switzerland 1993; The Ministry of Science, Technology and Innovation Denmark 2008; US House of Representatives 2014; Wei 2004; Wu & Chow 2013.

2. Policy awareness: Although Malaysia has had an STI policy since the 1980s, the analysis suggests that prior to 1986, the governance paradigm does not include STI perspective, but early and rapid adoption of STI occurred in the content of non-STI government policies, accelerated by the launch of the first NSTP. The early STI policies were required to be entrenched into the Government system, by integrating the STI objectives with various sectoral policies, under respective ministries and agencies.

A recent Academy of Sciences Malaysia (ASM) survey indicated that the engagement with the industry is also limited when framing or implementing such policies. There is also limited awareness of STI policy among researchers, the field troops in STI development. The failure of STI norms to seep down to the lowest levels of STI generation in government research institutions represents a major shortcoming where policy implementation is concerned. It means that STI continues to be pursued in these institutes in a policy vacuum, a situation that can often lead to wasteful duplication or conflict in purpose.

3. STI infrastructure: Poor orientation on STI policies and programmes is partly due to lack of outreach programmes and isolated STI councils at state, district or local levels. Currently, the STI mandated institution, Ministry of Science, Technology and Innovation (MOSTI), relies on various agencies to promote STI within their respective mandate, without a well-defined monitoring or measurement mechanism.
At present, there are 24 Ministries (including the Prime Minister's Department) and more than 400 commissions, central agencies, departments, statutory bodies, institutions and government-linked companies (GLCs) involved at one or the other stages of the STI Management Cycle (Figure 1-3).

From the governance perspective, there may be a need to evaluate individual roles, functions and contributions of institutions that currently promote or are involved in driving the STI agenda of the country. For instance, the second arm of the S2A initiative calls for popularisation of STI among all levels of society, yet the infrastructure to enable this is largely absent. A review and audit should be undertaken to measure the utilisation of the existing infrastructure and determination of new infrastructure for STI development. Indeed, a comprehensive evaluation will help identify lapses, duplication and obsolete elements in the institutional environment. Moreover, the current policy does not stipulate STI as an egalitarian ideal that should seep into all realms of government machinery, economy as well as the society, but focuses more on building capacity within existing STI institutions, including those from the private sector. This could be a limiting factor, when it comes to building the nation's STI infrastructure or capacity.

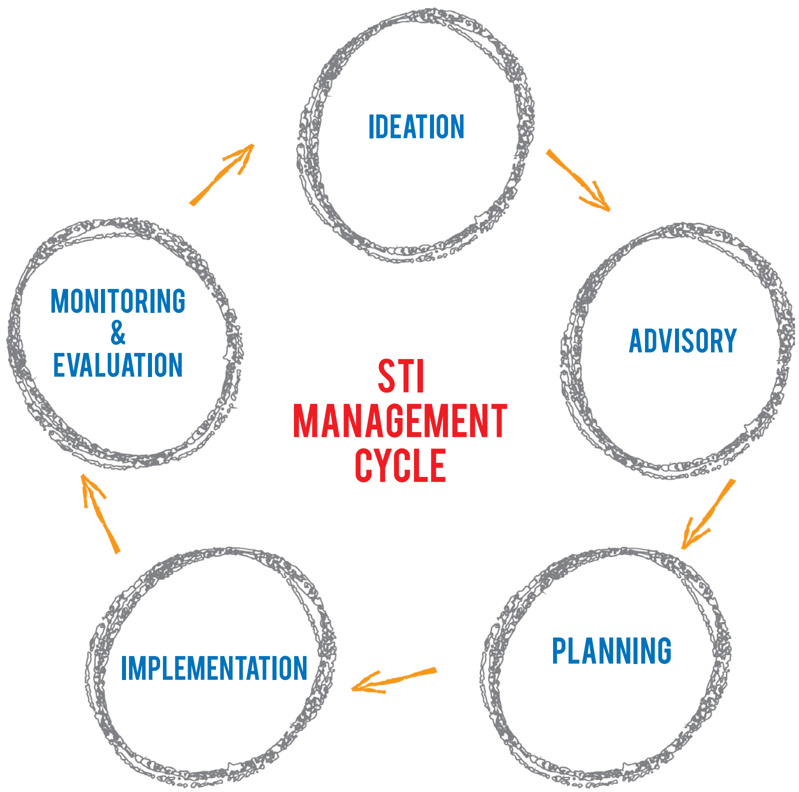


Figure 1-3. STI Management Cycle

Does Malaysia's STI Governance Framework Fully Acknowledge the Interdependence of Various Factors for STI Development?

The STI development may be spearheaded by a coterie of competent, skilled and experienced scientists, to fuel national STI initiatives and economic objectives. However, the motivation of such scientists largely depends on the kind of support system enabled by an effective governance structure, with coordinated action and focused results.Again, such a support system can exist if STI resonates throughout the society; from an early childhood exposure to STI, through development of appropriate human resources and environment, to policy and institution, both public and private and environment.

As science advances, policies would need to embody guiding principles and rules that would be necessary to ensure that fundamental rights and values are preserved. Increasingly, ethical frameworks for new and emerging STI fields are required to address issues such as privacy or in the case of bio-medical studies, animal welfare. In view of this, the development of STI governance infrastructure needs to be in line with the growing sophistication and demands of the STI policy instruments.

Way Forward: An Enabling Environment for Effective STI Governance

Governance means managing the resources to achieve objectives. The process of managing the resources involves foresight, advisory, planning,implementation, coordination, monitoring, evaluation etc. Similarly, resources include money, manpower, material and knowledge essential to meet the objectives as outlined in national policies. In carrying out seamless implementation of various STI programmes and initiatives as well as to achieve some coherence, there is a need to strengthen all the components of the STI Management Cycle (Figure 1-3). For reference, some of the models offered by South Korea and Brazil (Figures 1-4 and 1-5) could be mirrored in Malaysia, for a democratised and integrated STI framework.

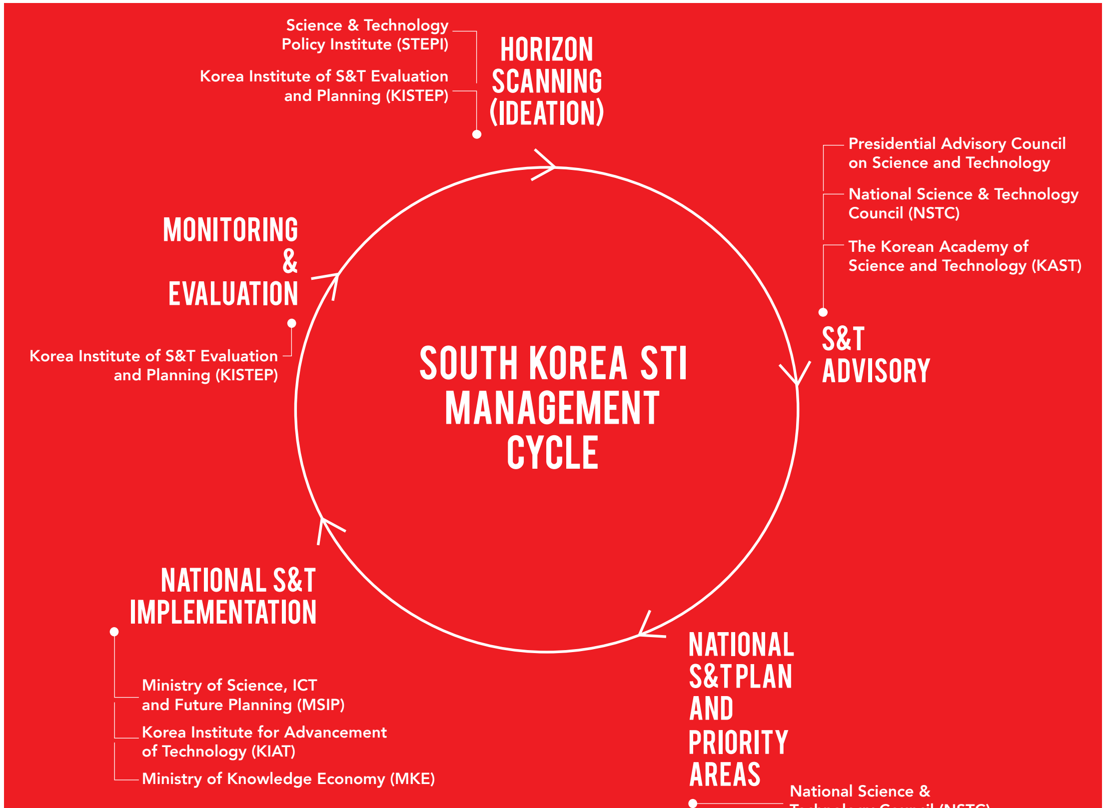


Figure 1-4. STI Management Cycle in South Korea
Sources: ERAWATCH; OECD 2012

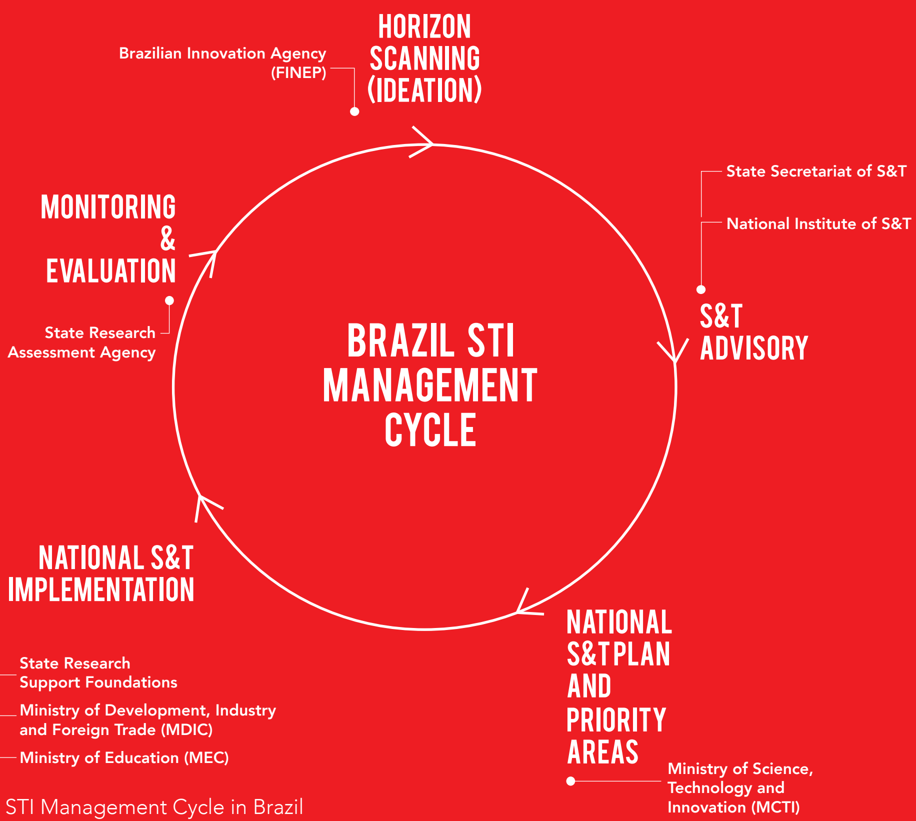


Figure 1-5. STI Management Cycle in Brazil
Sources: ERAWATCH; OECD 2012

1
The Establishment of a Centralised STI Coordination and Monitoring Body

For better STI planning, there needs to be harmonisation of efforts, collaboration of resources, and exchange of information between various stakeholders to include industries, ministries, implementing agencies and bodies, policy makers, regulators, amongst others. This could mean formulation of selective policies and programmes guiding R&D with targeted outcomes, especially in sectors or niche areas with competitive advantages, to be able to attain a position in global value chain. Research collaborations must be planned in areas of ICT, material sciences, biotechnology and matured industries like E&E, transport and equipment industries and agriculture related industries such as palm oil and rubber.

This can be achieved by carving out a role for a central coordination body, which will ensure seamless progression across various stages of the STI Management Cycle and develop overarching National STI Agenda (Figure 1-6) for a unified execution strategy.

The role of such a body should encompass continuous review of policy implementation for establishing milestones; aligning STI programmes and initiatives with ETP objectives; and putting in place effective governance and reporting mechanism. Such a body can also deploy a strategic tool – Spaghetti Map on STI Governance – to establish the degree of cross-pollination of ideas, budgets, objectives, action and outcomes that is taking place amongst various S&T players and proponents. Effectively, the solution could be to determine synergies and action towards one common vision.

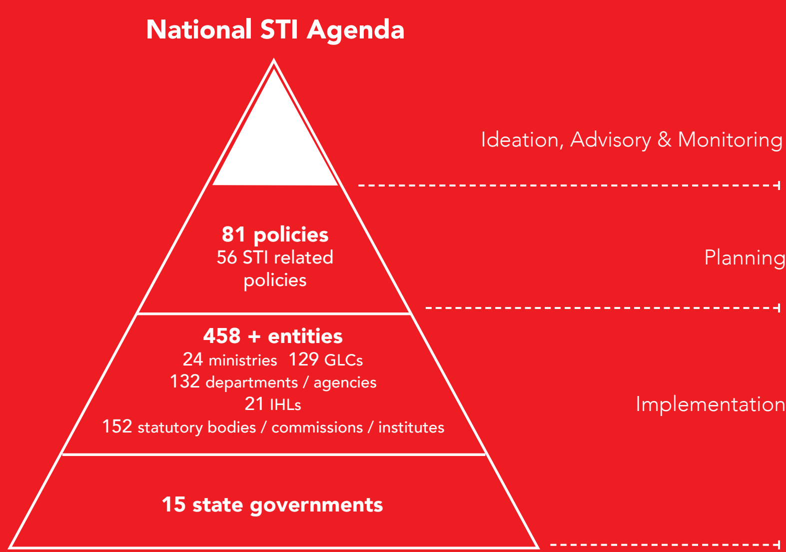


Figure 1-6. An overarching National STI Agenda for a unified execution strategy.

2

Strengthen the STI Management Cycle: Focus on Continuous Monitoring and Evaluation, as well as "Ideation"

The weakest link (as it seems, looking at the STI Management Cycle) is "Monitoring and Evaluation" and the "Ideation Process" (Figure 1-7). What we need is a well-defined monitoring mechanism to eliminate lapses, duplication and obsolete elements in institutional environment. There has been limited structured industry and peer review undertaken to measure the effectiveness of various STI policies. Similarly, there exists limited documented rationale, supported by evidence on various amendments, recommendations made when transitioning from one policy to another policy (Table 1-2 and Further Reading 1-5). This establishes the need to conduct some base-line studies or in-depth review of various STI Policies to establish Malaysia's current STI capacity to meet various targets and its potential to emerge as an STI-powered nation.

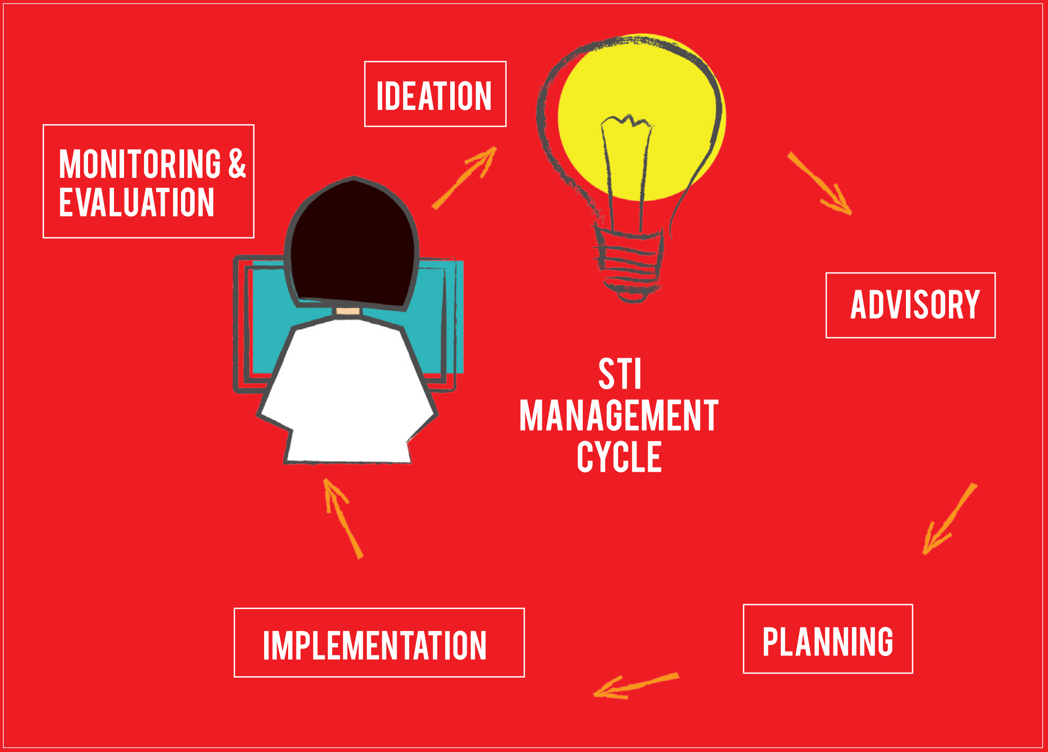


Figure 1-7. STI Management Cycle

Korean Institute of S&T Evaluation and Planning (KISTEP) model can be used in Malaysia, as it advocates an "Accountability" framework, emphasising on a systematic evaluation and monitoring mechanism. It proposes a balance between quantitative and qualitative performance monitoring and evaluation to analyse, defend and communicate value of R&D efforts, its impact and contribution to the nation.

Such "evaluation with accountability" also allows time for qualitative assessments with quantitative data process. For instance, the assessment for R&D could go beyond number of patents and determining their commercial purpose and technology value evaluation. On top of the number of R&D publications, the assessment could review the impact factor or the citation index in two to three years. In the process, the KISTEP model can help build an effective communication medium between multiple stakeholders to include researchers, the government, ministry and the science community, who may appreciate the evaluation strategy or action required to meet the vision.

Table 1-2. Malaysia's progress in STI Management

	STI POLICIES		
ACTION PLAN	**The National Science & Technology Policy (1986-1989)**	**The Second National Science & Technology Policy & Plan of Action (2002-2010)**	**National Policy on Science, Technology & Innovation (2013-2020)**
Achieved		Achieve at least 60 researchers per 10,000 workforce by 2010. Increasing the number of post-graduate students in science, technical & engineering disciplines to at least 10% of the undergraduate population by 2005.	
Not achieved	The government to gradually increase the GERD allocation to 1.5%	Increase public & private sector investments in R&D including infrastructure development targeting for gross national R&D expenditure level of at least 1.5% of GDP by 2010. Adoption of 60:40 ratio of students pursuing science, technical & engineering disciplines in upper secondary schools & universities.	
On-going			Increase GERD to at least 2.0% of GDP by 2020 Increase ratio of researchers per 10,000 workforce to at least 70 by 2020.

Sources: MASTIC 2014a; MOSTE 1986; MOSTE 2003; MOSTI 2013

3
Establish a Parliamentary Select Committee on STI to Build Political Will and Create Legislative Consensus towards Promoting STI agenda:
According to the Hansard Analysis (2008-2013), various debates on STI in the parliament were dominated by queries related to development projects (Table 1-4). Besides, there has been no formal platform in the parliament to discuss STI issues, with expert inputs.

A Parliamentary Select Committee on STI will sustain both interest and debate on STI to go mainstream in the public sphere (akin to the environment in the US, where the House of Representatives has a Science, Space and Technology Committee with a jurisdiction over all energy research, development, demonstration as well as projects. Similarly, South Korea has about 90 laws for S&T development and promotion, signifying that legislations are necessary to strengthen STI governance.

Table 1-3. STI related debates in Parliament

Year	2008	2009	2010	2011	2012	2013
Total STI topics	849	214	344	405	193	202
STI topics related to nation's development	633	163	188	183	109	108
Percentage	75	76	55	45	56	53

4
The proposed Science Act (of Malaysia) will be instrumental in setting up a robust institutional framework on science governance.
The Act will not only signify the Government's commitment to build Malaysia's STI capabilities and capacity but will also help resolve issues of transparency, accountability, partnerships etc. In enforcing the Act, STI democratisation could also be a "solution" in itself, if practised under an empowered and authoritative body or institution for tracking and measurement of performance. This would entail moving STI agenda and / or KPIs beyond the science community, and make it more inclusive by establishing clarity on the role, relevance and benefits to all.

Further Readings

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The focus areas and objectives of Malaysia’s STI policies over the years

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Hansard data mining and analysis to measure the STI awareness of Members of Parliament in Malaysia

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Review of STI regime in select countries

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National STI policies evolution and achievements

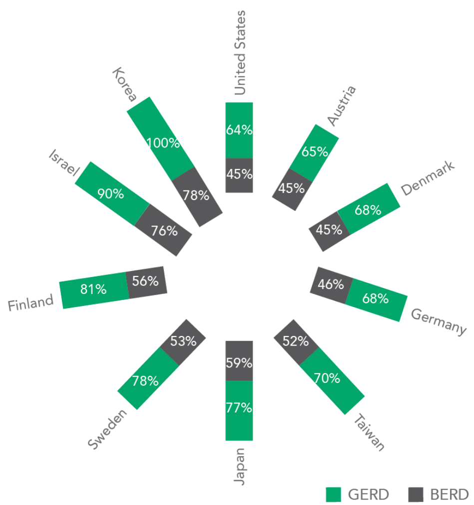
02

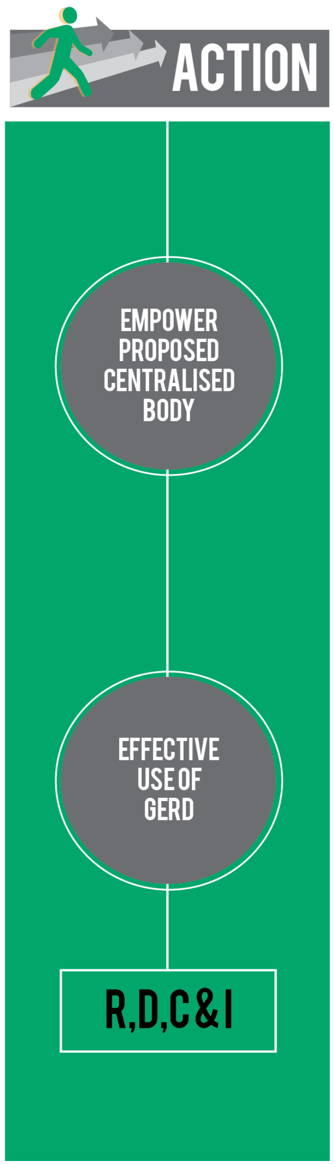
Research, Development and Commercialisation (R,D&C)

RESEARCH, DEVELOPMENT & COMMERCIALISATION

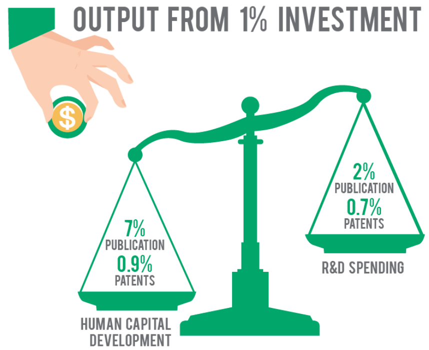
A CENTRALISED BODY

GERD AND BERD

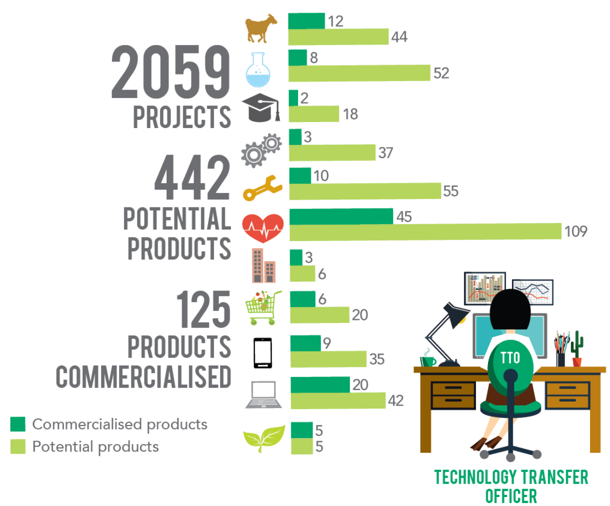




OUTPUT FROM 1% INVESTMENT



COMMERCIALISATION IN THE UNIVERSITY



02
Research, Development & Commercialisation

Does Public R,D&C Address National Priorities, Challenges and Potential Opportunities?

In the past two decades, Malaysia has progressed significantly with developments in R,D&C. Achievements include the establishment of quality scientific research institutions, streamlined R&D spending, improved university-industry collaborations in R&D, better scientific and engineering talent and achievement of positive commercialisation rates. All these areas have helped Malaysia to achieve high global rankings on its technological readiness as well as its capacity and capability for innovation.

However, in recent years, scholars, policy makers, industry players, regulators and other stakeholders operating in the ecosystem of STI have raised some important questions on the performance of R&D investments and commercialisation efforts. How is R,D&C contributing to the overall competitiveness of the country in the STI space? How do we identify and track the drivers and determinants of research output or performance? How can we make R&D more market-driven with a high commercial value?

To answer these questions, it is important to identify the national R&D priority areas, which have been in existence since the 1980s. Despite prioritisation, however, the implementation still lacks continuity and focus. There is a need to understand how the country is strategising and building its research capabilities and human capital with committed investments essential for the performance of scientific outputs.

By understanding the progress and identifying gaps, the innovation systems framework can be used to diagnose the input and performance of R,D&C.

Where Are We Today with the Evolution of R,D&C and its Success?

There has been a steady increase in fund allocation towards R&D from the First to the 10th Malaysia Plans (MP), covering the period from 1966 to 2015. These funds were allocated and distributed through various mechanisms (Figure 2-1). While MOSTI was the key custodian of R&D funds, over the years, other ministries and agencies such as the Ministry of Health, Ministry of Finance (MOF), Ministry of Plantations Industries & Commodities, Ministry of Agriculture & Agro-based Industry, Ministry of Natural Resources & Environment, Ministry of Education (MOE), Ministry of Communications & Multimedia, Ministry of International Trade & Industry (MITI), Ministry of Human Resources (MOHR) and the Ministry of Natural Resources & Environment have also received some allocations.

In the 9MP, there was a diversification of the R&D funds across 16 programmes with an additional number of recipients. This move benefited more sectors, including but not limited to, the Multimedia Super Corridor Pre-Seed Fund (MGS Pre-Seed), ScienceFund, InnoFund, Biotechnology Commercialisation Grant (BCG), E-Content and Information, Communication and Technology (ICT). Some GLCs/ Centres of Excellence (COEs) and government-based programmes were allocated research funds following the objective to streamline fund allocation as a response to poor rates of commercialisation and return on investment (Further Reading 2-1).

The continuous evolution or directional change in the governance of R&D funds signifies the dynamic market forces and the transformational journey of Malaysia (Further Reading 2-2). Amidst such an environment, one of the top-most determinants or measures of R&D scope (as recognised) is the GERD, which is represented as a percentage of the GDP. While the current policy sets the target of increasing Malaysia's GERD to at least 2.0% of the GDP by 2020, it is important to examine the impact of the increase in GERD. Although Malaysia had seen a rise in GERD from 0.5% to 1.13% from 2000-2012 (more than double), the country is still far from achieving its desired GERD of 2.0% by 2020 (Figure 2-2).

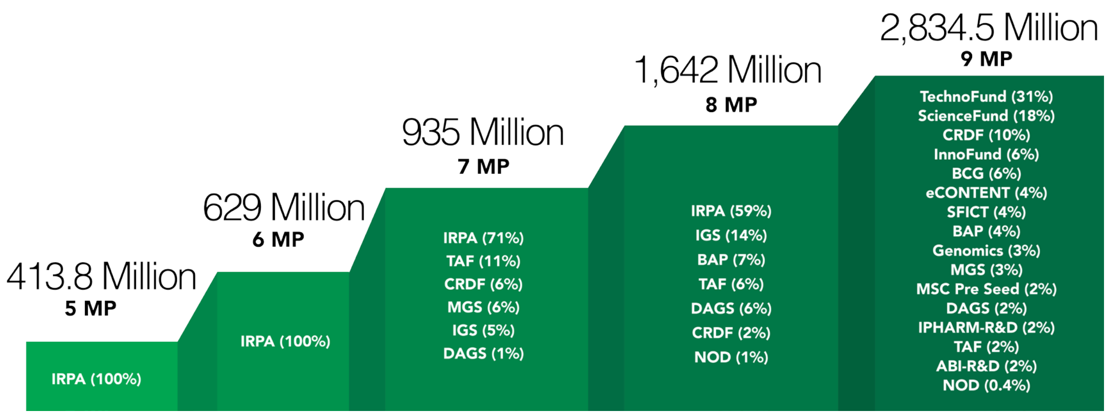


Figure 2-1. Malaysia's evolving funding programmes with multiple agencies across the Malaysia Plans
Note: The figures for 9MP include funding by MOSTI and exclude funding by MOF, SME Corp. Malaysia, MITI, MOE.
Source: NSRC 2013

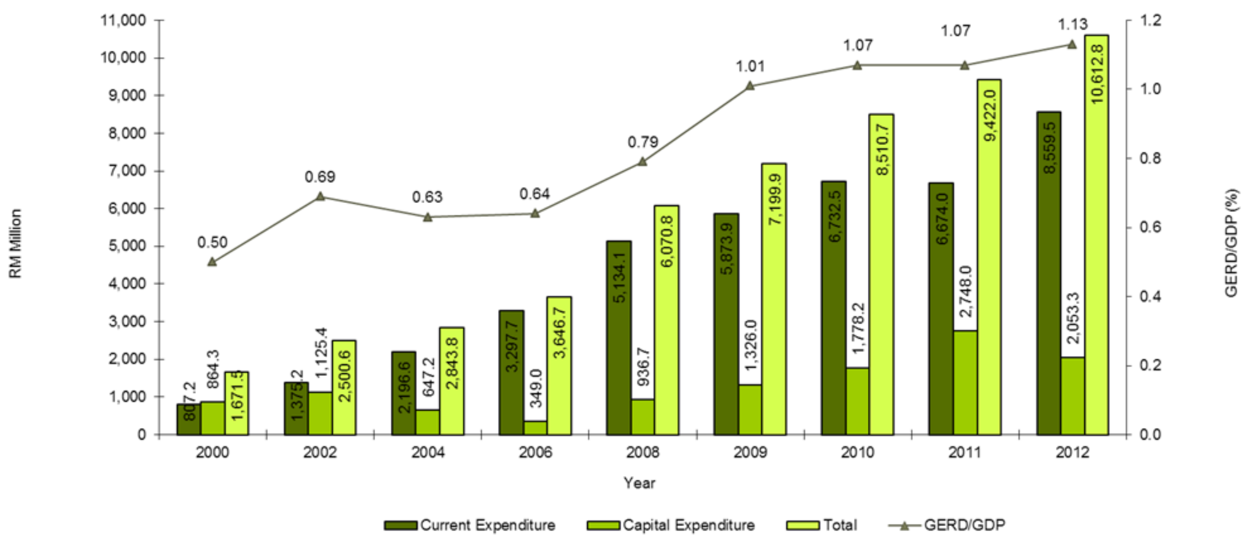


Figure 2-2. Gross expenditure on R&D, 2000-2012
Source: MASTIC 2014b

There was also a corresponding increase in the number of researchers within the labour force by more than three times, from 15.6 researchers per 10,000 labourers in 2000 to 57.5 in 2012. The total headcount of research personnel nearly quadrupled from 19,021 in 2006 to 75,257 in 2012 (Figure 2-3). Similarly, the number of researchers with PhD qualifications increased from 7,001 to 33,272 in 2006 and 2011 respectively, with nearly 85% of research personnel resident within universities and GRIs (Thiruchelvam et al. 2012).

This consistent and positive drift indicates progress and reflects the Government's commitment to gradually meet the projected targets for 2020, which would mean, a nearly 77% increase in GERD within a span of five years. The R&D allocations are also limited to the three fields of ICT, engineering sciences (later streamlined with technology in 2009) and natural sciences, which collectively dominate more than 70% of total R&D spending (Table 2-1). According to historical data, certain sectors, especially ICT and biotechnology, have had better R&D results than others. The recent, R,D&C programme evaluation by MOSTI also showed that ICT and and biotechnology have contributed greatly in terms of commercialisation, return on investment, publication and patent generation compared to other programmes due to the scale effect.

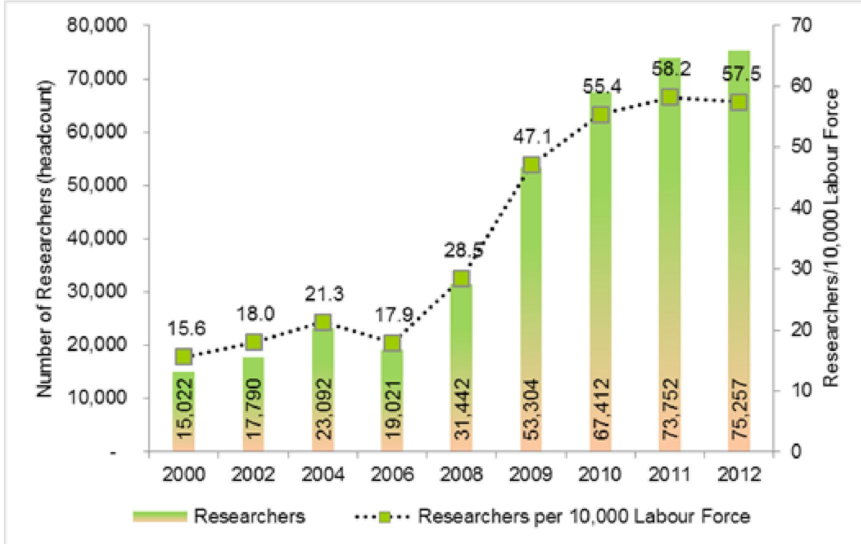


Figure 2-3. Number of researchers, 2000-2012
Source: MASTIC 2014b

Table 2-1. Top three fields accounting for 70% or more, 2004-2012

Field of Research	2004	2006	2009	2010	2011	2012
Engineering Sciences / Engineering & Technologies	36.0	32.3	12.0	27.6	24.2	33.7
ICT	27.0		63.2	45.5	38.2	10.8
Applied Sciences & Technologies	9.0	34.7				
Material Sciences / Natural Sciences		10.0	6.6		12.8	25.6
Biotechnology				6.6		
Total (%)	72.0	77	81.8	79.7	75.2	70.1

Sources: MASTIC 2014a; MOSTE 1986; MOSTE 2003; MOSTI 2013

Another important aspect is the composition of the R&D pie in Malaysia, which in 2012 was focused more on applied research (50.5%) followed by basic (34.5%) and experimental research (15.0%) respectively (MASTIC 2012). R&D spending by universities was equally spread between applied and basic research. In 2011, the spending for basic and applied research was RM 1,330.9 million and RM 1,116.2 million respectively (Malaysian Science and Technology Information Centre (MASTIC 2013). In stark comparison, experimental research received a greater emphasis in other economically advanced Asian countries such as Singapore and South Korea (Figure 2-4).

The contrast appears to be a natural progression as Taiwan and South Korea also focused on applied research during their early stages of development (in the 1980s and 1990s) to strengthen their industrial R&D. Only in 2008, after industrial R&D had been strengthened and a strong need for basic research arose, did South Korea and Taiwan allocate more R&D funding for basic research.

With ever increasing R&D investments, the output or performance is also measured by the number of publications and patent applications. Publications per principal investigator improved significantly, from one in 2007 among research universities to two in 2010 (Figure 2-5)[2].From 2005-2009, Malaysia emerged as one of the fastest growing nations in R&D publications, recording a 28% growth (Table 2-2).

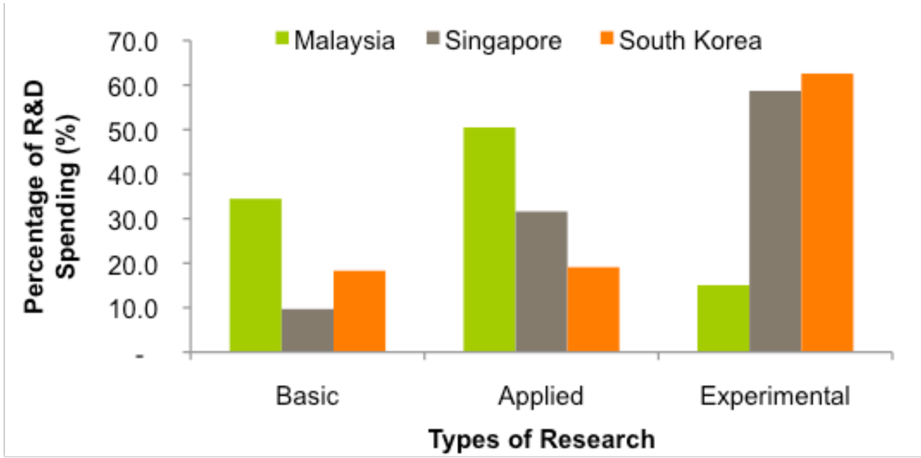


Figure 2-4. Percentage of R&D spending on Applied, Basic and Experimental Research, 2012
Sources: Agency for Science, Technology and Research Singapore 2013; MASTIC 2014b; and Prof Dr Sung Hyun Park, President of Korean Academy of Science and Technology (KAST), email communication (December 13, 2014)

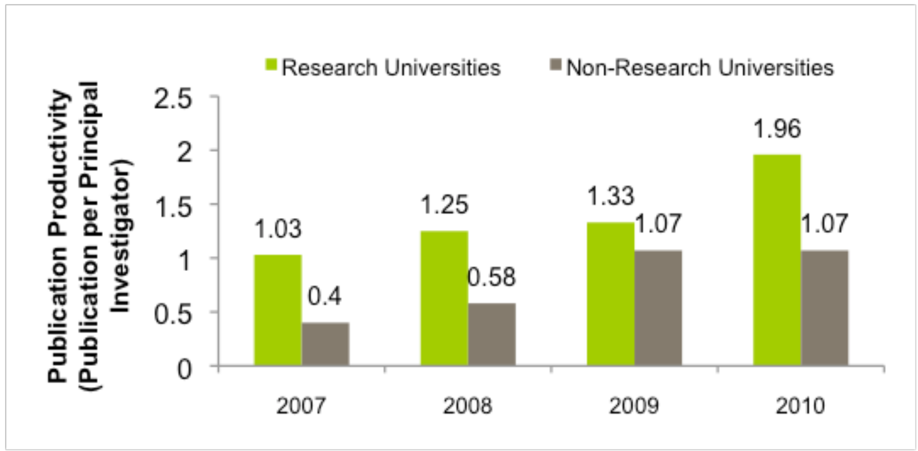


Figure 2-5. Publications per principal investigator, 2007-2010
Source: MOE 2013

[2] In the US, it is 1.5 publications per principal investigator for total scientific publication and 2.5 for the top 10% of scientific publications meaning that researchers are more productive in publishing the top 10% of journals. Malaysia's publication count per principal investigator is based on total publications including the humanities and social sciences.

Table 2-2. Article output and growth (%), 2005-2009

Country	Article	Growth (%)
Malaysia	26, 339	28.42
China	1, 063, 743	12.10
Brazil	162, 840	10.49
India	229, 885	8.24
Taiwan	143, 978	6.86
South Korea	212, 600	5.86
Turkey	115, 814	5.85
Spain	257, 123	5.62
Australia	223, 307	5.22
Italy	315, 907	3.49
Switzerland	128, 994	3.33
Netherlands	178, 026	3.08
Canada	337, 453	2.69
France	400, 815	2.17
United Kingdom	606, 604	1.75
Germany	550, 575	1.43
Sweden	115, 069	1.03
Poland	112, 246	0.93

Source: NSRC 2013

Funding for R&D publications is mainly sourced from the premier universities in Malaysia as well as directly from relevant Government ministries (Figure 2-6). However, over the years, the public universities have taken the lead in supporting various R&D initiatives through strategic investments or funding. Based on the Malaysian Research Assessment (MYRA) data, the five research universities contributed nearly 70% of the total publications in Malaysia. It also improved the h-index of the researchers and institutional citations as well as increased the number of patent filing. The establishment of five research universities in 2008, accompanied by an injection of research funds into the MOE, saw a drastic increase in the number of researchers and publications.

Malaysia has also demonstrated its potential through her progress in patenting as well as commercialisation activities. For instance, the patent analysis from 1989-2013 (Figure 2-7) indicates that Malaysia is slowly progressing in patenting activities. Local patents filed and granted show an increase over the period 1989 – 2013. Significant increase has been recorded since 2005. Among GRIs, MIMOS[3] is the top patent filer and the only Malaysian organisation in the Top 500 global companies recognised for PCT filing.

[3] As per 2011 data, MIMOS, a Malaysian frontier technology company, created a market funnel of RM1 billion, with 1,001 patent disclosures of which 18% were commercialised. The cumulative target of 10MP for MIMOS is to achieve a RM10 billion market funnel, with 38% IPs commercialised and 20% external R&D funding.

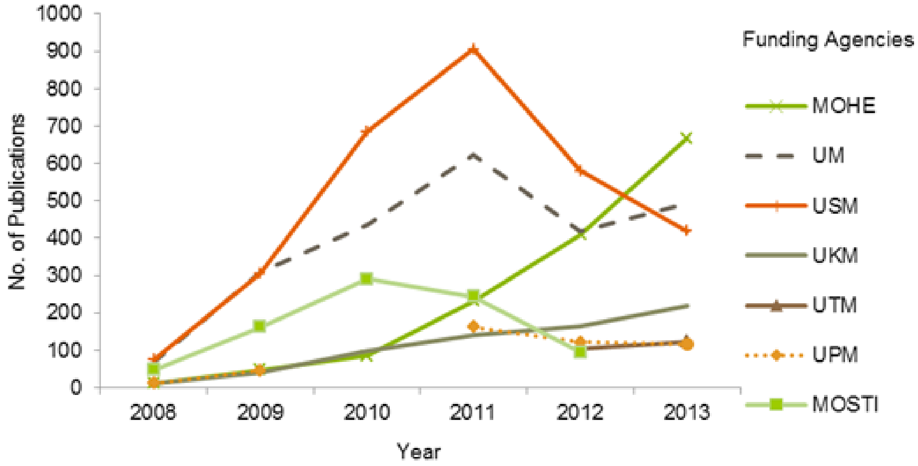


Figure 2-6. R&D publications by funding agency
Source: Web of Science (Thomson Reuters 2014)

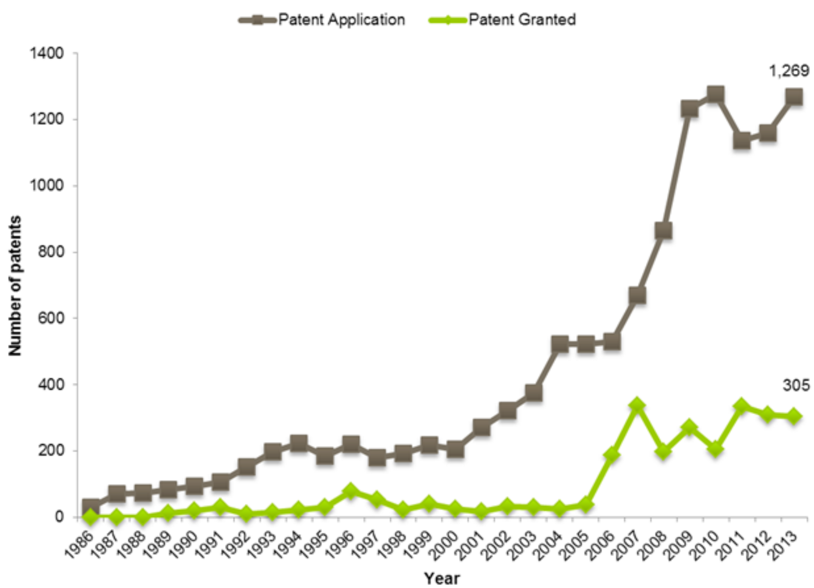


Figure 2-7. Patent application and patent granted, 1989-2013
Source: MyIPO 2014

An important finding is that there is a strong correlation between output (publications and patents), the amount of research funding and the number of researchers with PhD qualifications (Figure 2-8). However, the contribution of human capital or number of researchers with PhDs plays a greater role for publications and patents than funding (Further Reading 2–3).

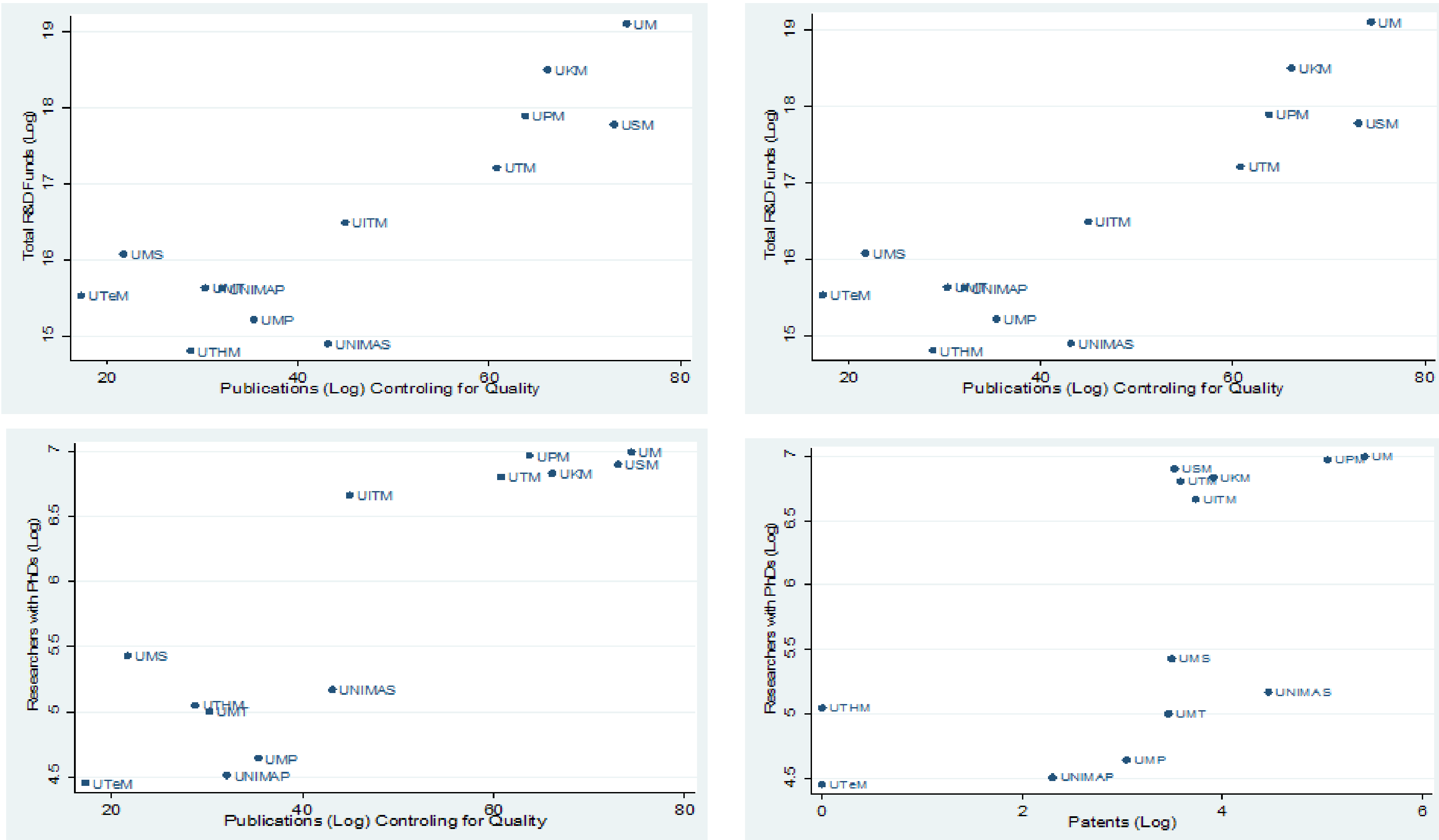


Figure 2-8. Relationships between R&D spending, human capital, publications and patents
Source: MOE 2013

One of the milestones in encouraging universities to patent their research findings was the launch of the Intellectual Property Commercialisation Policy (IPCP) in 2009. After the enactment of the IPCP (2009-2013), there were approximately 33 and 29 co-patenting activities for universities -industries and universities-PRIs respectively (Wong & Salmin 2014). This is also evidence of effective cooperation between universities, PRIs and industry for the exchange of knowledge and skills.

The commercialisation efforts were institutionalised by introducing specific objectives in the 6MP (1991-1995) as well as the subsequent plans to ensure that public R&D programmes are market-relevant with commercial value. The commercialisation success in Malaysia could largely be attributed to various grants such as the Commercialisation of R&D Fund (CRDF), Technology Acquisition Fund (TAF) and BCG.

To illustrate, the CRDF contributed the highest sales revenue which amounted to RM1.2 billion, with more than 5.4% of returns from the total amount of CRDF disbursed (RM0.22 billion) (Table 2-3). Rate of commercialisation was at 82% with a success rate of 22% (success here being defined as projects achieving / exceeding their forecasted sales). In addition, CRDF projects also attracted RM418 million in private sector investments[4] and this trend has increased throughout the 9MP period. The question now is whether the funds were channelled to commercialise the indigenous R&D efforts in Malaysian laboratories?

[4] Private sector investment here refers to investments made by the respective companies' post-commercialisation.

Table 2-3. Commercialisation and sales by R,D&C programmes

Fund Group	Projects Approved	Commercialised Projects	Sales Generated (RM Million)
Creation			
MGS Pre Seed	334	12	10.1
Research and Development			
ABI	41	-	-
IFNM	33	-	-
Genomics	25	-	-
ScienceFund	2834	-	-
NOD	10	-	-
Pre-Commercialisation			
DAGS	26	3	1.6
E-Content	97	40	48.7
InnoFund	365	2	-
MGS	70	60	508.3
ICT	18	-	-
TechnoFund	286	-	-
Commercialisation			
BCG	81	64	345.5
CRDF	154	129	1211.7
TAF	30	21	294.1
Total	**4404**	**331**	**2420.0**

Source: MOSTI 2014

Commercialisation success rates had been (traditionally) higher when the grant participants were independent firms as opposed to universities, who face challenges in commercialising their products and technologies[5]. For instance, in the past one decade, the success of the Malaysian Palm Oil Board (MPOB) is attributed, partly, to the participation of the industry at earlier stage of research activities. Funding is mainly through cess – a tax on revenues from the sale of palm oil, which support the research strategies of MPOB. The MPOB's model has been successful in terms of identifying the synergies and establishing collaborations through active engagement with the industry as well as the government.

In 2008, although USM's Institute for Research in Molecular Medicine (USAINS)[6] generated RM2.8 million in sales of IP consultancy, the overall commercialisation rate is low or limited among universities and GRIs (Chandran 2010). However, universities which specialise in specific fields or sectors have reported high commercialisation potential especially in the areas of medical and health, ICT, agriculture, industrial equipment and electronics (Figure 2-9).

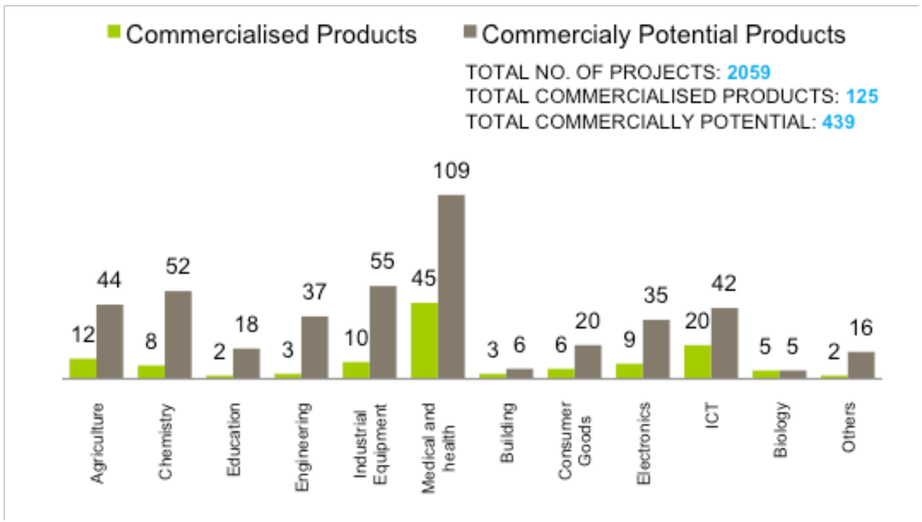


Figure 2-9. Fields of commercialisation by universities
Source: MOHE 2011

While R,D&C Continues to be Pivotal in Meeting the STI Objectives, Are There Any Gaps Which Can Be Converted Into Opportunities?

Malaysia has relatively low R&D investments (RM10.6 billion or 1.13% GERD/GDP in 2012) when compared to the average R&D spending of the G20 countries, which is 2.04%. In Malaysia, the average R&D spending consists of 0.08% of GDP spent by governments, 0.73% of GDP invested by the private sector and a further 0.32% of GDP from other sources (Figure 2-10).

To illustrate, even a developed country such as the UK spends 1.7% of their GDP on research. And, this is considered below average by most international measures, whereas South Korea is far ahead with 4.4% of their GDP. Conversely, in most countries, the private sector makes the larger contribution to R&D, but there are exceptions to the rule, for example Brazil and Argentina.

Moving forward, there is an opportunity for Malaysia to seek private sector funding to support the nation's R,D&C initiatives and programmes as evidenced by the data. It is also important to acknowledge that there is a direct correlation between R&D investment and commercialisation success rates.

[5] Based on interviews
[6] USAINS is active in IP creation and product development; forming a viable working model on how the Technology Transfer Office (TTO) should work. Established 15 years ago with the aim of revenue generation, USAINS today generates up to RM1 million in funding annually, supporting 30% of the university's operations.

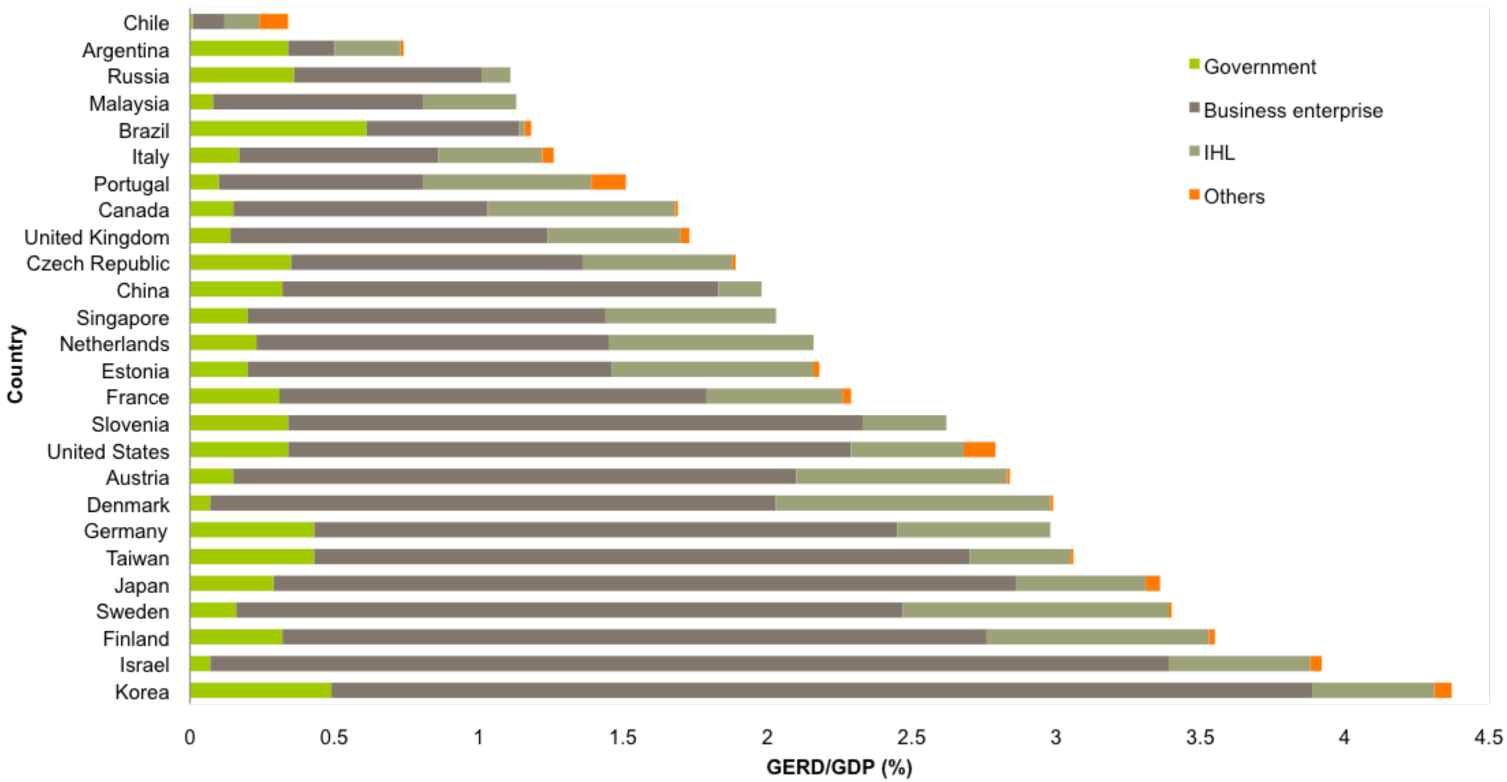


Figure 2-10. GDP invested in scientific research (%), 2012
Note: The vertical depth of the bars represents the countries' GDP, a measure of total national economic output. The width of the bars represents the percentage of that GDP invested in research and development (R&D). That means that the area of each block is proportional to the overall spending on research. The graph is divided into spending by governments, private businesses and other sources.
Sources: MASTIC 2014; OECD.StatExtracts 2014; Scienceogram 2013

However, in the existing scenario, there is also a mismatch between the number of researchers and the amount of funding (Figure 2-11), especially in the GRIs. This could also be a deterrent to the private sector funding meaningful research.

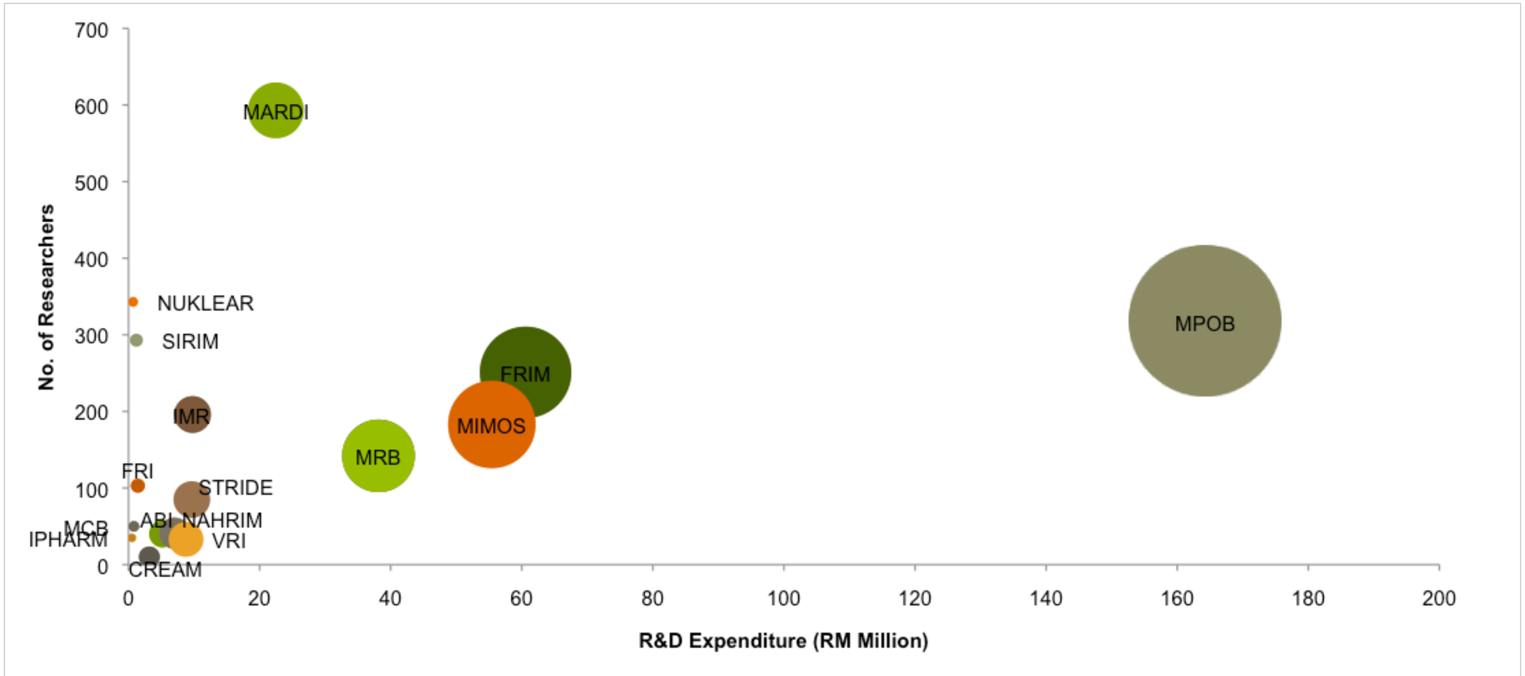


Figure 2-11. R&D expenditure and researchers, 2011
Note: Size of bubble reflects the relative size of R&D expenditure for 2011
Source: NSRC 2013

In terms of R&D fund allocation, the burning question that warrants attention is whether Malaysia should continue to place high focus on applied research without the active participation of industry alongside GRIs and PRIs, unlike Taiwan and South Korea where they leverage on strong ties between industry, GRIs and PRIs.

Despite the fact that fundamental research drives applied research, the majority of researchers are involved in applied research. This could be attributed to their poor understanding and low success rate (only 20%)[7] of applications for fundamental research in Malaysia, in addition to the high amount of funding channelled into applied research. However, it is important to note that the MOE is currently driving fundamental research to provide solutions for the industry in the form of commercialisation of ideas and technology. The Ministry has made RM1.25 billion from R&D product commercialisation in the past five years (through five research universities), exceeding their target of RM20 million by 2020.

Even in applied research, due to diversification of R&D funding and allocation, the budgets are assigned to a greater number of research projects, leaving little or no room to create enough pool or economies of scale (masses) in specific sectors or fields of research. This poses a challenge to sustain the research while the grant recipients and applicants themselves do not have access to comprehensive information[8]. The management, administration and coordination of the funds are also believed to be an issue due to the involvement of multiple agencies in Malaysia.

Typically in Malaysia, the progress of R&D is only monitored across a five-year cycle. Long-term research project continuity may not be a priority. In the 10MP (2011-2015), R&D activities are treated as a rolling plan[9], creating uncertainty among GRIs[10]. Research activity planning in the early stages is hampered given the short-term treatment of R&D activities, and may not necessarily reach the commercialisation stage.

In the previous Malaysia Plans, fund allocations were streamlined as a response to poor rates of commercialisation and return on investment (Table 2-4). Commercialisation rate takes into account the number of projects that have successfully generated sales revenue over the total number of projects for the respective Malaysia Plan. Less than 5% of public projects funded have been commercialised (Thiruchelvam 2013). For instance, in 2010, Malaysia's public universities commercialised 3.2% of R&D grants given by the Government. In most industries, 3,000 raw ideas are needed to produce one successful industrial product that can be commercialised (Stevens & Burley, 1997). Hence, given this ratio, MOSTI's current target of commercialising 60 products every year[11], with approximately 300-400 patents a year (Figure 2-7), seems to be rather idealistic in it forecast target.

Table 2-4. Commercialisation rate of R&D from 6MP to 9MP

Malaysia Plan	Commercialisation Rate (%)
6MP & 7MP	*5.1*
8MP	*3.4*
9MP	*8.0*

Source: Chandran 2010; MOSTI 2014

The 9MP also saw funding allocation specifically for ideation, R&D, pre -commercialisation and commercialisation, making it more comprehensive across all levels of R&D. Nevertheless, there has been no seamless process to allow a research project to move from one stage of funding to another. Records show that only 2% of the projects managed to move between different stages[12]. There is also a significant gap between the pre-commercialisation and commercialisation stages, as they are managed by different government entities.

What does not help the situation is the poor participation of the business sector, which otherwise can help strengthen the R&D output due to its commercial intent and application. Malaysia's business sector R&D expenditure per GDP was 0.7% in 2012, as compared to Singapore (1.4%), Korea (3.1%) and Taiwan (2.3%) (Figure 2-12).

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[7] Based on interview with MOE

[8] Through interviews, it was observed that researchers and industry face difficulty in comprehending all the existing schemes and grants. This also explains why the take up rate for some of the incentives and grants is low.

[9] R&D is treated as a 2-year plan. Funding for the 10MP is a rolling plan (a plan that has a cycle of two years).

[10] Based on interviews with GRIs.

[11] In the latest 2015 Budget, the Government has set a target for MOSTI to commercialise 360 high-impact innovative products within the next five years (The Government of Malaysia 2014).

[12] Based on interviews with fund managers.

Besides, R&D investment in the manufacturing sector is more skewed towards specific industries such as electronics and automotive (Table 2-5) and is mainly driven by foreign firms (Chandran et al. 2012). Such firms dominate in areas such as network and wireless technology, and sensors and server technology, compared to local firms that primarily invest in palm oil R&D. GRIs in Malaysia tend to invest more in fields dominated by foreign firms.

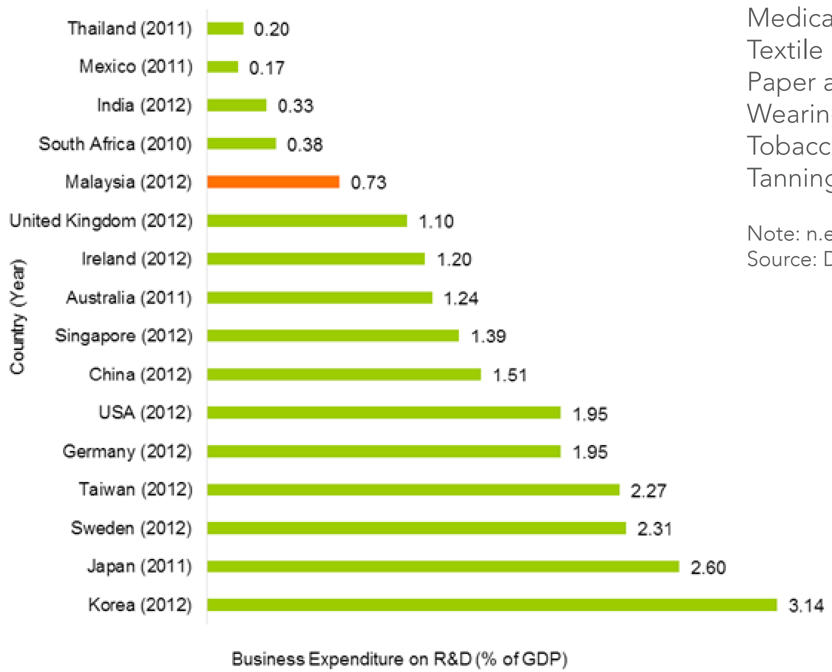


Figure 2-12. Business expenditure on R&D (% of GDP), 2012 or the latest available year
Source: IMD World Competitiveness Online (IMD 2014a)

Table 2-5. R&D spending by manufacturing sectors in RM ('000), 2011

Radio, Television and Communication Equipment	1,108.80
Office Accounting And Computing Machinery	292.94
Other Transport Equipment	130.31
Machinery and Equipment n.e.c	115.56
Rubber And Plastic Product	75.40
Food products and beverages	71.48
Chemicals and chemical products	38.93
Electrical machinery and apparatus n.e.c	32.31
Other non-metallic mineral	30.68
Motor vehicles, trailers and semi-trailers	30.40
Fabricated metal products	15.28
Coke, refined petroleum	15.25
Furniture; manufacturing n.e.c	13.25
Wood and wood based products	6.53
Basic metals	6.50
Publishing, printing and media	5.10
Medical, precision and optical instruments	4.24
Textile	3.90
Paper and paper based products	2.62
Wearing apparel	2.24
Tobacco products	1.12
Tanning and dressing of leather	0.32

Note: n.e.c. stands for not elsewhere classified
Source: DOSM 2012

Way Forward: Measures To Build Capacity and Establish the Socio-Economic Impact of Malaysian R,D&C

1
Empower Proposed Centralised Body to Promote Seamless R,D&C Implementation, Management & Monitoring

Empowering a body such as the National Science Research Council (NSRC) or an Independent Research Consortium will help oversee, manage and evaluate all R,D&C budgets. Additionally, it will be possible to evaluate beyond the ROI by integrating intellectual property (IP), industry set-up, role of solution-providers, interest of researchers and project managers for sustainable R&D, with socio- economic benefits.

Such a body is also imperative for Malaysia to establish local, regional and international research networks to include industry players, world renowned research institutions and researchers to enhance capacity and capabilities to undertake more meaningful R,D&C initiatives. Mapping the R&D focus of universities, research institutions (public and private) and the industry can also be part of the scope.

Fundamentally, we also need a standardised definition and a common understanding of various stages of R,D&C, to include pre-R&D, R&D in the context of experimental, basic and applied, pre-commercialisation and commercialisation. This will help bridge the current gap in both prioritising and implementation of R,D&C.

Commercialisation of R&D by universities is also low due to lack of expertise in identifying integration of IP (IP bundling) for commercialisation. Currently, there is no centre to coordinate IP bundling across institutions. A Technology Licensing Officer (TLO) or TTO can help to strategise IPs to produce viable products for commercialisation.

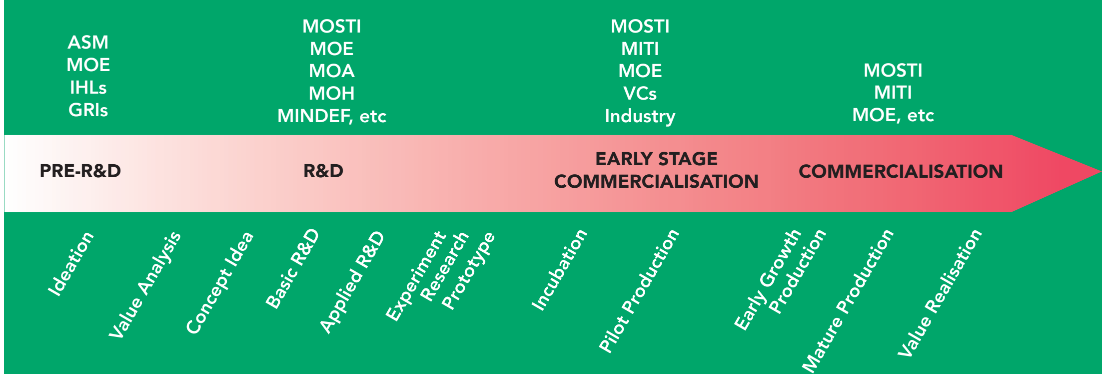


Figure 2-13. Seamless R,D&C process

2
Strategise and Focus on Effective Utilisation of GERD for Competitiveness

In view of Malaysia's ambitious GERD/GDP targets, Malaysia needs coordinated research prioritisation, capacity and strategy to ensure sustainable investments, steady industry participation and cross-pollination / partnerships amongst various R,D&C institutions.

For better planning and targeted results, empowerment of existing organisation/s for centralised funding mechanism or management is crucial. In addition, an introduction of a special purpose Ideation Fund may help evidence-based decision making, when choosing the areas of R,D&C as well as towards efficient allocation of resources to achieve optimum capacity. Similarly, more emphasis can be placed on basic research through existing institutions such as Agensi Inovasi Malaysia (AIM) and Malaysia Industry-Government Group for High Technology (MIGHT).

Further Readings

2-1 pg. 143
Challenges in commercialisation and impact assessment

2-2 pg. 144
Governance of R,D&C

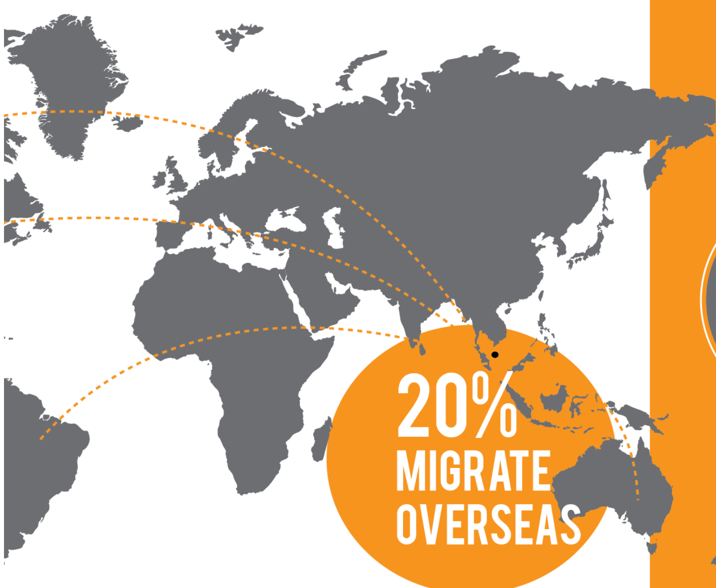
2-3 pg. 145
Correlation analysis on the drivers of publication and patent output

03

STI Talent

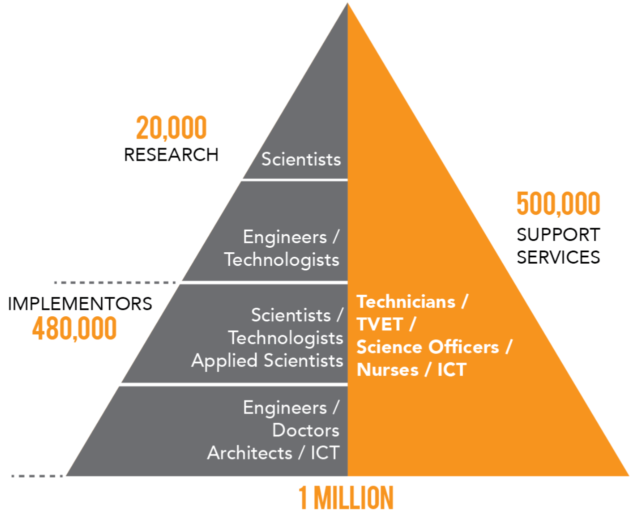
STI TALENT

DEVELOP	HARNESS	INTENSIFY
Inquiring mind & interest in S&T	Acquire scientific and / or technical knowledge, Contribute towards building an innovative society	High-level specialisation of science talent and development of expertise



ACTION

- SYSTEMATIC PLANNING & DEVELOPMENT
- BRIDGE GAP BETWEEN POLICY & REALITY
- RETAIN STI TALENT



	SCIENCE	:	NON-SCIENCE
TARGET	60	:	40
1986	31	:	69
1993	20	:	80
2001	29	:	71
2004	36	:	64
2011	44	:	56
2014	21	:	79

ENROLMENT

ELIGIBILITY

LOWBAR QUALITY TEACHING

41% DO NOT HOLD A DEGREE
37.1% SPM / STPM LEAVERS
3.8% DIPLOMA HOLDERS

70% DO NOT QUALIFY FOR DEGREE PROGRAMME

03 STI Talent

Do We Have Adequate Talent and the Right Skill-Sets to Support and Sustain STI Development?

As the Prime Minister YAB Dato' Sri Mohd Najib Tun Haji Abdul Razak highlighted, "We cannot be on the road to a knowledge intensive and innovation-led economy without talent to drive it." Duly, talent is unconditional, and most fundamental not only for the pursuit of STI targets, but to also sustain STI development and allow for an efficiency-driven economy.

Thus, while the nation continuously strives to build a high calibre and highly productive human capital base, enhancing knowledge of STEM remains a priority. It is an established view that the role and contribution of STEM is critical in addressing various economic, social and environmental issues as a result of human endeavours in promoting business, trade and industry.

In examining the operational definition of talent (as stated below), the question is – Do we have adequate talent and the right skills to support and sustain STI development?

"Human capital (or people) who are able to use their scientific, technical, conative (know-what, know-how and know-when) and life-long learning learning skills to promote under-standing of science to society; extend the boundaries of knowledge; provide pathways towards better, more sustainable life; and enhance the nation's economic growth."
(STI Talent Working Group)

This definition can be contextualised when we speak of the various indicators of a developed economy – our vision as a country – such as talent development, R&D and science and technology. Harnessing the potential of our human capital and creating a rich pool of STEM talent will also help meet the rising demand for engineers, healthcare professionals, scientists, computational experts, actuaries, geologists and other similarly specialised personnel. Such talent will fuel the priority or NKEA sectors identified by the government and positively contribute to fulfilling the ETP's objectives.

Recognising the role of talent in meeting the STI agenda, policy measures aimed at developing, harnessing and intensifying STI Talent in the country need to be adopted.

Nevertheless, before we take stock of the various initiatives and programmes that exist under each phase of the Talent Lifecycle, there may be some merit in gaining a historical perspective on STEM as part of Malaysia's evolving education system.

This will also help us understand better what it means to have a progressive educational system, a system that does not necessarily require continuously "changing" teaching methodologies or course curricula, but rather one which gravitates more students towards STEM, through early childhood orientation on STI and providing them with opportunities to participate in the country's socio-economic development through meaningful career development and placements.

Developing Talent

This phase involves the development of an ‘inquiring’ mind and interest in science & technology among pre-schoolers, which continues and intensifies at the primary, secondary and tertiary levels of formal education.

Harnessing Talent

The Talent acquires scientific and /or technical knowledge of science capital within five years of graduation and contribute towards building an innovative society.

While some talent may have already joined the workforce receiving additional training from their employers, a small percentage may be pursuing higher qualifications

Intensifying Talent

This phase involves high-level specialisation of science talent and development of expertise. Science talent may become subject matter experts with knowledge and skills that are essential for increasing productivity, efficiency and competitiveness of Malaysia in STI space.

Figure 3-1. Talent lifecycle: Operational definitions of developing, harnessing and intensifying talent

Was Malaysia's Early Education System More Effective and Amenable to Developing Talent?

Following Independence in 1957, the need for a trained workforce rose sharply for two reasons: Firstly, Malaysians had to assume greater responsibility over their nation's administrative functions; and secondly, the new country needed sustainable development with a focus on building a robust public infrastructure, primarily in sectors such as healthcare and education. The Government emphasised the need to encourage and nurture home-grown talents by offering scholarships and grants to students opting for science subjects. Public Service Department (Jabatan Perkhidmatan Awam or JPA) Scholarships, which are still offered today, successfully attract significant student populations to pursue STEM subjects.

The year 1967 was a milestone in Malaysia's history for it was when the Higher Education Planning Committee proposed a target ratio of 60:40 for science to arts students in order to meet demand. At the same time, more local public universities were also established with specialisations in S&T related fields. It was not until the year 1986, when the target ratio was formalised under a policy and action plan focusing on the development of STEM. Following the launch of the NSTP and the 5MP, science was made a compulsory subject from as early as Primary 1, beginning in 1989. Prior to this, science was a mandatory subject only from Primary 4, although in the first three years of school, students were introduced to scientific ideas via other subjects.

Despite policy measures and targets, the science to non-science student ratio dropped from 31:69 in 1986 to 20:80 in 1993 (Table 3-1). However, in the following years, the ratio showed an encouraging rise – 29:71 in 2001, 36:64 in 2004 and 41:59 in 2011. At the same time, the Government extended its scholarship programmes in the 1980s to applied sciences such as engineering, accountancy and architecture.

Table 3-1. Science to Non-Science students ratio

Year	Ratio
1986	31 : 69
1993	20 : 80
2001	29 : 71
2004	36 : 64
2011	44 : 56

Source: MOE 2012

In 1999, another significant change was introduced to enhance the effectiveness of teaching and learning science through the Assessments of Science Process Skills (*Penilaian Kemahiran Amali or PEKA*). The initiative was premised on the understanding that practical science classes strengthen theoretical knowledge; allow students to develop psycho-motor skills and the dexterity to use tools and equipment; help establish a strong correlation between theoretical knowledge and practical applications; increase creative thinking skills and higher order thinking skills; and develop an appreciation for scientific working methods (Dikmenli 2009).

However, with PEKA, the number of contact hours for science subjects was reduced, laboratory classes were not made mandatory and the centralised practical SPM-level examinations were abolished. This led to low interest and poor attendance in labs and negatively affected the 60:40 target. Currently, only 20% of schools have science labs, many of which are poorly equipped.

Over the past decade, we have witnessed many corrective policy measures in the education system, but a game-changer was the launch of the MEB[13] which expanded the teaching time allocation for science and mathematics and emphasised practical application of knowledge through laboratory and project-based work. The MEB set out a long-term strategic direction for STEM education, with the ultimate objective of positively influencing the quality of our talent.

Various programmes are currently being implemented to develop a talent pool, beginning with the Early Childhood Care and Education Policy to meet the diverse needs of the crucial early years of newborns until the age of six. Enrolment in 2009 stood at 67% for children aged 4+ and 5+, and today stands at about 77% (MOE 2012). Under the ETP, the Government has targeted a 97% enrolment by 2020.

[13]MEB was developed after considering views and recommendations from education experts from UNESCO, the World Bank, OECD, six local universities, principals, teachers, parents, students and other members of the public from every state in Malaysia.

The private sector is also contributing to the STEM ecosystem by way of an established private education system, which today includes 6,798 pre-schools, 67 primary schools, 76 secondary schools, 22 universities, 30 college universities and 324 colleges. The new league of private schools and universities – adopting British, American or Australian curricula and boasting sizable foreign student populations from countries such as Japan, Korea, China, the Middle-East, Indonesia and Africa – is growing to ground to exposing Malaysian students to cross-cultural influences, broader horizons of knowledge and a competitive environment. Thanks to the dynamic teaching and learning milieu made possible by the private education system, an opportunity has emerged for students as well as teachers (with diverse socio-cultural backgrounds) to develop their cognitive, analytical, creative and innovative skills through interaction and the exchange of views, ideas and knowledge.

What is most encouraging is that the private centres of higher education have boosted higher education enrolments, which increased to 30% among the 18-24 age group during the 8MP. Likewise, the number of students enrolled in science and technical subjects at both the undergraduate and graduate level more than doubled (OECD 2013). Some GLCs have set up tertiary institutions of learning to train personnel in specialised disciplines to sustain the talent pool in their respective industries. For instance, Tenaga Nasional Berhad (TNB) has UNITEN, which not only offers diplomas and Bachelor's degrees in engineering, but also in finance, IT and computer science. Telekom Malaysia (TM) has also set up the Multimedia University, which offers undergraduate and postgraduate programmes in engineering, ICT, business and multimedia, while its Multimedia College offers more vocational programmes in multimedia, mobile and wireless communication, business computing and computer science. Petroliam Nasional Berhad (PETRONAS) too, has set up Universiti Teknologi Petronas in 1997 to provide industry relevant engineering and technology programmes at undergraduate and postgraduate levels.

In 2011, the MOE introduced Technical and Vocational Education and Training (TVET), with the objective of nurturing a competent and skilled technical workforce to manage, operate What is interesting in Malaysia is that a national dual training system has been incorporated into the existing vocational education. In the two-year apprenticeship programme, students spend 70-80% of their time in the workplace, gaining hands-on experience and skills, and the remaining 20-30% of the time in selected training institutions. It is expected that graduates with on-the-job exposure will be able to apply their skills immediately in the labour market and contribute towards product modernisation and innovation (OECD 2013).

Looking back at the transformational journey of Malaysia's education system in the context of promoting STEM and building STI talent, can we today claim to have the right formula or policy frameworks that will assure adequate talent and skill sets to meet our country's current and future aspirations as an innovation-led economy? Are our talents well placed in the industry to assume leadership and entrepreneurial roles which will contribute to further development of STI?

How Is Malaysia Positioned Today with its STI Talent Pool?

Despite such infrastructural and talent enhancement support from the private sector, the decision to opt for STEM-related careers is influenced by low levels of awareness of the demand for specialised talent, attractive remuneration packages and prospects for dynamic career paths. As Malaysia advances closer to 2020, a natural trend would be increasing job prospects with high-income opportunities in sectors that have traditionally relied on STEM talent as well as in emerging and high-growth areas such as biotechnology, nanotechnology and environment-related fields. Similar trends have been reported by developed nations.

According to the US Department of Commerce, not only are STEM occupations in the country are growing faster (at 17%) than others (at 9.8%), but professionals in related fields are earning more (Science Pioneers 2014). Likewise, in the UK, average salaries for graduates in science occupations are higher than that of those in non-science occupations (Sjoberg & Schreiner 2005). Therefore, there is a need to communicate the demand for science professionals as well as the financially rewarding STEM careers to the population at large. The UK has, for example, launched an integrated communications campaign to inspire students to take up science and mathematics through career case studies on popular national youth radio stations, youth websites and in youth magazines. The campaign also reaches out to parents, teachers and career professionals to encourage and advise students to pursue science and mathematics as their post-16 options (International Gas Union 2012).

Against such a positive backdrop, with proactive measures and programmes in place from both private and public sectors, what is impeding the performance and growth of the Malaysian STI talent pool?

Does Malaysia Have A Pipeline of STEM Talent and Will It Be Sufficient and Competitive Enough To Meet The Country's Future Human Capital Needs?

STEM talent in the country is harnessed and further intensified by encouraging undergraduates to pursue postgraduate studies; acquire new STEM knowledge through extensive R&D, and hopefully join the workforce in one of the identified priority sectors that thrive on innovation and creativity. ASM's study on the impact of technology upskilling on industry and economic growth in Malaysia show that improvement in technology efficiency among skilled workers, particularly, in the three sectors of the economy (financial, business, education and public services; transportation and communication; and heavy manufacturing) would have substantial positive impacts to the country in terms of welfare gain, GDP and trade balances (Further Reading 3-1).

In spite of the substantial expenditure on education, there is a shortage of skilled labour in Malaysia. Labour force participation rates by education level show that the majority of workers only have at most, a secondary school education. In 2010, unskilled workers represented more than 75% of total workers employed; those with tertiary education and applicable skills made up only a quarter of the workforce.

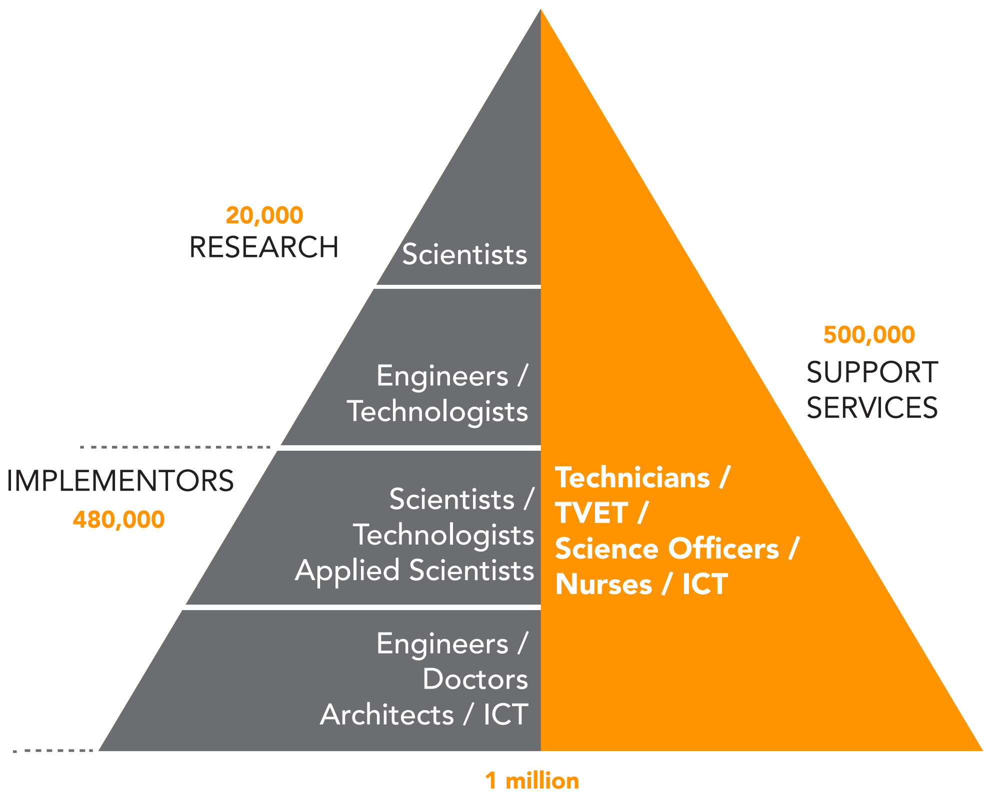


Figure 3-2. S&T human capital quantitative distributions by 2020
Source: Academy of Sciences Malaysia 2012

Only 28% of Malaysian skilled jobs are in the higher skilled bracket. Shortages in critical professions such as engineers, scientists and R&D personnel are indeed limiting the evolution of current industries (OECD 2013).

A national study, S&T Human Capital: A Strategic Planning Towards 2020 (2012) confirms that Malaysia needs at least one million S&T human capital by 2020, based on a 6% annual economic growth and the emergence of EPPs (Entry Point Projects) under the NKEAs as well as the emergence of new technology-driven sectors such as biotechnology, nanotechnology and advanced manufacturing (Figure 3-2). Of this number, 500,000 must have at least a diploma or university degree while the rest are to have completed a technical or vocational programme aimed at providing support services. At the same time, as a scientifically-driven developed nation, the ratio of researchers per 10,000 workers which currently stands at 58.2, which needs to be increased to 70 by 2020.

Skilled STEM jobs have commanded about 15% of total employment opportunities in the country over the past 10 years, from 2001-2011. Of the skilled STEM personnel, about 20% are needed in the capacity of researchers. At the current rate of student enrolment in STEM studies – both at the higher secondary and tertiary levels – the country will not have sufficient skilled personnel to drive the envisaged knowledge-driven, value-added economy.

Owing to the poor performance in S&T at the school level, the number of students opting to study science at the upper secondary and tertiary levels is also low. This may be due to factors such as the perception of unattractive career prospects in certain fields and industries, the lack of quality education offerings, unattractive STEM scholarships, etc (Table 3-2).

Table 3-2. Operational issues at tertiary education level

Issue	Description
Quality	• Low quality of matriculation / foundation students. • Matriculation/ foundation certificate not recognised. Student's highest qualification is therefore, the SPM certificate.
Incentive	• Unattractive scholarships in pursuing science at the tertiary level.
PhD	• Insufficient numbers of PhD holders to conduct research. • PhD holders do not pursue post-docs, hence inexperienced in leading/ supervising research. • Post-doc not considered an important requirement.
Programme / Organisation	• There are 15 institutions of higher learning (IHLs) (4 public and 11 private) that offer medicine and engineering but lack a science faculty. Thus, the issue here is a weak foundation.

Source: Academy of Sciences Malaysia 2012

Despite conscious efforts to promote the study of S&T, only 29% of students entering Form 4 opt to study science, and only 40% of those entering tertiary education opt for science and related programmes, including technical and vocational programmes. These figures fall very short of the Government's 60:40 target for students in S&T to those in the arts field. Furthermore, only 20% of students who enrol in tertiary education were found to actually graduate. This raises serious problems for the Government's target of producing 48,000 PhD holders by 2020 and 60,000 by 2023 under the MyBrain 15 initiative from fewer than 4,000 PhD holders in 2008, over half of whom were partly educated outside the country (OECD 2013).

Compounding to the situation is the exodus of talent. To quote the National Economic Advisory Council (NEAC 2010), "Not only is our education system failing to deliver the required talent, we have not been able to retain local talent of all races or attract foreign ones due to poor prospects and a lack of high-skilled jobs." So, can intensifying STI's brain gain and brain circulation help fill the talent vacuum created by the brain drain?

Malaysia's brain drain is quite intense, relative to a narrow skill base (World Bank 2013). In 2000, one in ten Malaysians with a tertiary degree migrated to an OECD country – that is twice the world average. It further suggests that the shrinking human capital base or the lower skill base may also have an important spillover effect on productivity growth, as innovation – one of the key driving factors of sustained productivity improvement – rests on a solid base of human capital. Talent retention, no doubt, needs a sustained exercise to position the right opportunities, as well as creating a rewarding professional environment for Malaysian talent to grow and contribute within the country.

Recognising various challenges, Talent Corporation Malaysia Berhad (TalentCorp) was established in 2011 to attract skilled Malaysians residing abroad to fill the country's growing deficits in skilled manpower (Further Reading 3-2). Competitive and attractive incentives as well as job benefits to enhance and boost local STI talents in all sectors are long overdue. But for Malaysians considering returning to Malaysia, social and governance issues such as affirmative action, government effectiveness and education quality are taken into account when making their decision. Other primary considerations include meritocracy, inclusiveness, corruption, career advancement and living conditions (The World Bank 2013).

In the current scenario, what deserves a mention is the establishment of the Institute of Labour Market Information and Analysis (ILMIA) under the Ministry of Human Resources (MOHR), in the 10MP. Among its objectives is to ensure the country's youth are guided to pursue appropriate upper secondary and tertiary academic and skill training programmes to ensure the country meets its target of having a 50% high-skilled workforce by 2020, from about 28% currently.

Are There Any Fundamental Aspects Negatively Affecting STEM Enrolment and Performance?

The current enrolment ratio for science to arts students is low when compared to the targeted ratio of 60:40. Similarly, over the last decade, while accessibility to pre-primary, primary and secondary education has increased by approximately 20%, STEM enrolment at the tertiary level has remained stagnant (UNESCO Institute for Statistics Database 2009). The low ratio indicates that the supply of human resources was not inclined towards S&T despite the introduction of appropriate policy programmes since 1967 (Table 3-3).

In addition, Malaysia's performance and scores reported in Trends in International Mathematics and Science Study (TIMMS) and Programme for International Student Assessment (PISA) have deteriorated as compared to other regional countries such as Vietnam (Further Reading 3-3). Vietnam was a star performer in the 2012 PISA, scoring higher than the OECD average in all three components of Science, Mathematics and English. The World Bank's 2013 Report highlighted some changes made to the education system in that country, which suggests some proven practices that Malaysia can adopt (Further Reading 3-4).

Hence, to explore the possible reasons for Malaysia's poor STEM orientation and average performance, we may have to look at the country's education system as a whole. Some of the key areas of concern could be highlighted as follows:

Table 3-3. Existing ratio and production rate of S&T human capital versus target

	2012		**2020**	
Level	**Ratio**	**Production Rate (Quantity/ yr)**	**Ratio**	**Production Rate (Quantity/ yr)**
Science Student in Secondary school	30%	135,000	70:100	315,000
Science Student in Tertiary education	40%	40,000	70:100	70,000

Sources: Academy of Sciences Malaysia 2012; MOSTI 2013

An absolute must to make science "exciting" for potential talent! There exists a point of view that science as a subject may not appeal or inspire the general student population, leading to a low take-up rate. The others opt for arts, technical, vocational or MLKV streams; with arts subjects being predominant. Only 21% of secondary schools nationwide attained the 60:40 of science to arts policy.

One possible explanation is ineffective teaching methodology. Malaysia, like China, adopts a theoretical approach to the teaching of science, which is textbook-based and examination-oriented. In an Advisory Report on the "Teaching and Learning of Science and Mathematics in Schools", it was found that the teaching and learning process did not contribute to the development of higher order thinking skills or critical and analytical thinking skills, thus failing to inculcate science process and manipulative skills (ASM 2010). This could also mean an absence of interaction outside of the classroom, with no practical value or application of the theory taught.

In countries that perform better in TIMSS and PISA, the teaching is based either on an inquiry approach (e.g. Canada) or a combination of inquiry and practical approaches (e.g. Australia), which involves more questioning and discussion (inquiry) as well as demonstrations and experimental investigations in real environments or industry (practical) (Further Reading 3-5). For inquiry or practical approaches, it has been argued; teachers must have the knowledge, interest and motivation to impart scientific knowledge with passion.

Another view is that ad-hoc changes in policies affect student outcomes and, as a result, their interest levels. When the language of instruction for science and mathematics in schools was changed from Bahasa Malaysia to English in 2003, the performance of Malaysian students in these two subjects dropped in both the TIMSS assessment as well as in the local Primary School Achievement Test (Ujian Penilaian Sekolah Rendah or UPSR) examination. In view of this, in 2009, the Government announced that the teaching of Science and Mathematics in English would be phased out in stages, and starting in 2012, Bahasa Malaysia would be the medium of instruction once again.

These factors at the primary and secondary school level may be dissuading the STEM talent pipeline to continue at the tertiary level and beyond. It is worth noting that the decline in interest in science is a global phenomenon but various countries have implemented action plans to curb the trend and promote interest in STEM subjects generally. For instance, the USA National Academies' Committee on Science, Engineering and Public Policy (COSEPUP) identified 10 actions that policymakers could take to enhance their S&T enterprise. These were presented in an extensive report, published in 2007, called Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. In the UK, a report by the Royal Society, Vision for Science and Mathematics Education released in 2014, made a number of recommendations towards reshaping the educational system to support the country's leadership in science and engineering.

The Bar for Teaching Talent Must Be Raised for Effective Science Education

Much of the responsibility for quality science education rests on teachers and the teaching profession. "One must ensure teachers of science of the highest quality are provided for students in primary and lower secondary schools. This is critical as attitudes toward science-based careers are formed in schools during the years when individual personality formation occurs. This is a time of intense self-reflection for young people and such attitudes are formed both consciously and subliminally. While family, peers and broad societal influences and values will always predominate, the curriculum mediated by teachers is the decisive factor in attracting interest in science and mathematics" (International Gas Union 2012).

In Malaysia, the number of teachers employed at the primary and secondary level has been increasing over the years. However, the ratio of science and mathematics teachers to students, at 1:17, is still less than half the international average of 1:8. Whether or not a better ratio will improve effectiveness is an important consideration.

Questions have also been raised as to the qualification of our science teachers, and if they are sufficiently equipped with the required knowledge and orientation for effective subject delivery. Approximately 41% of science teachers in the country do not possess a Bachelor's degree, with 37.1% holding only SPM/STPM qualifications and 3.8% holding diplomas. Additionally, a high number of teachers holding Bachelor of Education did not have the prerequisites to enter the degree programme. The requirement for the programme is to have at least three distinctions for SPM. However, 70% of those offered a place in the programme fall short of this requirement. Only 3% of the offers went to applicants considered as high-performers (World Bank 2013). This is in stark contrast with countries such as South Korea, Taiwan and Finland, where student outcomes are among the highest in the world in TIMSS and PISA.

Tap Lateral Opportunities to Build A Technical Talent Pool for the Industry

There are lateral opportunities that can be tapped to enhance the skills and competencies of the technical workforce, namely vocational and technical training programmes introduced by both private and public sector players. However, such programmes are perceived as lacking 'credentials' or the same 'credibility' as university qualifications. As a result, the take-up rate by secondary school leavers and potential technicians are rather low. For instance, statistics show that only 10% of students enrol in technical and vocational education as compared to over 18% in engineering, the latter whom are generally not trained in the maintenance of highly complex scientific instruments and machinery. Such a poor response may significantly influence Malaysia's aspiration to increase its pool of engineers and technical personnel, and shift its focus from assembly in the manufacturing sector towards higher-valued, front-end aspects such as design (OECD 2013).

According to a 2013 survey by Deloitte Consulting Malaysia, there is potential for greater industry-academia and private-public collaboration to manage issues relating to workforce shortage. 60% of the organisations admitted to not working closely with learning institutions to improve the quality and quantity of manpower supply while an even greater 68% stated that they do not work closely with government agencies/ bodies to enhance the attraction of identified critical jobs to the industry.

Countries that establish closer link between industry and academia have experienced better results in terms of graduate employment rate. In Taiwan, from 2006 to 2011, employees in STEM related industries took up more than half of the total employment. The link between industry and STEM development in the country is very high, with industry funding no less than 72.5% of the total GERD in 2011. Its industry also has strong links with universities and technical colleges in Taiwan, with some universities providing training to personnel in companies that have STEM-related businesses. Moreover, thanks to a better understanding of industrial requirements, universities are adapting their programmes to be more relevant to the workspace. For example, recognising that industry today prefers to employ engineering students with interdisciplinary knowledge, universities are promoting a more interdisciplinary curriculum with programmes such as IC design and manufacturing, electronic packaging and energy and resources.

The Burning Question Is, Are We Talent-Ready for 2020?

In meeting the target of 500,000 skilled STEM personnel by 2020, we would require a sufficient amount to not fall short of figures as compared to other developed nations. In most advanced countries, skilled STEM workers make up about 30% of the totalworkforce. In Malaysia, the targeted 500,000 skilled STEM workers would only comprise 3% of our expected total workforce of 15 million in 2020 (Table 3-4).

There are too many gaps along the entire STEM talent chain, from the secondary school level to the R&D level, to meet the requirements of 2020. According to the study, not enough students are opting for science streams at the upper secondary level and even fewer are choosing to pursue STEM studies at the tertiary level (both at universities and technical colleges). The numbers continue to dwindle at the Master's and PhD levels. To meet our 2020 STEM needs, it is estimated that we need a 0.2% increase per annum in the number of STEM diploma holders; 10-40% increase per annum in STEM degree holders; and 5-10% increase per annum in PhD holders.

The number of STEM faculty members at the IHLs as well as researchers at PRIs also needs to increase. Government-backed IHLs and PRIs need an estimated 23,000 RSEs by 2020. Based on the current rate of entry for faculty members, there will be a shortage of 18,777 faculty members in 2020. As such, the quality of STI talent or science graduates must not be overlooked in trying to build or meet the numbers. There is a need to define indicators that could measure such quality through employability rate, entrepreneurship, standards of universities and faculty etc. To summarise, there will be a significant gap in the country's STEM talent pool by 2020. Without careful and integrated planning, the country will lack the critical human resources and skills required to take it forward to 2020 (Further Reading 3-6).

Table 3-4. Talent Juxtaposition of Current and Targeted Cohort Size

Cohort	2012 (Current)		2020 (Projection)		Advanced Countries
Total Workforce (WF)	13 mil		15 mil		
Skilled WF	29%	3.48 mil	40%	6 mil (EPU & PEMANDU Projection, 2013)	
STEM WF	1%	120K	6.7%	1 mil	
Highly skilled STEM WF	0.7%	85K	3%	500K (MPKSN Projection, 1999)	30% (Average)
RSEs	58 : 10,000 WF (69K RSEs)		70 : 10,000 WF (105K RSEs)		

Source: MOSTI 2012; MOSTI 2013; MASTIC 2014b

Way Forward: Developing, Harnessing and Intensifying Talent

1

Systematic Planning and Development for STI Talent

The Human Capital Roadmap for Science and Technology 2012 – 2020 (HCRST) (Further Reading 3-7) has already been strategised and documented, which includes:

a) A strategic framework that will guide human capital development in S&T services and delivery decisions in line with the NEM of Malaysia;

b) S&T human capital goals and priorities, the determination of measurable success factors, and the identification of concrete outcomes that will drive the development of an actionable roadmap;

c) A review of the current status of people, processes, technology and culture to determine their current state and opportunities for measurable and business-aligned outcomes; and

d) The delivery of prioritised recommendations and an outlined action plan that forms the basis of a multi-year roadmap and plan that will drive measurable results.

2
Bridge the Gap Between Policy and Reality

Through a process of indepth review and analysis, there is a need to bridge the gap between policy and reality. Drastic intervention measures need to be taken at each domain of the human capital value chain in order to reach the targeted number of 500,000 skilled S&T workforce.

3
Strategise on Retaining STI Talent

Through various policy measures and incentives, there is a need to devise a 'sustainable' action plan for retaining STI Talent, especially to fuel the high-priority sectors of the economy. Such a plan could outline methodologies and criterion to identify the right talent, with the right skills and expertise, who can be incentivised with a career roadmap in the country, with opportunities created through public private partnerships.

Further Readings

3-1 pg. 146
The impact of technical / technology upskilling on industry and economic growth in Malaysia

3-2 pg. 153
The phenomenon of brain drain and the role of TalentCorp

3-3 pg. 154
Is the poor performance on various rankings and scores instrumental is dissuading public away from STEM and related subjects?

3-4 pg. 154
The Vietnamese experience

3-5 pg. 155
Approaches implemented in STEM teaching

3-6 pg. 156
Critical skill shortage, 2002 and 2007

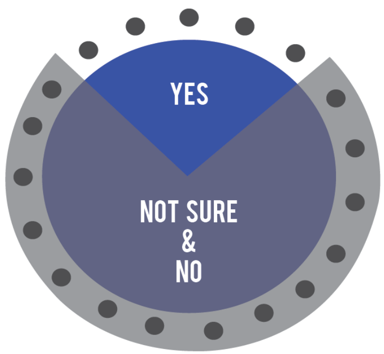
3-7 pg. 157
Human Capital Roadmap for Science and Technology 2012-2020

04

Energising Industries

ENERGISING INDUSTRIES

AWARENESS OF NATIONAL POLICIES/ INFRASTRUCTURE SUPPORTING SMEs & THE INDUSTRY TO ACHIEVE LOCAL, REGIONAL GLOBAL GROWTH



TOP THREE EXTERNAL INNOVATION INFORMATION SOURCES, 2008

1. 37.6% CLIENTS
2. 36.8% SUPPLIERS
3. 31.9% COMPETITORS

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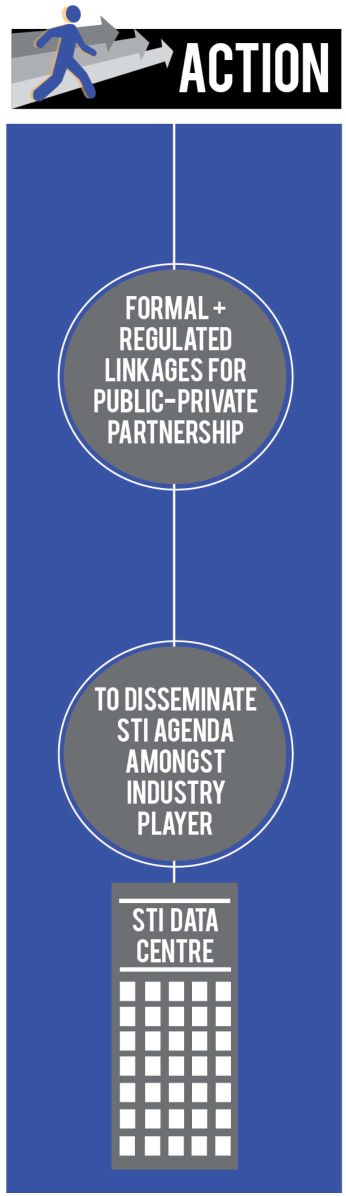
8. 16.8% UNIVERSITIES...

WITH A POTENTIAL OF INCREASE

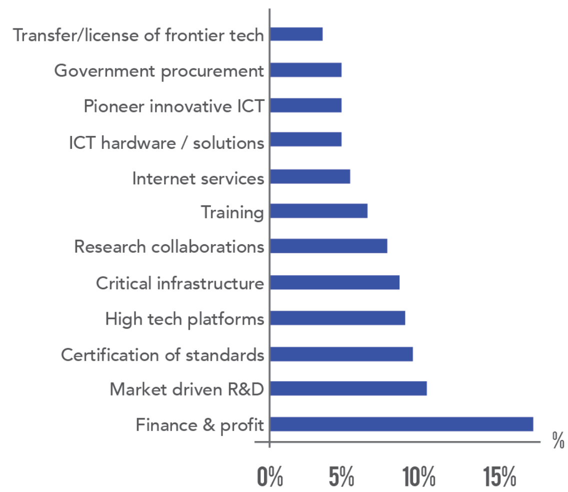


59% FIRMS HAVE A R&D UNIT

48% FIRMS HAVE THE CAPACITY TO INNOVATE

32% FIRMS USE LOCAL GOVERNMENT DATABASE TO OBTAIN STI DATA

TOP PRIORITIES THAT AIDED BUSINESS GROWTH/DEVELOPMENT



Science Outlook 2015

04
Energising Industries

Is the Industry Prepared to Collaborate or Act Independently to Tap Into the STI Potential?

It has been said that there exists limitless opportunities in every industry. Where there is an open mind, there will always be a frontier. In the context of Malaysian industry, the frontier has always been the immense potential and opportunities for growth in areas that will help position the country as a progressive nation, with the right orientation to emerge as a developed nation by 2020. STI is one of the high priority areas with defined parameters of growth in various policy frameworks[14].

The NPSTI highlights the need for energising industries to foster new economic growth, primarily through increased private sector investments and commitment to the agenda of STI. The direction is distinctive and in line with the national aspiration of creating a high-income economy led by innovation. Towards this end, the focus remains on enhancing the understanding, capability and capacity of industry for innovation. NPSTI has identified and defined 10 policy measures to energise the industries and stimulate new growth powered by STI in various forms. These include reducing the dependence of the industry players on the Government for R&D by maintaining a minimum R&D expenditure ratio between the private and public sector; enhancing industry-driven collaborations and developing enterprises with distinctive capabilities in STI.

[14]The National Innovation System; NSTP, NSTP2, NPSTI

One of the most interesting measures is also to encourage social-, grassroots- and prosumer-driven innovation. This is possible by taking an inclusive approach towards the adoption and implementation of innovation as both a tool to engage with and understand consumers and a solution for gaining a competitive edge in the global marketplace.

In driving such policy measures, the Government recognises the need to establish some clarity in defining innovation, which goes beyond R&D initiatives or high technology or patents. As the Malaysian Prime Minister (2014) once put it, "It is counter intuitive for us as a nation to associate innovation with and restrict it to just technology and R&D. Innovation is about turning a new idea into something profitable or something that creates new value." The Government continues to drive home the thought that a broader perspective on innovation is critical for industry players, in order for them to examine how their businesses can embody 'innovation' in their processes, modules and practices for greater productivity, capacity, pricing and competitiveness. As an idea and a concept, this is more appealing to the industry at large and fits their rationale of what can be termed as "business sense".

Acknowledging this fact, the Government through its innovation arm Agensi Inovasi Malaysia (AIM), launched the National Corporate Innovation Index (NCII). The NCII, with active input and participation from various industry giants, aims at developing a comprehensive, well-reasoned view of innovation investment and returns, educate the private sector community and encourage their innovation endeavours. Such initiatives reinforce the Government's commitment to promote the STI Agenda to the community of high-potential industries and energise them to meet or derive specific national development objectives.

What Are Some of The Positive Developments Towards Energising Industries Through the Set Policy Measures?

One of the key determinants towards driving or enhancing innovation is to stimulate the 'risk' appetite of the industry or entrepreneurs for greater investments in R&D and the corresponding commercialisation. Although OECD (2013) stated that only 5.5% of firms actively participate in R&D, mainly multinational corporations (MNCs), ASM Industry Perception Audit (2014)[15] found that industry (also including Small and Medium Enterprises (SMEs) preparedness in adopting technological innovation is evident in their willingness to allocate funds and undertake research, in addition to establishing external collaborations with universities and research institutes. 77% of small-size companies spend RM100,000 or lower a year for innovation (MyTIC 2012). 47.6% of the surveyed industry players highlighted their firms' capacity to innovate and produce new technologies, whereas 19.1% of them outsource the use of technology and 9.5% acquire technology in turnkey form due to their incapability to make any adaptations (Further Reading 4-1). The industry is receptive to research that provides direct solutions to their business and promises ROI, rather than supporting the knowledge-advancement and human capital development objectives of R&D.

Traditionally, the business enterprises were the largest contributor to R&D activities in Malaysia for 12 years – from 2000 to 2012. The business sector contributed 64.5% of R&D expenditure in Malaysia, in 2012, while GRIs and IHLs contributed 6.9% and 28.7% respectively (Figure 4-1). Although this is a positive trend, there is still potential for more work to be done considering the fact that the business sector takes up 92% of the total industry size (when measured in terms of GDP contribution) in Malaysia. As a benchmark, Thailand aims at increasing the proportion of its business expenditure on R&D to 70% of total spending by 2016 (National Science Technology and Innovation Policy Office). To seek greater involvement of the industry, there may be merit in understanding what really motivates the business sector or the industry players in general to significantly invest in R&D or STI initiatives.

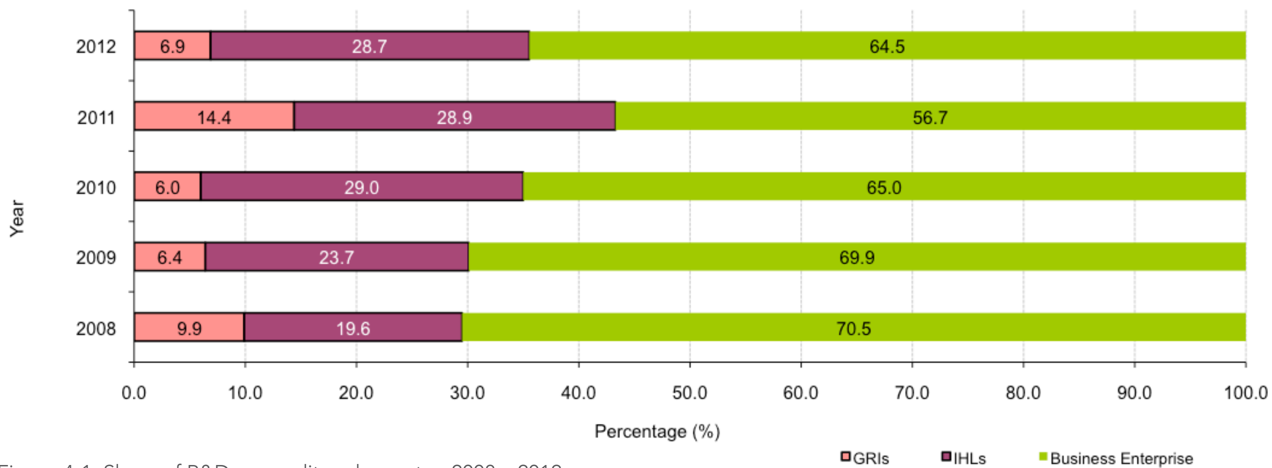


Figure 4-1. Share of R&D expenditure by sector, 2008 – 2012
Source: MASTIC 2014b

[15] Industry Perception Audit 2014, conducted for the purpose of Science Outlook Study and documented in the Conduct of the Study section

One of the primary motivating factors is availability of funds or access to public funds for R&D. According to the Economic Report 2013/2014, the Malaysian Government is committed to supporting the planning and implementation of programmes and activities that are focused on enhancing creativity and innovation. To illustrate, in 2013, the Government allocated RM600 million to five research universities to conduct high-impact research in fields such as nanotechnology, automotive technology, biotechnology and aerospace. The Government also funds research projects of national relevance and impact through various grants[16] and initiatives such as the Nation's Incubator Programme – aimed at promoting incubator activities in priority industries as per the defined NKEAs under the ETP. Funds are also channelled through various Government agencies as well as NGOs[17] that support the implementation of the innovation agenda.

For instance, the central coordination agency for all SME development in the country – SME Corp. Malaysia – and AIM jointly implement High Impact Programmes (HIPs)[18] on the Technology Commercialisation Platform to assist SMEs from the development of "Proof of Concept" to the commercialisation stage. Similarly, initiatives such as the Venture Capital Programme are also popular in the country, with 57 venture capital management companies registered in Malaysia as of August 2013 (MOF 2014). Such programmes help the industry players benefit or create value through accelerated development of products and services which make use of creative deployment of technology or innovative solutions.

Another motivating factor for the industry is the opportunity to and benefit of, co-creating STI programmes and activities in strategic collaboration with industry associations, GRIs and IHLs, with the option to share all intellectual property derived from the partnership.

While clients, suppliers and competitors were industry's main sources of information for innovative activities in 2008, there is an increasing acceptance of universities as a primary source of innovation information (Figure 4-2). It would be interesting to examine whether this upward trend intensified after the formation of the research universities in 2008.

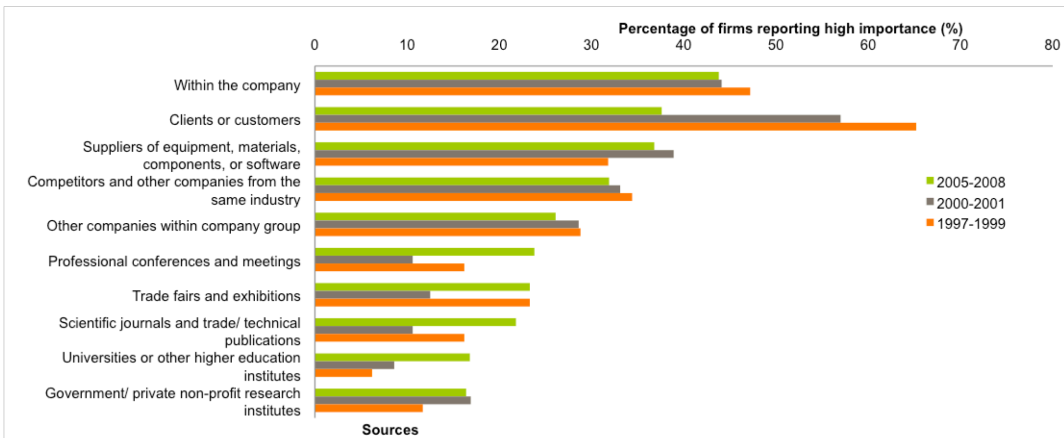


Figure 4-2. Innovation information sources
Sources: MASTIC 2001; MASTIC 2003; MASTIC 2011

[16] ScienceFund, TechnoFund, InnoFund by MOSTI; Product Development & Commercialisation Fund; Intellectual Property Financing Scheme.
[17] Agensi Inovasi Malaysia (AIM); Yayasan Inovasi Malaysia (YIM); Intellectual Property Corporation of Malaysia (MyIPO); Malaysian Association of Creativity & Innovation (MACRI); Malaysian Green Technology Corporation (MGTC); Malaysian Technology Development Corporation (MTDC); MyNIC Berhad; National Strategic Unit (NSU)
MOF amongst others.
[18] There are 32 initiatives including the six HIPs defined under the SME Masterplan (2013-2020), with an allocation of RM30 million.

Many systematic collaboration models continue to thrive in Malaysia, forging strategic linkages between industry, academia and government as well as between the public, industry and academia. One side effect of these relationships is that they positively promote various STI and related programmes. A classic example is that of the Malaysian Technology Development Corporation (MTDC), which was established in 1992 and evolved in its role to create an effective ecosystem for commercialisation of home-grown technologies through the facilitation of effective partnerships.

Another promising initiative was the Collaborative Research in Engineering, Science & Technology (CREST) in 2012, which has been entrusted with the role of an industry catalyst to devise new strategies or accelerate economic growth for the Electrical and Electronics (E&E) industry in Malaysia. The E&E sector currently contributes RM37 billion in Gross National Income (GNI), provides 522,000 jobs and is expected to contribute RM90 billion in GNI and create 679,000 jobs by 2020.

The role of CREST rests on the need to drive collaborations between industry, academia and government organisations in three key areas – R&D, talent development and commercialisation. The potential opportunities created through such partnerships go beyond mere numbers and monetary value. To date, there are a 11 MNCs, 22 local companies and 13 universities working on 59 projects, collectively valued at RM45.6 million.

In the same league, Malaysian Global Innovation and Creativity Centre (MaGIC, launched in 2013) is also on its way to demonstrate the value of industry-university collaboration in creating a new wave of entrepreneurial activities in Malaysia, while catering to the special needs of local start-up companies and initiatives.

Other collaborative models that encourage multiple stakeholders (industry, SMEs, Government, public, youth, academia, associations and NGOs) towards meaningful interaction, exchange of ideas and resources, and pragmatic STI solutions for deployment, are also present, and are led by various purpose-driven apex bodies and institutions.

Even in building and sustaining collaborations, industries are further motivated by various fiscal and financial incentives for spearheading innovation and related activities. Under the current policy framework, the Government aims at developing new approaches through various industrial policies that include incentives for enhancing STI knowledge transfer and capability development. Currently, Malaysian SMEs benefit from a host of tax exemptions and breaks, especially the high technology or emerging technology companies involved in promotion of exports, strategic knowledge-intensive activities, commercialisation of R&D findings, specialised machinery and equipment, communications, utilities and transportation, green technology sectors, etc. (National SME Development Council, 2012; The Economic Planning Unit, 2010).

Another factor for the industry is the opportunity to and benefit of, co-creating STI programmes and activities in strategic collaboration with industry associations, GRIs and IHLs, with the option to share all intellectual property derived from the partnership.

In June 2013, the Fiscal Policy Committee (FPC) was established by Bank Negara Malaysia (BNM – the Central Bank) to serve as the central policy-making committee for the formulation and implementation of fiscal strategies, with due consideration to their impact on the overall macro-economy. BNM prioritises high-impact investment projects, mainly led in collaboration with the private sector such as the broadband infrastructure and development of regional economic corridors. Incentives are also provided to help enhance the productivity of SMEs towards local, regional and global business competitiveness.

SME Corp. Malaysia and other industry bodies such as the Malaysian Industry Development Authority (MIDA) also offer grants and funds to spur new growth for the SME community pursuing technological and innovative endeavours. The focus is more towards providing solutions such as improved access to finance, advisory services, marketing, technology and ICT awareness and orientation, thereby improving SME capability and developing them into better and more profitable businesses.

There are many lessons that can be learnt from other countries such as China, India, Japan and Korea, which illustrate contrasting development strategies. For example, China has a more traditional, labour intensive export strategy, whereas India adopts a new knowledge intensive service export strategy. Industrial policy and infant industry protec tion have been important in the development of both China and India, and it can be argued that they would not be the strong global players they are today if they had not had various industrial policy interventions (Further Reading 4–2). While some of these policy-level interventions can be reviewed for adoption in Malaysia, it must be noted that industry awareness needs to be raised on the existing financial and fiscal incentives, especially for STI-driven companies and entrepreneurs.

Outside of the incentive-motivated industry environment, there also exist local industries with distinctive capabilities that need to be recognised for tapping greater STI potential. For instance, according to MIDA (2014), efforts are on to map the value chain and ecosystems for frontier industries such as the rare earth (RE) metal oxides, an industry supported by the existing policy framework, e.g. Atomic Energy Licensing Regulations 2011. In November 2014, ASM launched a Blueprint premised on the future global and regional demand for RE, which justified an investment by Malaysia to create a totally domestic rare earth supply chain. Malaysia– with its track record since the 1960s as a RE producer and exporter and host to the largest single light RE separation facility in the world – is well positioned to attract specialised refining and fabricating vendors to cover the entire spectrum of rare earth-enabled products.

Similarly, the lithium-based energy storage ecosystem is also a high potential area of focus, considering the encouraging developments in low carbon economy, green technology and renewable energy. For example, the ETP Annual Report 2012 indicated a target of manufacturing 2,000 electric buses and 100,000 electric cars by 2020. Towards this, one of the initiatives implemented under the EPP includes the setting-up of local lithium ion (Li-Ion) battery manufacturers given that the battery accounts for 40 to 60 per cent of the electric car's costs. The ultimate objective through this initiative is to help Malaysia emerge as a manufacturing and export hub for electric cars in the Association of Southeast Asian Nations (ASEAN).

When creating or building ecosystems for such industries in the future, there is a need to take a balanced approach, with equal focus on both downstream and upstream, which would mean enhancing R&D and creating a more skilled workforce in such areas. The roles of GRIs, which were established to develop new products and technology in specific fields, have to be revisited and realigned. Such an approach will encourage the creation of sustainable frontier industries or industries of the future, which will contribute to Malaysia's vision to emerge as a knowledge-intensive, innovation-driven, high-income society. In addition, the integration of special communities into the mainstream society as well as national development should be one of the core objectives of any STI policy framework.

Against this backdrop of strengths and opportunities, it is also important to take note of some obstacles and fundamental weaknesses that exist in the system based on industry data as well as the qualitative audit conducted, the following key observations were noted that effective implementation of the targets set out by the current NPSTI is negatively affected by poor orientation of the industry players towards STI. This is due to the lack of information as well as minimal industry involvement in the process of strategising national STI policies and frameworks. The issue about industry awareness is largely due to an absence of a formalised, sustainable "STI Stakeholder Engagement Model".

All the companies interviewed by ASM highlighted the fact that the industry does not have enough opportunities for conversations and engagement on STI. Limited exposure to global developments leaves industry players lacking the knowledge for them to understand, let alone embrace, the value of STI. This could be one of the primary reasons why industrial planning is not aligned with national priorities.

Those with awareness on various STI and related functions, bodies, policies and benefits, also recognise the existence of multiple lead agencies which work in isolation and affect the overall effectiveness of implementing STI policies.

In addition to the overarching NPSTI, there are at least 56 national policies that recognise the role of STI in promoting their agenda, with more than 20 ministries implementing them across the various sectors of the economy. Industry players have voiced their concerns about overlaps in addition to challenges faced when dealing with so many different agencies and learning about policies that may not even be aligned to their needs. Along with poor awareness, the industry also has an issue sourcing funds for R,D&C. What make matters worse is the absence of a centralised body or agency to keep track of funds allocated and sanctioned by various ministries (governing different sectors) for undertaking R&D and/or for implementing STI programmes and initiatives.

As per the limited information available in the public domain and Government archives, on average, RM5.38 billion has been allocated in the 9MP and 10MP towards STI programmes and initiatives. MOSTI also has several funds at its disposal for the use of industry (Further Reading 4-3). Most recently in 2014, under the auspices of the Jawatankuasa Pelaburan Dana Awam (JKPDA) – a joint secretariat between AIM and NSRC – the 1DANA Portal was launched as a central source or funding hub for public funding programmes and public R&D facilities. The portal also provides expertise based on economic growth sectors including projects that are ready to be commercialised by PRIs, GRIs and universities, as well as publicly-funded funding programmes.

One of the biggest issues Malaysia faces in terms of technology adoption and/or commercialisation is a clear gap between supply and demand. The local industry is generally trading in practice as 90% of the SMEs were concentrated in the services sector (Department of Statistics, Malaysia, 2011). Industry supports the view that many high-end services supported by high technology may not be available in Malaysia. For example, services supported by high bandwidth technology are not available in the country, unlike other developing countries where it may be used for e-learning, e-commerce, etc.

Similarly, the global standard for the commercialisation of new technology or R&D is at 10%, which has also been the benchmark here in Malaysia (Parlimen Malaysia 2011). Under the 10MP, the expectation is to hit 5% by 2015 from the 4% reported in 2011. The industry reinforces the fact that for commercialisation, adoption is the biggest barrier, although it does depend on factors such as the track record of the technology provider, its branding, aftersales service, sustainability, etc.

Likewise, there is a huge gap between the available technology and the needs of the market, which poses a challenge to indigenous innovative products or solutions. The industry promotes a view that universities and research institutes may assume that their findings are primary, but their R&D outcome is not parallel to the industry's needs and therefore, cannot be commercialised. However, the industry needs to appreciate the role of universities or RIs as solution providers, towards successful commercialisation of ideas through exchange of knowledge rather than targeting commercialisation of products and services. For instance, the revenue generated by MOE is derived from commercialisation of ideas, which is further divided into six components namely, talent, publications, intellectual property, training, consultation and contract research.

The next critical issue that needs to be resolved is the disconnected approach in the tripartite relationship between the industry, the universities and the Government. Industrial linkages are seen as a source of knowledge and a catalyst for R&D development in universities, especially for the purpose of commercialisation (Chandran et al. 2009). The Government continues to promote various university-industry linkages (Figure 4-3), with a view to facilitate meaningful exchange of information, R&D priorities, funding requirements and sustainable outcomes. Some of the institutions, which help foster such relationships or linkages include AIM, MIGHT, SME Corp. Malaysia, Platcom Ventures and MASTIC.

The Public-Private Research Network (PPRN) is another programme introduced by the Government to study the needs of the industries and resolve specific issues faced by companies in relation to application of technology. An incentive of RM50 million was introduced under this programme to promote demand-based innovative programmes. PPRN aims at establishing an ecosystem that is triple-helix in nature and knowledge-friendly, where knowledge is produced, assimilated and distributed to those companies that need it to upgrade their technologies and business models.

However, the industry holds the view that university researchers are not fully utilised in innovating products or services as they fail to properly share evidence of R&D value in order for the industry to confidently fund the proposed research. The biggest concern, as highlighted by the industry, are the review committees that approve R&D proposals (submitted under industry-university collaboration), who may not have the STI expertise to fully understand the value of the collaboration as well as the outcomes. Having said this, there is a need for evidence on how the industry has deployed its resources to promote R&D for advancement of the STI agenda as well as their own business.

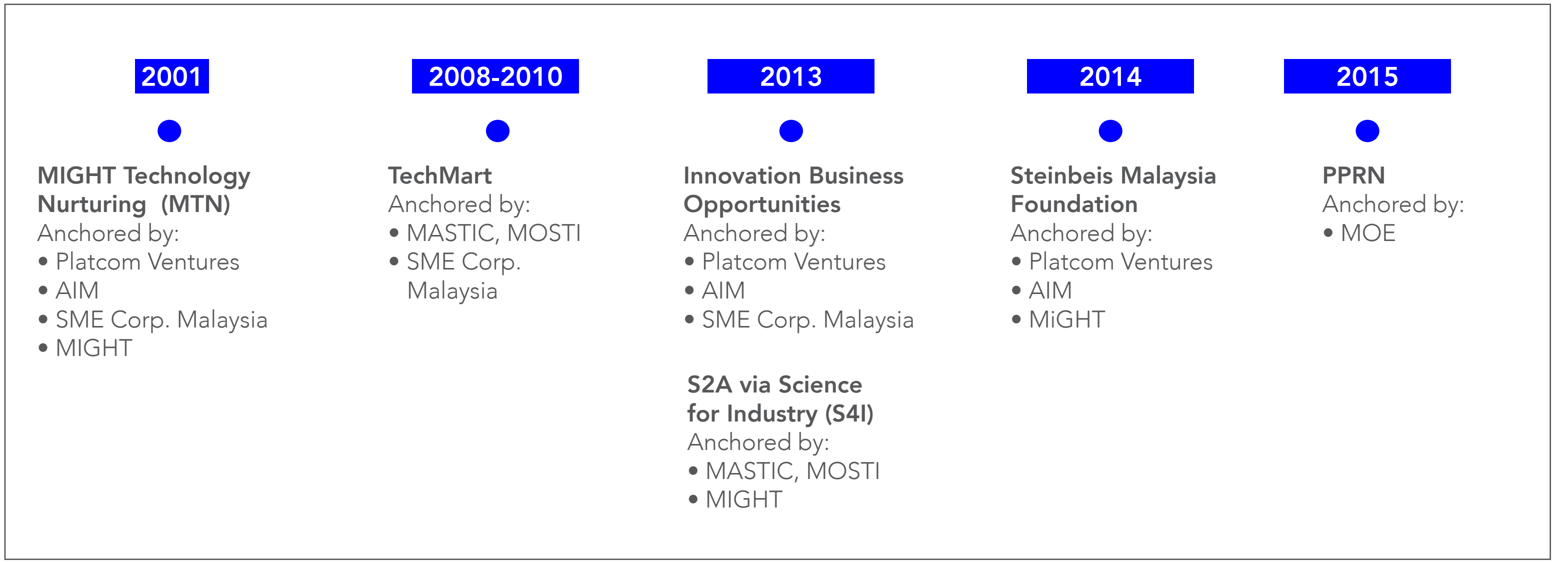


Figure 4-3. University-Industry Linkage Initiatives

Way Forward: An Ecosystem That Will Motivate The Industry to Undertake More R&D as well as to Contribute Significantly to The STI Agenda of Malaysia

1
Strategise Effective Implementation of Formal and Regulated Linkages for Public-Private Partnerships

Enable an "STI Stakeholder Engagement Model", which will not only define the "critical stakeholder universe" essential for STI policy implementation success but will also define the nature and extent of collaborations (sustainable) between the industry and other STI proponents (including academia) to meet the objectives of NPSTI through various STI Stewardship Programmes.

2
Aggressive and Seamless Information Flow to Disseminate STI Agenda amongst Industry Players

The low STI awareness amongst the industry can be due to limited opportunities for conversation / engagement on STI, limited exposure to global developments and poor knowledge to embrace the value of STI (Figure 4-4).

Question: Are you aware of any national policies / or and infrastructure that supports SMEs & the Industry to achieve local, regional and global growth?

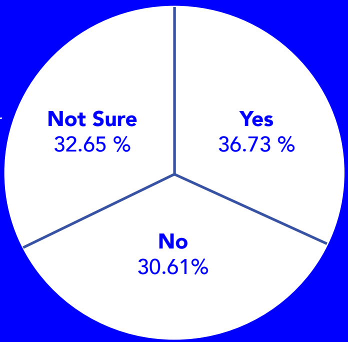


Figure 4-4. Poor awareness of STI Policies among industry players
Source: Industry Perception Audit 2014

A National STI Data Centre can help obtain and create a centralised 'knowledge repository', providing universal access to the most critical and credible Malaysian STI information (for the benefit and empowerment of the industry). Such a centre can also help synergise and coordinate all STI funds, plans, policies, and programmes across sectors, to avoid duplication of efforts and maximise output. For instance, Korea invests heavily in research infrastructures and has established the National S&T Information Service (NTIS), a centralised database on Science and Engineering (S&E) human resources and S&T infrastructure, to monitor these developments in a more efficient manner.

Besides, an awareness and enculturation campaign for the industry using appropriate and innovative ICT channels will help enhance the level of understanding as well as involvement in promoting STI agenda. The industry associations, with measurable KPIs, can educate and mobilise the industry towards creating a better STI ecosystem. This should encompass nominating industry associations as well as successful companies to represent on various policy-making committees, R&D review panels, consultation clinics of ministries etc., to make STI initiatives more relevant and measurable in terms of their impact on the industry. This could also mean establishment of a National STI Exchange Centre for the industry to cross-pollinate and tap local, regional and global growth opportunities. The industry associations can establish a modus operandi similar to the European Roundtable of Industrialists (ERT).

Drawing on the global experience of its members, ERT identifies important issues related to European competitiveness and examines how public policies could facilitate improvements. ERT makes its views known to the political decision-makers at national and European level by means of reports, position papers and face-to-face discussions. At the European level, ERT discusses its views with members of the European Commission, the Council of Ministers and the European Parliament. At the national level, members communicate ERT's views to their national government and parliament, as well as business colleagues, contacts in industrial federations, other opinion-formers and the press.

Further Readings

4-1 pg. 158
Industry perception audit key findings and ad verbatim

4-2 pg. 174
Industrial policy interventions in China, India, Japan and Korea

4-3 pg. 176
STI funds under MOSTI

05

STI Enculturation

STI ENCULTURATION

OVERALL, MALAYSIANS HAVE
HIGH INTEREST,
IN STI BUT
KNOWLEDGE IS LOW

8673
STUDENTS PARTICIPATED

93.5%
AGREED LEARNING SCIENCE IS IMPORTANT IN THEIR DAILY LIVES

88.7%
ACKNOWLEDGED LEARNING SCIENCE IS IMPORTANT IN STIMULATING THEIR THINKING

90.4%
RECOGNISED THE IMPORTANCE OF SCIENCE PROBLEM-SOLVING ABILITIES

2014 National Science Challenge

ACTION

EARLY EXPOSURE TO SCIENCE

PLAYERS IN POPULARISING SCIENCE

- Media
- Parents & society
- Government & ministries
- Scientists
- Prosumers
- Business

ENGAGE PUBLIC THROUGH MULTIPLE PLATFORMS

- Online
- Public Forum
- Mass Media

DEVELOP SCIENCE ENCULTURATION INDEX

A STRATEGIC LONG-TERM STI ENCULTURATION PLAN

POPULAR PLACES OF STI INTEREST

31%
VISITED THE ZOO

23%
VISITED THE MUSEUM

10%
VISITED PETROSAINS

7%
VISITED PUSAT SAINS NEGARA

POPULAR MEDIA FOR INFORMATION ON STI

89%

NEWS

63%

53%

05
STI Enculturation

How Exciting and Meaningful Is the STI Agenda to the Society Outside of the Science Community?

The NPSTI in its introductory chapter reported "an overarching goal of establishing a scientifically advanced and progressive society, one that is innovative and forward-looking, which is not only a consumer of technology but also a contributor to the scientific and technological civilisation of the future. It is imperative that STI be strengthened and mainstreamed into all sectors and at all levels of national development agenda. STI should be pervasive and touch the lives of every Malaysian."

The policy continues, "Inculcating a culture of STI at all levels is critical to enhance the scientific, creative and innovative thinking among Malaysians. STI should be imbued naturally and practiced. A strong commitment by the stakeholders is vital to promote, support and popularise STI programmes."

The task at hand is to acknowledge that "Science beyond Scientists" is not just a school of thought but a philosophy that can help Malaysia build a civilised society that is sensitive to various aspects of development, while the nation achieves its 2020 milestone of being a developed economy. In other words, enculturation of science in society is as critical as the application of science for development. Such a process begins with the very basic understanding of how "science" is a part of everything that we do and live with.

Universe Today, a science website dedicated to popularising science to the public, put it succinctly, "Science is everywhere in today's world. It is part of our daily lives, from cooking and gardening, to recycling and comprehending the daily weather report, to reading a map and using a computer. Advances in technology and science are transforming our world at an incredible pace, and our children's future will surely be filled with leaps in technology we can only imagine. Being 'science literate' will no longer be just an advantage but an absolute necessity. We can't escape from the significance of science in our world."

In Malaysia, many policies and programmes were implemented in the past by government and non-government bodies alike to establish the significance and promote the holistic purpose of "science". However, one of the initiatives dubbed as the "Decade of Innovation", announced by the Deputy Prime Minister on 5 November 2012, in conjunction with the 'World Innovation Kuala Lumpur Forum' in 2012, served as a spring board to gain a new perspective on science in society. The "Year of Science and the National Innovation Movement 2012" (SGI2012) was also launched with an allocation of RM100 million, accelerating efforts following other national programmes such as Innovative Malaysia 2010 and the Promotion of Science and Mathematics 2011. These programmes garnered participation and contribution not only from government agencies, but also the private sector, schools, NGOs and the public.

The journey, however, began with the creation of a "mind-set", an eco-system and a culture of "innovation" across all levels of industry and society. Towards this, the Government introduced various grants and schemes such as the Community Innovation Fund (CIF), which was aimed at encouraging transformation of knowledge or ideas into products, processes and services that will improve the socio-economic standing and quality of life of communities. Many such funds and programmes (Further Reading 5-1) continue to be instrumental in the enculturation of STI.

Overall, Malaysians were interested in STI and only a small percentage was unsure or did not know much about STI (MOSTI 2014b). Compared to the 2008 findings, the percentage of very interested responses in selected STI-related issues had more than doubled in 2014. However, in comparison to the US and EU, Malaysian respondents showed the lowest level of interest in STI issues. On average, 78% of Malaysian respondents were interested in STI compared to 89% in the USA and 83% in the EU (Further Reading 5-2).

In terms of the Malaysian public's knowledge of STI, less than half of all respondents (46%) were able to correctly answer factual knowledge in the 2014 survey. The same trend has been observed over the past 16 years (since 1998 until 2014). The public's lack of knowledge about STI may have far-reaching consequences. With fairly low STI literacy, the public might not be able to follow science news reports and participate in public discourse on STI-related issues. Where STI literacy is low, there is also a risk that policy makers might not be able to use scientific evidence appropriately in justifying their policy choice.

Despite all efforts (at both policy and grassroots levels), an important question for debate is: beyond cursory appreciation of technology in their day-to-day lives, do the various aspects of STI excite or enthuse the Malaysian society enough for greater participation in scientific endeavours?

One of the major challenges faced by developing countries such as Malaysia is making S&T an essential part of the culture of the people. Society must adopt the love of knowledge, especially science, among its people (Bhola 1989). A country's people and their histories, cultures, languages, habits and socio-economic needs must be taken into account as well. What may work for a developed country such as Finland may not be a viable solution in a developing country like Vietnam or Malaysia. Lastly, we must also review and understand the outcomes of the 60:40 strategy, which was introduced by the MOE to increase the take-up rate for science education as well as to popularise science among the student population (Further Reading 5-3).

Has the STI Enculturation Process Begun and If Yes, Is It Sustainable Enough to Create A Positive Impact on the Society as well as the Economy?

Since 2013, through the NPSTI, the Government has established the need for the following four measures to popularise STI among the public:

1. Establish an advisory body to guide STI public awareness and promotions;
2. Expand and empower science centres to popularise STI in society;
3. Promote STI among school children, professional bodies and science-oriented societies; and
4. Conduct outreach programmes to raise awareness on ethics and humanities in society.

While efforts are ongoing in each of these areas, STI Enculturation has so far produced some positive results. To illustrate, the MEB offers an honest observation of science education in Malaysia. While it acknowledges the various challenges, the MEB also reaffirms the inherent potential for Malaysia to emerge as a regional centre of excellence for quality human capital. This is evidenced by successful representation of young Malaysian talent in recent years in reputable global science-based events.

Locally, the National Science Challenge (NSC), Malaysia's premier science competition for high school students, has been successful in imparting science knowledge as well as in enhancing science exploration, innovation and communication among children and professionals. According to demographic data collected by ASM in 2014 (with respondents from 363 schools and almost 8,673 participants of the NSC), learning science was acknowledged by at least 85% of the participants as important to their daily lives and responsible for stimulating their thinking and problem-solving abilities.

In fulfilling its multiple roles as an S&T advisory body and think tank, ASM continues to promote the STI agenda through various platforms to engage and connect its fellows with media, industry as well as societies. For example, ASM (in collaboration with MOSTI) had regularised Estidotmy, a monthly science magazine published by local media publication, Utusan Malaysia between 2002 and 2012. A total of 114 editions of Estidotmy were published in the period. Assuming a 'pass-along' rate of about 2.5 readers, Estidotmy would have garnered a total readership of 99.75 million during those years.

Although Estidotmy was a strong and impactful medium, it was discontinued due to lack of funding after 2012. Similarly, the science portal ScienceBuzz was launched in 2011 to bridge the gap between scientists and society via simplified and practical notions/knowledge on 'science' in and for the society. In 2004, ASM organised the Nobel Prize Centennial Exhibition, aimed at producing Malaysian Nobel prize winners. In 2013, ASM collaborated with the Nobel Museum to organise Sketches of Science and Faces of Science, offering an opportunity to the Malaysia public to be acquainted with Nobel Laureates and local scientists.

In addition to these targeted initiatives, the Government's National Science Centre (Pusat Sains Negara – PSN) continues to attract public interest by creating an element of "fun" in the learning of science through various interactive science exhibits, programmes and activities. PSN also publishes S&T literature and acts as an adviser of informal science learning through its social service initiative, the Community Programme. It also offers the Educator Programme which sensitises the teaching community and Public Outreach Events such as PSN at the Village Programme, Science On Wheels Programme, Science Wanderer Programme, Science Camp Programme and Science On The Move Programme, amongst others. The positive impact of these platforms on STI Enculturation can be gauged by the level of community participation as well as its reach. Based on the published PSN 2011 visitor statistics, however, only 4.33% of the population was reached through PSN's two branches in the country.

In the same league is the National Planetarium, which promotes many outreach programmes targeted at schools as well as the general public. These include astronomy workshops for teachers, an Earth Hour-Night at the Planetarium, public talks and an interactive website for young children complete with educational games and content.

Another example of a common-interest enculturation platform bridging the Government, business communities and the public is Petrosains, the Discovery Centre, a science centre set up in 1999 by PETRONAS in the heart of Kuala Lumpur to promote the oil & gas industry to the young. Petrosains conducts extensive outreach programmes (including teachers' programmes), national-level competitions and a science festival benefiting communities nationwide. With a vision to "Create Wonder and Inspire People" through engaging and imaginative Experiences', Petrosains adopts strategic and structured approaches to develop interest and engagement in STEM. It serves to arouse curiosity among future generations, inspire them to ask questions, think critically and seek to discover answers to the world's intriguing mysteries via the study of science. Over the years, Petrosains has evolved into an exploratory science centre for children and adults, with over five million visitors to date (Figure 5-1). Petrosains also operates and manages other centres and organises travelling exhibitions and events with a further reach of over nine million visitors to date.

PETROSAINS

The Discovery Centre since 1999
4.59 million visitors and counting

4.07 million visitors
PETRONAS Twin Towers Visit Operation

1.17 million visitors
PETRONAS PlaySmart Centres

1.29 million visitors
PETRONAS StreetSmart

0.98 million visitors
PETRONAS DinoTrek

0.44 million visitors
Events & Programmes
Over,

12 million people reached since 1999

Figure 5-1. Petrosains The Discovery Centre
Source: Petrosains Sdn Bhd 2014

Through Petrosains' Volunteer Scheme (Further Reading 5-4), the Centre has been able to establish a successful model to engage not only science-based graduates and professionals, but also school leavers and students from various fields to work with the young and teach them about science, while at the same time, gaining confidence to be better communicators and instilling an appreciation for science as culture and as a part of everyday life. Through Petrosains and its creative programmes, PETRONAS remains committed to educating the public about science by creating excitement and arousing passion concerning the subject matter.

An equally successful model was introduced by the Penang Science Cluster (PSC), which is a home-grown, highly innovative science education non-profit organisation created to promote the value of STI amid circles of business leaders, schools, students and their parents. It aims to spark interest in S&T and create a culture of innovation and entrepreneurship among the youth of the country. For instance, in collaboration with business communities, the cluster introduced its pioneering TechMentor Program, which appoints a volunteering mentor (engineers from industry, parents and undergraduates) to some of the sponsored primary and secondary schools for a period of six months.

Apart from that, critical hardware and software are also installed (loaned) for a hands-on, inquiry based curriculum culminating in a project for the students. PSC is a good example of how dedicated teachers, business leaders and schools can come together for the love of science. The cluster also illustrates the positive role and contribution of the business communities in terms of knowledge transfer, skills and resources, as well as grants and financial support outside of the Government system for STI Enculturation.

Over the years, PSC has also institutionalised the Penang International Science Fair (PISF), where industry and organisations not only display their products but also demonstrate science and technological aspects through fun workshops for students. Such workshops, meant for hands-on S&T learning or enculturation, are also promoted through the Penang Science Cafes, which are local science community centres accessible to the public.

The good news is that many governmental and non-governmental organisations including private sector companies and individuals are actively promoting "science for society" and for national development. In many instances, these actors or proponents of STI operate on their own, while seeking funding and resources from the science coterie. Details of some of the organisations and programmes which are contributing to the critical phenomenon of STI Enculturation in the country are listed below:

- The Global Science and Innovation Advisory Council, chaired by the Prime Minister Y.A.B. Dato' Sri Mohd. Najib Tun Haji Abdul Razak, acts as a sounding board for various stakeholders to improve and optimise the country's capabilities in the field of science and innovation;
- MOSTI, the apex STI ministry, annually conducts numerous nationwide STI outreach programmes in tandem with the national STI programme; and
- The Association of Science, Technology and Innovation (ASTI) is an association of educators, scientists, industry representatives and individuals committed to advancing the role of the scientific community in inspiring the youth of the nation to join and excel in the world of science. With approximately RM2 million in funds raised annually, ASTI spearheads many outreach and educational science platforms such as the Young Inventors' Challenge, Science Fair for Young

Children, Creative and Critical Thinking Camps, etc.

- In 2014, Wencomm, a NGO dedicated to higher learning, commissioned a column entitled, Scientific Malaysian, in Nanyang Siang Pau, a leading local Chinese media publication. It was aimed at enhancing public orientation and interest in STI as well as to popularise STEM education. The column carries thought-provoking feature articles on science & life, brief news branded as Science Short Waves as well as science quizzes, puzzles and activities.
- Science publications, news and documentaries continue to be released by various industry experts, thought leaders, media and associations:
- Business FM (BFM) Radio's "The Bigger Picture" often discusses developments and issues related to social and life sciences;
- Scientific Malaysian is a non-profit initiative connecting Malaysian scientific researchers across the world to deliberate on various research issues in Malaysia and develop the networks through collaborative undertakings;
  - Constellation, an online webzine published by the International Muslim Association of Scientists and Engineers (IMASE), which aims at creating a forum for writers and academics where they can share Islamic perspectives on scientific, societal and technological development through papers, opinion articles, poetry, reports, etc.;
  - More than 30 science-based television shows are broadcasted on national and satellite television to educate

Despite These Positive Efforts, Is There Something Deeper, Something Cultural or Fundamental That Is Impeding STI Enculturation in Malaysia?

A number of STI issues were surveyed and the level of interest among the respondents varied throughout the years. Interestingly, interest in space exploration, the use of nuclear technology to generate power and the use of computer technology, increased considerably relative to the other issues. However, the following arguments suggest that such increased interest could be ephemeral:

- The heightened interest in space exploration can be attributed to the "National Angkasawan Programme" and Datuk Sheikh Muzaffar's successful spaceflight, which was given broad coverage by the media.
- There has been a steady decline of interest in environmental pollution issues, which is a cause for concern as it is a critical issue affecting the community and environment.
- The interest in computer technology may be limited to its application as a necessity in the workplace and to increase social media networks for lifestyle and entertainment reasons.

In conclusion, the data suggest that there is a relatively high level of interest in S&T amongst the Malaysian public. However this interest seems to be temporal driven by current issues, and does not translate into corresponding level of scientific literacy. This has resulted in a lack of basic S&T knowledge and skills, which could also be largely attributed to the education system.

Science Education as Enculturation: A popular view is that science education can be seen as a process of enculturation. In other words, certain policy issues related to effective and efficient science education can impede the popularisation of science.
In a published paper on the Development of Science Education in Malaysia, it was suggested that the many deliberated changes in the education system may have contributed greatly in the decline of interest in STI and/or STEM disciplines (Loke 2000). Below is the development of Science Education in Malaysia in brief:

1960s: Science was taught in subjects such as hygiene, gardening and nature studies. In 1961, the National Education Policy was created, and science was based on the Cambridge Examination Syllabus. It was still very much influenced by the British curriculum, and in 1969, the lower secondaryschools' integrated science syllabus was adapted from the Scottish Integrated Science Project.

1970s: Reviews of science education in Malaysian schools were conducted.

1980s: Malaysian primary and secondary schools were introduced to new science curricula: Alam dan Manusia (for Years 4 to 6, 1984), Kurikulum Bersepadu Sekolah Menengah (KBSM) Science in place of Integrated Science for Forms 1-3 and KBSM Kimia, KBSM Biologi and KBSM Fizik for Forms 4 and 5.

1990s: Malaysia's education underwent a democratisation with science held at the highest priority to meet Vision 2020. Kurikulum Bersepadu Sekolah Rendah (KBSR) and KBSM were reviewed, and science became a compulsory subject from Year 4 onwards.

2000 onwards: Science was being firmed as a subject for students to excel. The MEB strived to strengthen the national education system, narrow the education gap, improve the teaching profession and accelerate excellence. Yet there was a contentious moment when Science – previously taught in Bahasa Malaysia – was taught in English but this ruling was overturned in 2009.

Addressing enculturation of STI in education may be a challenge, in view of the three most fundamental questions:

1. Having well-qualified teachers may be an influencing factor but is the teaching community passionate about science and its benefits to the society as well as the nation?
2. Can successful Inquiry Based Science Education (IBSE) projects be replicated nationwide for greater impact (Further Reading 5-5)?
3. Can we attribute the student registrations for science subjects at the SPM level to their level of interest or orientation, rather than social or familial pressure, or even financial motivation such as scholarships, etc.?

In exploring proven strategies for popularising STI, a good country for Malaysia to emulate would be the US, where both the mainstream and social media continue to play a huge role in communicating the role and value of STI for development.

Through online platforms, public forums and mass discussions on the application of science in a person's life, through stories on scientific theories and anthologies on science, and with many role models and celebrities in the STI space, science has permeated many levels of the industry as well as society. To illustrate, the mobile application called Science Population by the American Association for the Advancement of Science presents information on global population growth and its impact on critical areas such as lifespan, education, health and economics. It also features news articles and peer-reviewed research, videos, podcasts and interactive graphs on various science-related subjects.

In the paper Popularisation of Science: Historical Perspectives and Permanent Dilemmas by Massarani and Moreira (2004), it has been noted that the public plays a role in legitimising science but all efforts will not prevail without the backing of the scientific community. The author emphasised that the popularisation of science is an activity in a permanent process of (re)construction, involving research institutions, universities, governments and the players or talent, namely scientists, communicators, journalists, researchers and students.

Way Forward: Enabling and Sustaining the Process of STI Enculturation in the Country

The establishment of a strategic, long-term STI Enculturation Plan: Institutions such as ASM can expand its role on behalf of the science community of Malaysia, to pool the resources and funds for a structured, sustainable and measurable STI Enculturation Plan, which will define the roles of multiple stakeholders and the platforms for public engagement, the frequency as well as the content to popularise science amid non-science communities.
The plan can include:

1
Early Exposure to Science in Schools
Early childhood orientation to science can help build a community of future STI enthusiasts and professionals, who will foster new growth in the STI space. In addition to Early Childhood Care and Education Policy, there is a need to intensify efforts towards making science a popular fun topic for young children through innovation programmes.

2
Popularising Science to Society Through Various Stakeholders, Influencers, Partners and Beneficiaries

i. Role of Government or Ministries: Their role is critical in introducing or enhancing various informal science-learning initiatives throughout the country. For instance, in Singapore, the Science Centre is funded by its Ministry of Education, with a mandate for all the schools to regularly visit the centre and participate in its programmes. Through various partnerships and initiatives with the private sector, schools and universities, the Government as well as the ministries can influence various policy measures to make possible highly qualified teachers, high-quality science labs, pre-school orientation on STI and scientific ambitions among students and aspiring professionals.

ii. Role of Scientists: There is an opportunity for the Malaysian science community and its advocates to engage with and influence adults to create a culture of science among the public. In Your Own Voice, an essay by actor Alan Alda for Science and The Media Report (published by the American Academy of Arts and Sciences in 2010), provides an interesting perspective on how scientists can endear themselves to the public. Alda sums it up with a simple solution – scientists should not dumb down their work, but speak as if they are conversing with a friend or their child. Scientists in Malaysia can take a proactive role as "Communicators of the Cause of Science", and meaningfully and sustainably engage the media as well as the public outside of the science community. This in itself will publicise and popularise research, scientific endeavours and achievements, as well as the socio-economic contributions of STI in a credible manner.

iii. Role of Prosumers: The producers, who are also the consumers of technology, can assume greater responsibility as ambassadors of science. For example, Phison Electronics Corporation manufactures USB flash drives, memory cards and solid-state drives (SSDs). The USB flash drives have become a ubiquitous must-have for every professional and student to store their files. Facebook founder Mark Zuckerberg has reinvented social media – creating a social media website for billions of people and with he himself as a user. Another prosumer of technology is Apple, the makers of personal computer products such as the iPad, Macbooks and iPhones. Social media is one of the main drivers of prosumer activity. It allows and encourages feedback and interaction among users and helps to build an audience. Further studies can be conducted on the various products and services acquired by prosumers to help understand the levels of acceptance or satisfaction, enabling future partnerships between researchers and prosumers.

iv. Role of Business: Outside the educational space, the business sector could also play an active role in the marketplace to create touch points through targeted programmes, allowing public access across age groups to gain exposure and interaction on various aspects of STI. For instance, a growing number of corporations are imparting quality cience education, with the objective to bridge the gap between the marginalised or underprivileged and the mainstream society, through their corporate social responsibility (CSR) platforms. Such sustainable initiatives are helping to either promote greater educational outcomes at the school level or to create a ‘science culture’ in the country, which would greatly enhance interest in STEM subjects, the performance of students academically and eventually the choices they will make with regard to their career options (Further Reading 5-6). Further studies need to be undertaken to understand the business nature of STI, by analysing the demand and supply for STI and related jobs.

3
Engaging Public through Multiple Platforms (Mass Media, Online and Forums):
Encourage Malaysian scientific communities to popularise critical science areas and share scientific theories and anthologies through online platforms, public forums and mass discussion.

To illustrate, Yates (1998) in his paper, Achieving Scientific Literacy through the Mass Media and Other Communication Technologies: A NASA Perspective discovered that science educators reported an undeniable connection between the mass media and science teaching. However, this connection is not always used to its fullest extent. The impending role of Malaysian media in influencing and promoting the success of the STI agenda amid various stakeholders needs to be appreciated to tap into its power and potential. For instance, one way of using a public medium to popularise science is by encouraging the public to watch and analyse concepts within science-fiction films, thereby providing an understanding of science as a discovery process and improving their attitudes towards science.

4
Establishing an STI Enculturation Index:
An STI Enculturation Index will help derive meaningful data, which can be used by critical influencers (such as schools, educationists, parents, industry leaders) to garner interest for STEM disciplines as well as scientific initiatives.

Further Readings

5-1 pg. 179
Funds promoting enculturation of STI

5-2 pg. 179
Public Awareness on STI

5-3 pg. 181
Strategy Report on achieving 60:40 Science / Technical : Arts Stream (60:40 Report)

5-4 pg. 182
PETROSAINS' Volunteer Scheme

5-5 pg. 183
Inquiry Based Science Education (IBSE)

5-6 pg. 183
Sustainable CSR initiatives

06

Strategic International Alliance

STRATEGIC INTERNATIONAL ALLIANCE

MALAYSIA'S STI RELATED TREATIES

BILATERAL	MULTILATERAL
113 OUT OF 949 11.9%	17 OUT OF 108 15.7%

FOCUS ON MULTILATERAL TREATIES

STRENGTH OF NETWORK COLLABORATION IN PUBLICATION AND PATENT

ACTION

INCREASE STI-FOCUSED INTERNATIONAL ALLIANCE

TARGET & IMPROVE MALAYSIA'S STI CAPABILITIES TO STRATEGIC PARTNERS

ECONOMIES WHICH HOLD POTENTIAL IN TERMS OF REVENUE CONTRIBUTIONS

MALAYSIA'S POTENTIAL STI COLLABORATORS

- Food Chemistry: Brunei, Thailand, Indonesia, Laos, Myanmar, Philippines, Cambodia
- Biotechnology: Brunei, Indonesia, Singapore
- Furniture, Games: Laos, Singapore, Thailand, Vietnam, Myanmar
- Basic Materials Chemistry: Cambodia, Singapore, Vietnam, Indonesia
- Semiconductor: Thailand, Cambodia
- Environment: Philippines, Myanmar, Laos, Indonesia, Brunei
- Computer Technology: Myanmar, Singapore, Thailand, Vietnam

06
Strategic International Alliance

Can Malaysia Tap Into Global Potential Through Strategic Collaborations in the STI Space?

The need to enhance strategic international alliances was not articulated or highlighted in the initial S&T frameworks (at least, until the current policy was introduced), as the focus has been primarily on building and strengthening national capabilities and capacity for research, technology and innovation.

However, history has witnessed Malaysia's commitment to collaborate, co-create and foster strategic partnerships for socio-economic growth through various MOUs, agreements and treaties in the S&T cooperation with high-potential partner countries. For instance, the "Look East Policy" (LEP) of Malaysia, introduced by YAB Dato' Seri Dr Mahathir Mohamad in 1982, allowed the country to forge partnerships with the likes of Japan and South Korea for the exchange of capital (both human and financial), goods and most importantly, a vision of a boundless future.

The very premise on which the LEP took flight i.e. strategic international cooperation continues to be instrumental in the cross-pollination of people, products, processes, practices and principles of governance, while helping to forge new business and trade collaborations, even in S&T space.

Malaysia has come far on its chartered development path (Figure 6-1) and is now well-positioned to strengthen bilateral relations with the region and the world through the second wave of the LEP, under the leadership of Prime Minister, YAB Dato' Sri Mohd. Najib Tun Haji Abdul Razak. The second wave will continue to attract international enterprises and resources to Malaysia under various economic partnership agreements, with emphasis on areas such as green/ emerging technologies and knowledge based high-income potential industries.

Resource Based	Basic Input Factors: - Land - Labour	1 MP 2 MP
	Basic Input Factors: - Poverty eradication via smallholders scheme in plantations	2 MP 3 MP
Production Based	Basic Input Factors: - Infrastructure - Collateralised risk-free capital - Labour	4 MP
Industrialisation & Technology	Basic Input Factors: - Aggressive Industrialisation - Advanced technology infrastructure	5 MP 6 MP 7 MP 8 MP
Innovation Led Economy	Basic Input Factors: - Creativity - High Income - Knowledge-economy - Technology - Market	9 MP 10 MP

Figure 6-1. Malaysia's charted development path.
Source: Akademi Sains Malaysia 2013

The NPSTI has defined specific KPIs to attract more foreign investments to support national STI aspirations, increase strategic collaborations in technology development as well as in priority areas with identified countries, build expertise and technological capabilities to penetrate international markets through win-win partnerships, etc. This calls for the need to tap into Malaysia's local, regional and global networks for human capital development, meaningful exchange of knowledge and technology as well as for cross-border R,D&C opportunities.

How Active Has Malaysia Been in Establishing Regional and International Cooperation?

The various prospective purposes for strategic alliance and collaboration help create interdependence between autonomous economic units, bringing new benefits to the partners in the form of intangible assets, obligating them to make continuing contributions to the partnership. For instance, Table (a) in Further Reading 6-1 describes the various alliances that are practised globally, for various purposes.

Malaysia, as a developing nation, has been a member of a number of multilateral organisations including the United Nations (UN), Organisation of Islamic Conference (OIC), Non-Aligned Movement (NAM), Commonwealth, ASEAN, Group of Seventy Seven (G77), Developing Eight (D8), Asia Middle East Dialogue (AMED), Far East Asia Latin America Cooperation (FEALAC), Indian Ocean Rim Association for Regional Cooperation (IOR-ARC), Asia Europe Meeting (ASEM) and Asia Pacific Economic Cooperation (APEC). These partnerships have helped the country to participate in various global policy deliberations, positively impacting Malaysia's position in the competitive marketplace (Ministry of Foreign Affairs Malaysia, 2014).

One can see a pattern in the bilateral treaties and MoUs established by Malaysia with 88 out of 119 countries in the form of international collaboration for co-authorship, joint-publication, registration of overseas patents and COEs (which are on the increase). To-date, 26 bilateral MoUs have been signed between the Malaysian Government and other countries for cooperation in STI such as the MoU on Science and Technology with Myanmar (2013), Mozambique (2012), Saudi Arabia (2011), the United States (2010) and Russia (2003), as well as the MoU on Marine Science with China (2009). Meanwhile, there are 87 scientific and technological cooperation agreements, which fall under the auspices of Umbrella Agreements which focal point is the Ministry of Foreign Affairs. These agreements are mainly related to the economic, scientific, technical and cultural cooperation between Malaysia and other countries (Table 6-1).

Table 6-1. Bilateral cooperation between Malaysia and foreign countries according to region

	S&T Cooperation under the auspices of		
Region	Umbrella Agreement[1]	Specific S&T Affairs[2]	Total MoU/ Agreement
Americas	9	2	11
Africa	26	5	31
Asia	31	14	45
Europe	19	3	23
Oceania	2	2	4
TOTAL	87	26	113
	Non S&T-related Agreement		836
	TOTAL BILATERAL AGREEMENTS		949

Note:
[1] The focal point is MOFA.
[2] The focal point is MOSTI.
Source: MOSTI 2014; KLN 2014

Meanwhile, although Malaysia has signed 108 multilateral treaties as published by the Ministry of Foreign Affairs, only 15.7% or 17 of the treaties are STI-related (Further Reading 6-2 and 6-3).

In comparison, with ASEAN and the Emerging Economies (BRICS and MIST), Malaysia had the most bilateral treaties/ MoUs with BRICS (11 treaties) compared to ASEAN (eight treaties) and MIST (five treaties). This reflects huge potential for future collaborations and mutually beneficial exchanges of skills, knowledge and expertise.

Analysis of the socio-economic indicators shows that Malaysia is on a par with MIST and BRICS, who are also members of the G20 and comprise a mix of the world's largest advanced and emerging economies (Table 6-2). This provides an opportunity for Malaysia to identify synergistic opportunities with BRICS and MIST economies for mutual gains.

Similarly, under the ASEAN Framework Agreement on Services (AFAS), Malaysia has offered market-opening or liberalisation measures in the form of allowing the establishment of equity ownership and the presence of professionals from ASEAN countries. Once again, this is an interesting opportunity for Malaysia to build its human capital especially with the concessions under the AFAS Eight Package, which allows up to 70% foreign equity in research and development services (Further Reading 6-4). In the same league, ASEAN has also concluded a mutual recognition agreement (MRA) on engineering services in 2005, which helped create new opportunities for the exchange of talent as well as expertise among the ASEAN MRA signatory countries.

Table 6-2. Malaysia is on a par with MIST and BRICS

Indicators	BRICS	MIST	MALAYSIA
Total GDP in trillion (2012)	14.6	3.9	0.3
Average annual GDP Growth (2012)	4.3%	4.1%	5.6%
Population Median age (2010)	30	30	26
Ease of Doing Business (2012 average rank)	102	65	18
Enabling Trade Index (2012 average rank)	83	55	24

Source: Corpart 2013; EIU 2014; United Nations Statistics Division 2014; The World Bank 2012a; World Economic Forum 2012

With active interest to participate in ASEAN economic collaborations, Malaysia also gained access to one of ASEAN's largest trading partners – South Korea. Malaysia is expected to gain an advantage by tapping into South Korea's competitive sectors such as engineering and ICT in the coming years.

While Malaysia continues to prioritise the rule-based multilateral trading system under the World Trade Organization (WTO), the country is also pursuing regional and bilateral trading arrangements to complement the multilateral approach to trade liberalisation. Malaysia has concluded, signed or implemented five bilateral Free Trade Agreements (FTAs) with countries such as Japan, Pakistan, New Zealand, Chile and Australia. At the regional level, Malaysia and its ASEAN partners have established the ASEAN Free Trade Area. ASEAN has also concluded FTAs with China, Japan, Korea and India, as well as Australia and New Zealand.

Malaysia and its SMEs (through the SME Corp. Malaysia) are represented at many international platforms with ASEAN SME Working Group, APEC SME Working Group, East Asia SME Round Table Meeting (EARTM) and Standing Committee for Economic and Commercial Cooperation of the Organisation of the Islamic Cooperation (COMCEC) – all of them catalysing win-win partnerships. SME Corp. Malaysia has also been involved in various FTA negotiations with the intention to position growth appetite and potential of Malaysia's SMEs (MATRADE 2011). Hence, there is an opportunity for Malaysian SMEs to recognise and build S&T capabilities and tap into greater global potential.

What Opportunities Exist for Malaysia and Which Countries Should Malaysia Focus on for Strengthening Linkages and Establishing New Alliances?

All of the ASEAN countries except Singapore are at Stage 1 to 2 of development (Table 6-3). However, they all have high S&T capabilities, with collaborative opportunities in many areas such as electronics, biomedical science, food-biotechnology, manufacturing technology, engineering, information technology, material science, mathematics, engineering and chemistry.

Malaysia can consider establishing linkages for development of capabilities with the 59 economies which are either in transition from the efficiency-driven stage of development to innovation-driven (not unlike Malaysia) or which have matured and are already innovation-driven economies such as South Korea and Singapore. Collaborations to enhance R, D&C and talent development could be established with these countries, which have a high appetite for innovation as well as for technological development. For instance, in the past, the Economic Partnership Training Program under the Economic Partnership Agreement Malaysia -Japan (JMEPA) benefited more than 15,000 professionals and technicians in the country (SME Corp. Malaysia, 2013).

Meanwhile, looking at the network of collaboration through publications and patents in ICT and biotechnology – the two top fields which dominated R&D allocation in Malaysia over the past five years (Table 2-1) – we can see that the Malaysian network of collaboration lacks international exposure (international collaborators), a factor that may limit its potential (Further Reading 6-5).

Table 6-3. World Economic Forum's stages of development by countries

Subindex	Pillars	Economies	Stages	ASEAN	MIST	BRICS
Basic requirements	1. Institutions 2. Infrastructure 3. Macroeconomics Environment 4. Health and primary education	Factor-driven	Stage 1 (38 economies)	Cambodia Myanmar Lao PDR Vietnam		India
			Transition Stage 1-2 (20 economies)	Philippines		
Efficiency enhancers	5. Higher education and training 6. Goods market efficiency 7. Labour market efficiency 8. Financial market efficiency 9. Technological readiness 10. Market size	Efficiency -driven	Stage 2 (31 economies)	Indonesia Thailand	Indonesia	China South Africa
			Transition Stage 2-3 (22 economies)	Malaysia	Mexico Turkey	Brazil Russia
Innovation and sophistication factors	11. Business Sophistication 12. Innovation	innovation -driven	Stage 3 (37 economies)	Singapore	South Korea	

Source: World Economic Forum 2014

However, if we look at historical data in terms of research publication output, there is a trend of increasing collaborations between Malaysians and international researchers according to Thomson Reuters' Web of Science database (Figure 6-2). Prior to 2008, Malaysia collaborated mostly with China, and Japan and US remained amongst the top five countries for many years. As of 2013, Malaysia's top three country collaborators in indexed research publications are Australia, Iran and England (Figure 6-3).

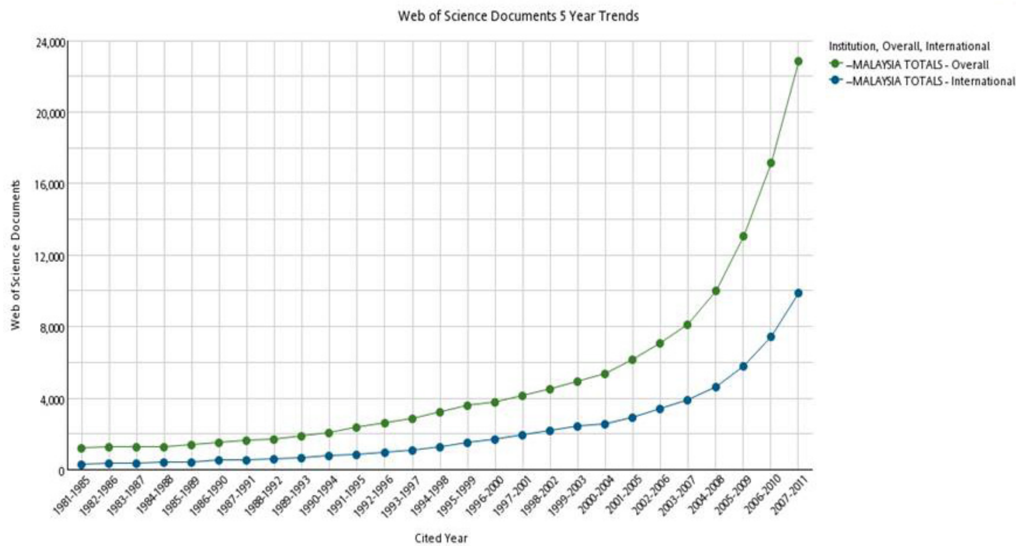


Figure 6-2. Malaysia's indexed publication collaboration trend, 1981-2011
Source: Web of Science (Thomson Reuters 2014)

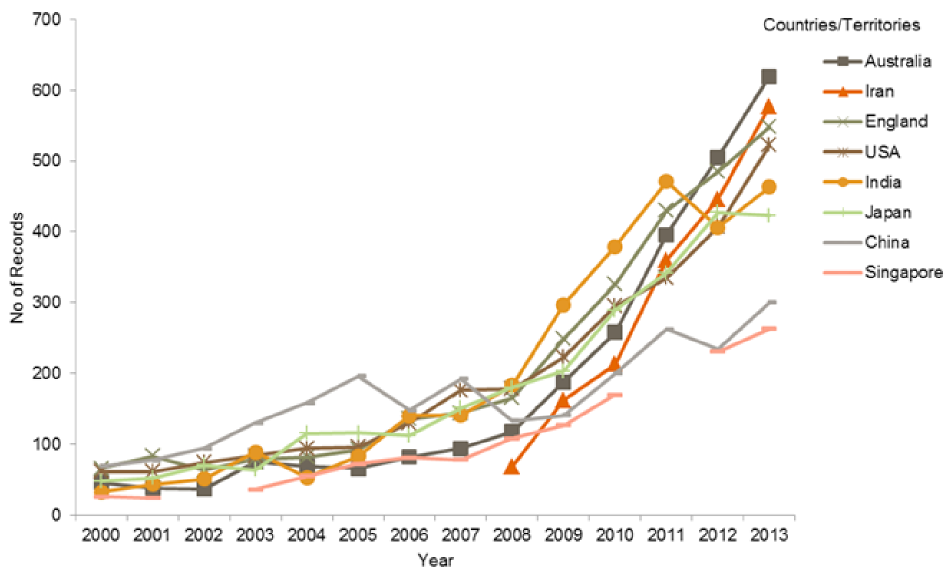


Figure 6-3. Malaysia's indexed publication collaboration by country, 2000-2013
Source: Thomson Reuters 2014

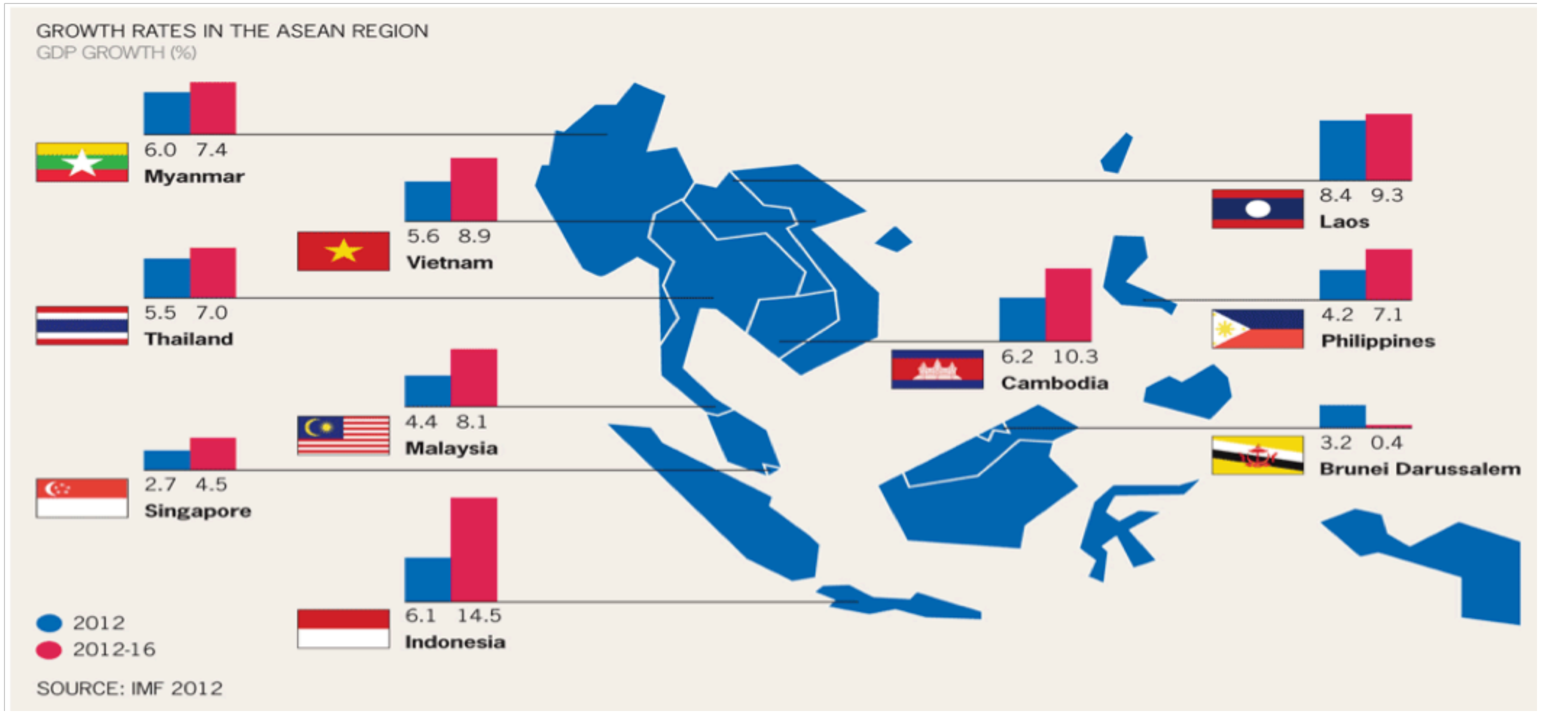


Figure 6-4. Growth rates in the ASEAN region.
Source: Grant Thornton 2012

The regional integration of the 10 ASEAN member countries into a single market under the ASEAN Economic Community (AEC) in 2015 is another big opportunity for Malaysian companies to position themselves and their competencies. With a high potential and yielding market created by the AEC that caters to a population of 600 million people, the prospects and opportunities for Malaysian industry players seem promising. According to Grant Thornton (2012), despite the slowdown in the global economy as a result of the continuing sovereign debt crisis in the Eurozone, the region is expected to grow robustly in the medium-term. In the period between 2012 and 2016, these economies are expected to expand by 10% per annum on average, which is double the rate of the global economy. This growth is expected to account for 6.5% of total global growth over the next five years, thereby increasing the share of global output for the ASEAN region to 3.9% in 2016 (Figure 6-4).

As we move towards the formation of AEC 2015, 12 broad sectors have been identified for liberalisation by ASEAN member states. These are expected to provide many STI opportunities (Table 6-5). It is also recommended that the liberalised sectors serve as a general guideline to realign the new thematic tracks of APASTI 2015 – 2020. The thematic tracks identified in the Krabi Initiative will be re-designated as strategic prospective initiatives under the expanded APASTI themes.

The ASEAN Community of Science and Technology (COST) Report (2014) highlights the various STI strengths of ASEAN countries along with their national innovation profiles, to reinforce the opportunities available for Malaysia as the AEC takes shape (Further Reading 6-6).

Beyond ASEAN, Malaysia must continue to expand its footprint as well as business networks with BRICS (Further Reading 6-7). In the past, there have been many STI-related agreements between Malaysia and BRICS, as listed in Table 6-6.

Table 6-4. AEC alignment to APASTI 2015 – 2020 and Krabi Initiative

AEC 2015 Liberalised Sectors	**APASTI 2015 – 2020 Thematic Tracks**	**Krabi Initiative Thematic Tracks**
1. Business Services 2. Educational Services 3. Tourism & Travel Related Services 4. Communication Services 5. Environmental Services 6. Recreational, Cultural and Sporting Services 7. Construction and Related Engineering Services 8. Financial Services 9. Transportation Services 10. Distribution Services 11. Health Related and Social Services 12. Other Services	1. ASEAN Innovation	• ASEAN Innovation for Global Market • Science and Innovation for Life
	2. Digital ASEAN	• Digital Economy, New Media & Social Networking
	3. Natural Resources	• Water Management
	4. Infrastructure	• Cross-cutting
	5. Food Security	• Food Security
	6. Energy & Environment	• Energy Security
	7. Biodiversity	• Biodiversity for Health and Wealth
	8. Green Technology	• Green Technology
	9. Human Capital	• Cross-cutting
	10. Medical Health	• Cross-cutting

Table 6-5. Existing STI-related agreements between Malaysia and BRICS

Brazil	• Agreement Between the Government of Malaysia and the Government of the Federative Republic of Brazil On Scientific and Technological Cooperation.
Russia	• Economic and Technical Cooperation Agreement between Malaysia and USSR. • Agreement between the Government of Malaysia and the Government of Russian Federation on Science and Technology Cooperation. • Agreement on Cultural and Scientific Co-operation Between Malaysia and USSR.
India	• Agreement on Cooperation in Science and Technology. • Agreement on Economic and Technical Cooperation.
China	• Agreement on Science, Technology and Innovation Cooperation. • Agreement on Cooperation in the Field of Marine Science and Technology. • Agreement on the Establishment of a Joint Economic and Trade Commission.
South Africa	• Memorandum of Understanding Between the Government of Malaysia and South Africa on Science, Technology, and Innovation Cooperation • Agreement Concerning Economic, Scientific, Technical and Cultural Cooperation

Source: KLN 2014

What Are Some of the Positive Developments or Trends That Will Help Forge Malaysia's International Alliances?

The Government has introduced various reward/incentive mechanisms for high-potential Malaysian companies from priority sectors with predetermined criteria, in the form of funds to build infrastructure and resources needed to forge international alliances. This will gradually evolve into a phenomenon that will help 'internationalise' the efforts and capabilities of the Malaysian industry and ultimately position Malaysia as a STI-powered economy.

Private and public universities are increasingly updating and expanding their international STI networks for meaningful exchange of knowledge, talent, resources, R&D outputs and commercialisation opportunities. However, the role of universities will need to be emphasised especially in garnering global interest in Malaysian STI endeavours as well as in creating and sustaining the STI talent pool through strategic programmes and partnerships.

During Government-to-Government (G2G) and FDI negotiations, various government agencies and proponents are building a strong case of STI-enabled companies from the identified NKEA sectors with R&D priorities, emphasising their collective potential as well as capacity to enter into strategic international alliances. Moving forward, public and private sector players will have to join forces to actively promote/communicate their STI capabilities or appetite to create a "live" ecosystem ready to be at the forefront of new economic growth.

What Are Some of the Issues in the Way of Achieving Success with International Collaborations and Initiatives?

According to MICCI 11th Malaysia Plan Submission (2014), despite all the FTAs, there is a need to establish a formal advisory process for distributing information to stakeholders regarding the benefits and opportunities arising out of such FTAs. There is also no evidence on how various multilateral agreements and MoUs are reaping benefits for Malaysia or its development objectives related to STI and other priority areas. Going forward, it is also pertinent that Malaysia focuses on identifying opportunities to establish strategic international alliances to fuel the identified NKEA sectors with quality STI talent, R,D&C funding, private sector partnerships and trade opportunities.

The submission also suggests that Malaysia should project itself as the "Employer of Choice" to attract high quality global talent to supplement the local workforce. However, one of the key issues in the acquisition of foreign talent, as highlighted in the submission, is addressing the schooling needs of the expatriates. While additional licenses have been issued for international schools, the Government should conduct a careful study on the demand requirements aligned to potential foreign investment in order to develop sufficient international schools at an affordable price.

While the exchange of STI talent or the return of Malaysian STI experts residing abroad to develop both capabilities and capacity is an option well considered by the Government, the local market or industry may not be intellectually stimulating or competitive enough to sustain the interest and employability of such a talent pool. While there are programmes designed to motivate the return of Malaysian scientists from foreign markets, the issue of the local STI ecosystem still exists, i.e. there are not enough opportunities or even a matured environment to retain such talent.

The development of knowledge and access to the front-edge of basic research could be the outcomes of Malaysian researchers' mobility in acquiring scientific and technological information. This would positively affect the connection and integration of Malaysian talent with the international S&T community. Government -sponsored talent sent overseas to acquire STI knowledge and skills must be encouraged to return to serve the STI agenda of the country.

According to Euromonitor International (2010), while the majority of Asia Pacific migrants traditionally went to the West and the Middle East, the largest migration flows are now within the region. Migration within the Asia Pacific region is characterised by the rising movement of workers from one country to another on short-term contracts as the region's labour markets have become better integrated. Likewise, the rising intra-regional migration has been driven by a growing demand for labour from the region's newly industrialised countries such as Malaysia, South Korea, Taiwan, Hong Kong and Singapore. Workers emigrate in search of higher income opportunities offered by these countries. Besides that, migrant workers play an important role in several Asia Pacific economies such as Malaysia and Singapore. Rising labour migration will improve the region's labour markets and facilitate the flow of remittances, trade and investment between different countries, thus having positive impacts on consumption and economic growth.

STI knowledge, competencies, infrastructure and funds continue to pose challenges for Malaysia in terms of forging international alliances, establishing leadership or even achieving excellence in the field. Malaysia, represented by its industry with its lack of drives, may often fail to properly position its strengths and STI value proposition for it to be considered as a potential partner by other countries. There may be a need to improve the overall image of Malaysia by nurturing STI ambassadors in the local industry, ambassadors who are able to identify, recommend and establish strategic international alliances to promote the national STI agenda. Thus, strategic alliances should not be established at the cost of undermining local capabilities, products and resources, but more to build their potential through acquisition of new skills and knowledge and further their growth aspirations.

What Lies Ahead for Malaysia in A Globalising World?

The nature of globalisation continues to evolve and change. Technology continues to enable and enhance the flow of capital, ideas and innovation in ways that are increasingly hard to anticipate. The challenge for businesses is how to monitor, evaluate and respond as rapidly and effectively as possible, to a dynamic environment that cannot be dealt with simply with an "off the shelf solution" (EY 2013).

The Globalisation Index has five measurements to assess a country's individual global ranking including: openness to global trade, global capital movements, global exchange of technology, global labour movements and cultural integration. The Index suggests that globalisation advancement will continue to be driven primarily by technology and the cross-border flow of ideas. It also highlights the improved globalisation scores in the last 12 months for medium sized rapid growth markets like Malaysia, Vietnam, Thailand and the Philippines as well as smaller European countries including Belgium, Slovakia and Hungary.

Looking at the published scores of the Globalisation Index Data Score 2014 (Further Reading 6–8), we can benchmark Malaysia's overall competitive positioning with the likes of Taiwan and South Korea and more developed nations such as Singapore and Hong Kong, with high potential opportunities for cross-border and collaborative trade, business, talent and knowledge exchanges. For instance, Hong Kong's main strength lies in the exchange of technology and ideas (5.45 points higher than the global average). Similarly, Belgium's score on exchange of technology and ideas have also improved significantly, mainly due to a deepening broadband penetration and an increase in the number of Internet subscribers.

Irrespective of the country and its size, by identifying synergies with technologically advanced, innovation powered and scientifi cally superior (in terms of knowledge and infrastructure) economies, strategic international cooperation or collaborations can be established to spur socio-economic development (Further Reading 6-9).

With Malaysia's liberalisation and regional integration for business and trade, strategic international alliances will become extremely critical to further national interests and achieve the country's aspiration to emerge as a developed economy. The successful implementation of our progressive policies will be determined by our ability to break all barriers of trade and the extent to which Malaysian industry is able to establish international partnerships to gain competitive advantages in local, regional and global marketplaces.

Way Forward: Identifying and Establishing Practical Models for Strategic International Alliances

1
Increase STI-focused International Alliances to Gain Better Benefits

i. Individual Country (Inter-Ministries)

The success of any STI initiative within a country will depend very much on the respective ministries of STI in engaging with other ministries to effect change. Based on the observations and analysis, it is proposed to partner with respective ministries from various countries and develop a comprehensive engagement plan. The intra-ministry engagement plan will serve as a starting point for internal stakeholder education on the benefits of STI and how the ministry of STI can assist in the development of those initiatives alongside the identified ministry.

ii. Intra ASEAN – MOSTI to MOSTI equivalent

Similarly, in keeping with the three primary inhibitors of STI development as faced by ASEAN (availability of human access to funding and bureaucracy), there is a need to define development strategies for Intra- ASEAN collaborations. Namely, through the setting of ambitious targets for the eight thematic tracks identified under the Krabi Initiative to be met in tandem with AEC 2025 (Global Market, Digital Society, Green Technology Food Security, Energy Security, Water Management, Biodiversity, Science and Innovation for Life)

iii. International (ASEAN-Rest of World)

The ready availability of ICT infrastructure has led to the rapid development of open-source and crowd-source solutions in many areas. These include inventions, innovation and problem solving techniques. As part of the development of international alliances with the ASEAN – Rest of World, development of comprehensive ICT and mobile engagement platforms will allow the ASEAN scientific community to efficiently and effectively engage with STI stakeholders in Malaysia.

iv. Scientists as Torch Bearers

The scientific world is becoming increasingly interconnected, with international collaboration on the rise. International or multilateral collaborations bring significant impacts that enhance the quality and efficiency of scientific research. The famed physicist Stephen Hawking once said, "Scientists have become the bearers of the torch of discovery in our quest for knowledge." Indeed, such knowledge can reside anywhere globally, which connects the science community and their endeavours. Therefore, there is a need to establish linkages and partnerships with research institutions, technology houses, innovation hubs, STEM talent and experts sitting in different parts of the world. Considering the multipolar scientific world, The Royal Society UK emphasised on the importance of multilateral collaborations in their book titled, "Knowledge, networks and nations: Global scientific collaboration in the 21st century" (Further Reading 6-10).

2
Target Strategic Partners and Improve Image of Malaysia's STI Capabilities

Collaborative partnership is a key factor in the growth of any countries. A partner can provide capital, share resources or supplement one another's expertise and strengths for their mutual benefits. Collaborative partnerships may also create significant obstacles in terms of the level of STI strengths, skilled and expert workers or different industry capabilities. Hence, it is important for Malaysia to target strategic partners such as ASEAN, BRICS and MIST, which will eventually improve Malaysia's image in STI capabilities.

Similarly, collaboration with the private sector is typically limited to areas that are of economic interest to them as investors. Beyond this, cross-border alliances with private sector to promote STI initiatives can be pushed as:

- An investment with clear economic benefits for the stakeholders involved;
- CSR; and/or
- A technology transfer programme (as part of a larger trade deal).

Further Readings

6-1 pg. 184
Types of STI centric international strategic alliance

6-2 pg. 186
List of STI-related multilateral treaties adhered by Malaysia

6-3 pg. 187
A summary of multilateral treaties by regions

6-4 pg. 188
ASEAN Framework Agreement on Services (AFAS) and Mutual Recognition Agreements (MRAs)

6-5 pg. 188
Network of Collaboration in publications and patents in ICT and biotechnology

6-6 pg. 191
ASEAN -Areas of strength in STI issues, challenges and advantages for Malaysia to explore alliances

6-7 pg. 197
Malaysia's focus outside of ASEAN

6-8 pg. 199
Globalisation index data score

6-9 pg. 199
Malaysia's potential STI collaborators

6-10 pg. 200
Reasons for Malaysia to focus on multilateral collaborations compared to bilateral

Further Readings

Further Reading 1-1

Analysis of existing national policies

Introduction

In general, STI policies are divided into:

1. policies written for STI; and
2. the use of STI for policies.

STI policies are written to deliver the support for a nation's socio-economic transformation programme. The nation's STI capacity and capability will be strengthened in terms of institutions, mandates, personnel, management, funding and linkages by introducing STI policies that are formulated to strengthen education, research and capacity building relevant to the needs of the country. In STI for policy, its components are factored into the evidence based policy formulation process to bring about national transformation.

Methodology

For the first part, 81 governmental policies were studied using a human assisted text based data mining algorithm and cross checked by a research officer. All recurring policies and its updates/variation, e.g. Dasar Otomotif Nasional 2006, 2009 and 2014, are assessed separately to identify explicit elements of S&T either as an objective or means to achieve an objective. A policy is deemed 'explicit' if it covers the use of STI to achieve the objective of the policy, the presence of research and development component in the policy or proposes research and development to achieve policy goals. Alternatively, a policy is deemed 'implicit' when statements regarding STI as a vague or general goal of the policy. Wherever available, the implementation period is identified and relevant policies are clustered according to similar themes, e.g. social policies or economic policies. The keywords used in the search are both in English and Bahasa Malaysia with selected samples in Table (a).

Policy Map Description

All of the 81 national policies examined are clustered according to science and technology, social, sports, youth, economy, governance, industry, agriculture, energy, IP, automotive, natural resources and foreign themed policies (Table (b)). The timeline is arranged in chronological order from 1988 until 2014 with milestones marked according to the Malaysia Plans (Rancangan Malaysia).

Table (a). Samples of data mining keywords used

No	Malay	English
1	Penyelidikan, selidik, kajian, tinjauan	research, study, survey, R&D
2	Teknologi, pengetahuan	technology, knowledge
3	Sains, saintifik,	science, scientific
4	Pemindahan teknologi, pemindahan pengetahuan	technology transfer, knowledge transfer
5	Pembangunan	development
6	Komunikasi, perhubungan	communication
7	Inovasi	innovation

Policy Summary / Data

Legend

- Contains explicit mention of STI
- Contains implicit or ambiguous information on STI
- Absence of STI information
- Inadequate information to sufficiently judge STI content

Table (b). Policy Summary / Data

Policies

Science & Technology

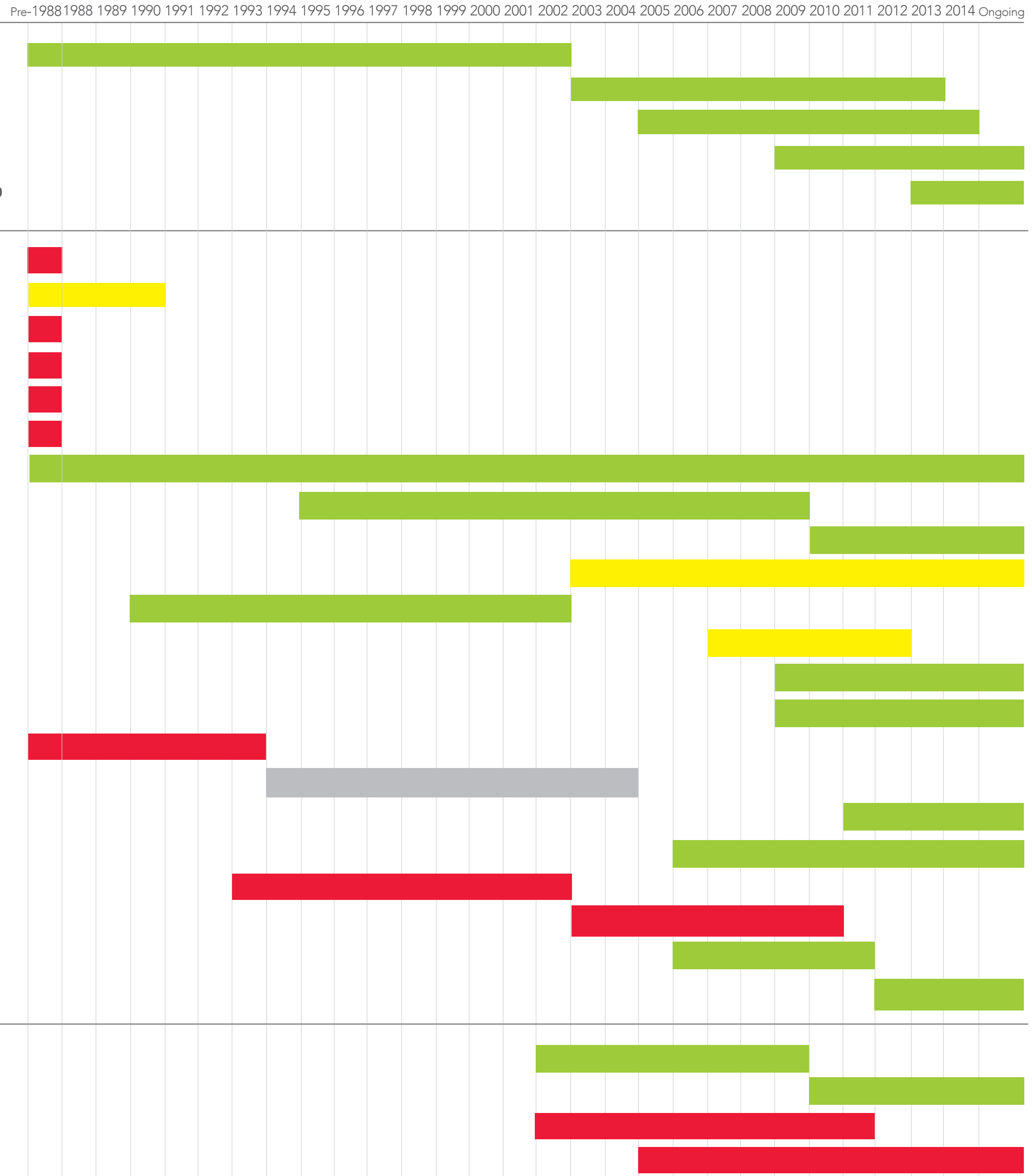
- 1st National Science and Technology Policy (STP 1) 1986
- 2nd National Science and Technology (STP 2) 2003
- National Biotechnology Policy 2005
- National Green Technology Policy 2009
- National Policy on Science, Technology & Innovation (NPSTI) 2013-2020

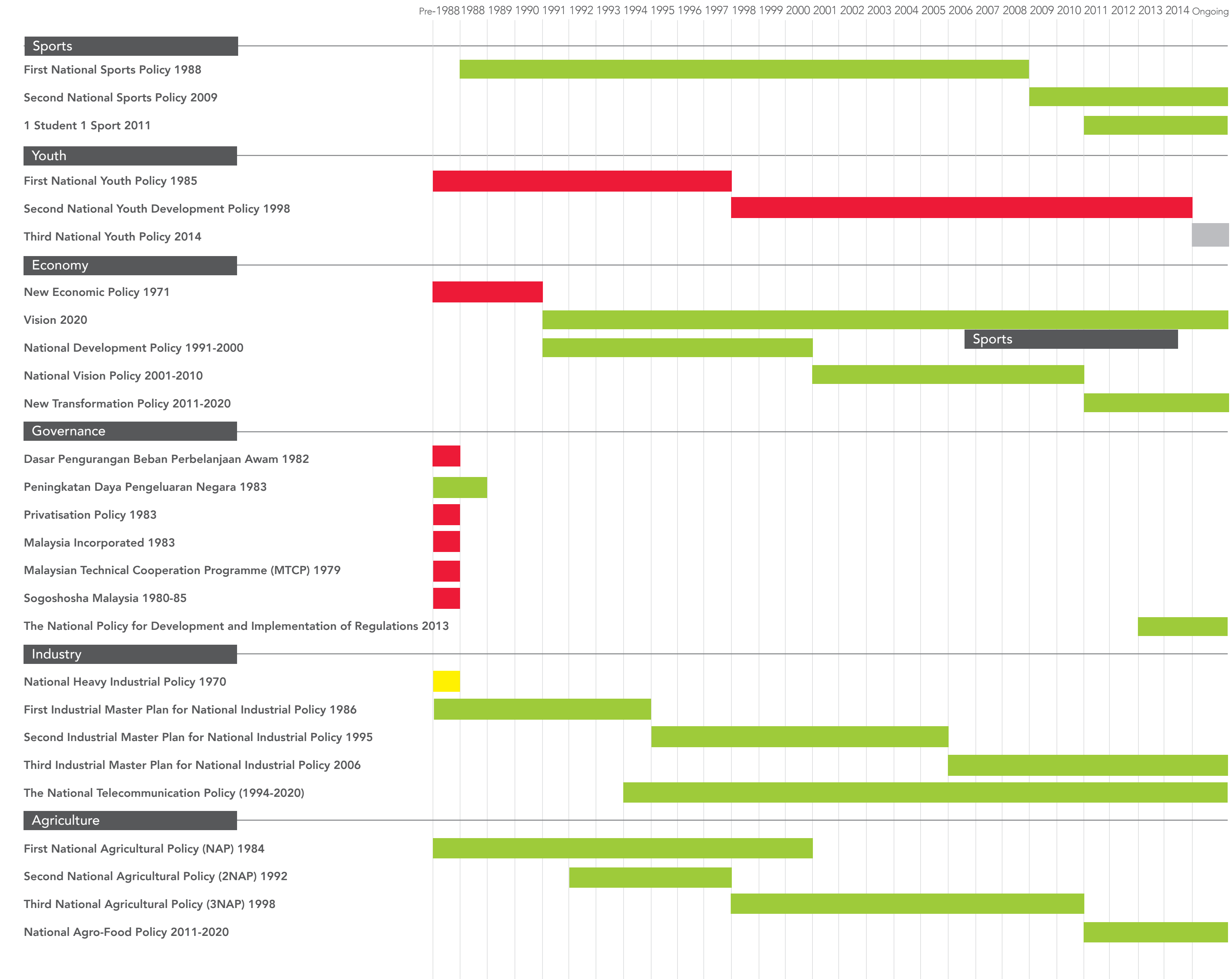
Social & Well-Being

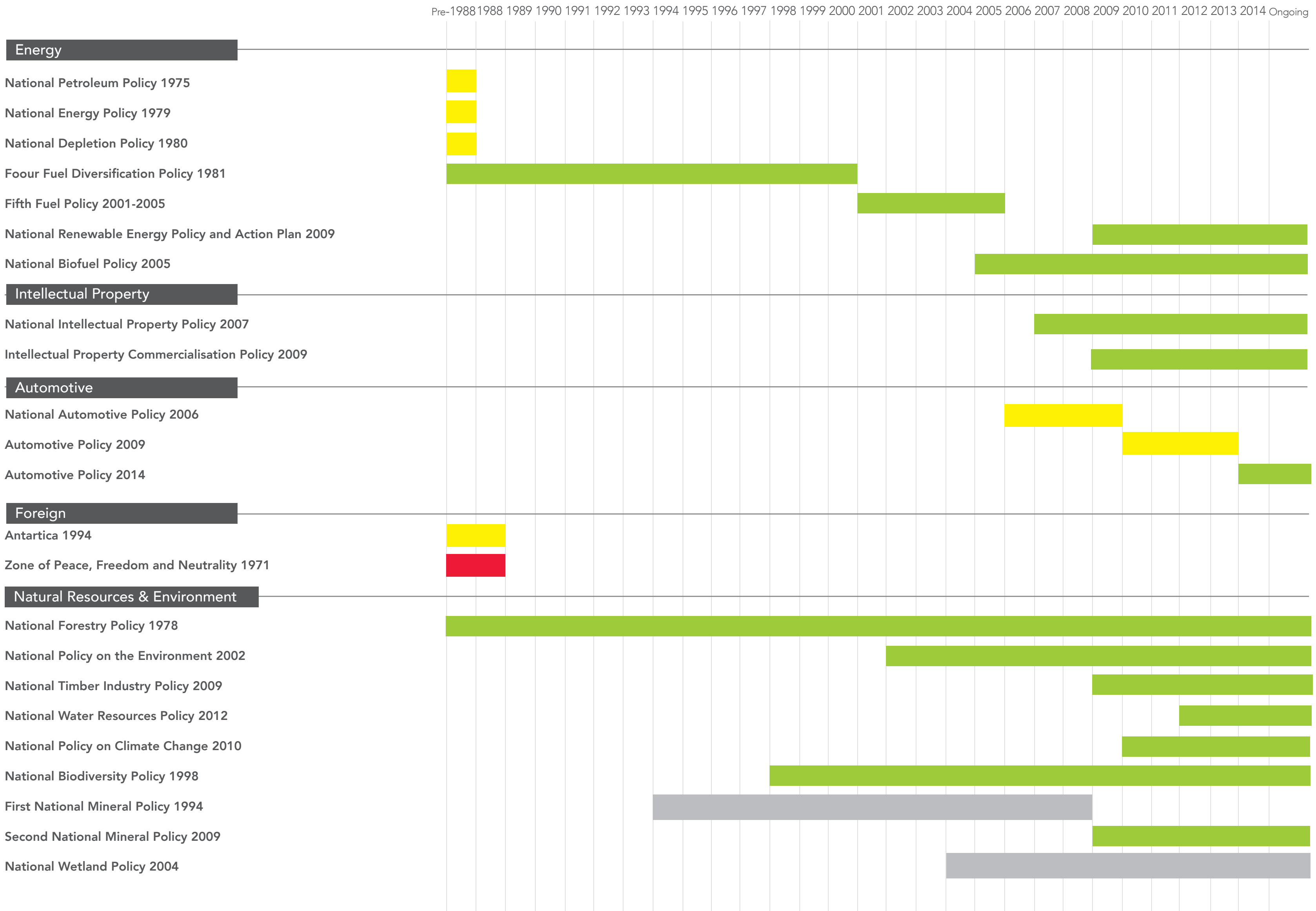
- Bersih, Cekap dan Amanah Policy 1982
- National Culture Policy 1971
- National Population Policy 1982
- Look East Policy 1982
- National Education Policy 1961
- Policy of inculcating Islamic Values 1985
- National Policy for Women 1983
- First National Policy for the Elderly 1995
- Second National Policy for the Elderly 2010
- National Social Policy 2003
- National Welfare Policy 1990
- National Policy For Persons with Disabilities 2007
- National Child Protection Policy 2009
- National Child Policy 2009
- Halacara Baru Dalam Pembangunan Kampung dan Luar Bandar 1984
- Transformasi Pembangunan Luar Bandar 1994
- National Housing Policy 2011
- National Urbanisation Policy 2006
- First National Tourism Policy (1992-2002)
- Second National Tourism Policy (2003-2010)
- First Malaysian National Medicines Policy (2006)
- Second Malaysia National Medicines Policy (2012)

Consumer

- First National Cooperative Policy 2002-2010
- Second National Cooperative Policy 2011-2020
- National Consumer Policy 2002
- Fair Trade Practices Policy 2005




Pre-1988 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 Ongoing
Sports
First National Sports Policy 1988
Second National Sports Policy 2009
1 Student 1 Sport 2011
Youth
First National Youth Policy 1985
Second National Youth Development Policy 1998
Third National Youth Policy 2014
Economy
New Economic Policy 1971
Vision 2020
National Development Policy 1991-2000
Sports
National Vision Policy 2001-2010
New Transformation Policy 2011-2020
Governance
Dasar Pengurangan Beban Perbelanjaan Awam 1982
Peningkatan Daya Pengeluaran Negara 1983
Privatisation Policy 1983
Malaysia Incorporated 1983
Malaysian Technical Cooperation Programme (MTCP) 1979
Sogoshosha Malaysia 1980-85
The National Policy for Development and Implementation of Regulations 2013
Industry
National Heavy Industrial Policy 1970
First Industrial Master Plan for National Industrial Policy 1986
Second Industrial Master Plan for National Industrial Policy 1995
Third Industrial Master Plan for National Industrial Policy 2006
The National Telecommunication Policy (1994-2020)
Agriculture
First National Agricultural Policy (NAP) 1984
Second National Agricultural Policy (2NAP) 1992
Third National Agricultural Policy (3NAP) 1998
National Agro-Food Policy 2011-2020



Note: This list is not exhaustive.

Sources: Bicquelet & Weale 2011; Conway 2006; Doubleday & Wilsdon 2013; Goodwin 2014; Grijzenhout et al. 2014; Henderson 2012; Johari et al. 1964; Kaptein & Marx 2010; Maffio 2002; Malaysia 1965; Malaysia 1971; Malaysia 1976; Malaysia 1981; Malaysia 1986; Malaysia 1991a; Malaysia 1991b; Malaysia 1996; Malaysia 2001a; Malaysia 2001b; Malaysia et al.1996; Malaysia et al. 2009; Malaysia et al. 2011; Malaysia & Kementerian Sains 1998; Malaysia & Kementerian Tenaga 2005; Malaysia & Prime Minister's Department 1976; Malaysia & Unit Perancang Ekonomi 2006; Martin 2011; Marx 2009; Marx & Aders 2010; Onyimadu et al. 2014; Razak et al. 1971; Rozenberg & Martin 2011; Russo 2011; Russo & Wiberg 2010; Salah et al. 2013; Shaikha et al. 1989; Sheate & Partidário 2010; Smith 2013; van Kammen et al. 2006; White et al. 2010

Result summation

The policies are summarised in a graphical form (Table (b)) to allow simultaneous visualisation of relevance, timeline and similarities. Analysis showed that:

1. 80% of early policies written before 1986 do not explicitly state the use of STI, or STI as an objective.
2. Several post-1986 policies do not state explicit or implicitly on STI such as:
   a. First National Tourism Policy (1992–2002)
   b. Second National Tourism Policy (2003–2010)
   c. National Consumer Policy 2002
   d. Fair Trade Practices Policy 2005
   e. National Youth Policy 1985
   f. National Youth Development Policy 1998
3. 59% of the policies explicitly states STI as an objective or means to achieve an objective [Table (c)].

Conclusion

Though Malaysia has had STI policies since the 1980s, most policies that predate the 1986 NSTP do not have explicit reference to STI. A policy is only deemed 'explicit' if it covers:

i. the use of STI to achieve the objective of the policy;
ii. the presence of research and development component in the policy; or
iii. proposes R&D to achieve policy goals.

As such, only 20% of pre-1986 policies have STI reference compared to 91% of governmental policies announced after 1986 (Table (d)).

This suggests a paradigm shift in policy design that may be attributed to the launch of the first NSTP in 1986 as most of post-1986 policies contains current terms such as research and development that is absent from older policies. The post-1986 policies that do not possess any STI references are mostly non-technology such as the First National Tourism Policy (1992 – 2002), the Second National Tourism Policy (2003 – 2010), the National Consumer Policy 2002, the Second National Youth Development Policy 1998 and the Fair Trade Practices Policy 2005. The early STI policies were required to be entrenched into the Government system, by integrating the STI objectives with various sectoral policies, under respective ministries and agencies. The analysis suggests that prior to 1986, the governance paradigm does not include STI perspective but early and rapid adoption of STI occurred in drafting government policies, accelerated by the launch of the first NSTP.

Table (c). Examples of STI related statements in policies

National Women Policy 1989	*Strategi Pelaksanaan: Memajukan dan Menyelaras Penyelidikan Mengenai Isu Wanita*	*Menyedari hakikat bahawa kurangnya data dan maklumat mengenai kedudukan wanita sebenarnya, maka kerajaan hendaklah menggalak dan membantu penyelidikan dan kajian mengenai wanita.*
National Policy for the Elderly 2010	*Strategi: Penyelidikan dan Pembangunan*	*Menggalakkan pelaksanaan kajian mengenai warga tua bagi tujuan pengumpulan maklumat untuk kegunaan perancangan program pembangunan warga tua.*
National Automotive Policy 2014	*Teras hala tuju dan strategi: Teknologi dan kejuruteraan*	*Industri automotif kini sedang bergerak ke arah industri hijau atau pembangunan mampan bagi mengurangkan kesan terhadap alam sekitar dari segi penggunaan tenaga dan juga pemanasan global. Oleh itu, aktiviti R&D dalam bidang teknologi hijau perlu bergerak seiring dengan pasaran dan permintaan industri automotif.*
National Mineral Policy 2009	*Teras 4: Peningkatan Penyelidikan dan Pembangunan (R&D)*	*R&D akan dapat dipertingkatkan melalui:* *• penyediaan sumber kewangan dan insentif yang mencukupi;* *• penggalakan kerjasama serantau dan antarabangsa;* *• perlindungan hakmilik harta intelek dan pengkomersialan hasil penemuan R&D* *• pengukuhan perkongsian pintar dan memupukkan kerjasama antara kerajaan, industri dan institusi-institusi pengajian tinggi; dan* *• penubuhan badan penyelaras yang berkesan seperti Lembaga Pembangunan Mineral Malaysia.*

Table (d). Analysis of STI elements in Malaysian national policies

Policy Description	Total	With STI elements Number %		Without STI elements Number %	
Pre-1986	25	5	20%	20	80%
1986 and beyond	56	51	91%	5	9%
Total policies	81	56	69%	25	31%

Further Reading 1-2

The focus areas and objectives of Malaysia's STI policies over the years

Agriculture-based Economy

1960s

Before 1MP

STI-related activities conducted were to fulfil public missions (food, water, health, infrastructure) and for the production and improvement of commodities (rubber). This can be observed through the establishment of Institute for Medical Research (1900), Department of Agriculture (1905), Forest Research Institute Malaysia (1926), Rubber Research Institute (1926), Department of Irrigation and Drainage (1932) and Dunlop Research Station (1910), Chemara Research Station (1920) and Prang Besar Research Station (1921). Smallholders' scheme in plantations was for poverty eradication, FELDA (1956).

Foreign technology was adopted.

The Pioneer Industry Ordinance (1958) was introduced as an initiative to replace foreign imports with domestic production (import -substituting industries).

Roads and ports facilities were developed to service the export industry.

1MP (1966-1970)

S&T was first articulated in national agenda in Rukun Negara (1970).

Tin and rubber was the main export commodity followed by palm oil, cocoa, forestry, minerals, pineapple and tobacco later on. At one point in time, Malaysia was the world largest producer of tin and rubber (tin and natural rubber market collapsed in early 1980s). MPOB was established in 1974.

Malaysia became a member of ASEAN in 1967.

Investment Act (1968) was enacted to promote investments. Export-related incentives were given. Free Trade Zones, i.e. FIZ Bayan Lepas was established in 1972.

MARDI was established for agricultural research in 1969.

1970s

2MP (1971-1975)

Dedicated Ministry of Science (1973) and National Council for Scientific Research and Development (1975) were established. Prior to this, the management of STI was done ad-hoc.

Malaysia ventured into oil and gas when PETRONAS was established (1974) and National Petroleum Policy (1975) was launched.

In 1974, the Green Book Programme set out to diversify crops.

SIM (1974), now known as SIRIM, was established to promote industrial standards and quality.

3MP (1976-1980)

Malaysia entered into heavy industries by setting up of HICOM (1980) for the production of commercial vehicles; PROTON (1983), PERODUA (1993) and MODENAS (1995).

Production-based Economy

1980s

4MP (1981-1985)

The Privatisation Policy and Master Plan (1983) and the Malaysia Incorporated Policy (1983) were launched, resulting in today's Light Rail Transit, Kuala Lumpur International Airport, TNB, TM (enablers of STI).

Pejabat Cap Dagangan dan Jaminhak/Paten, now known as MyIPO, was established for intellectual property protection in 1983.

The First Science Advisor to the Prime Minister was appointed in 1984.

In 1985, MIMS now known as MIMOS was established.

5MP (1986-1990)

The first chapter on S&T in Malaysia Plan. STI component was factored into the national development plan resulting in a significant increase in research funding - IRPA fund was launched in 1988.

The National Science and Technology Policy (1986–1989) was launched.

Explicit policies and institutions to promote technology development were evident in Industrial Master Plan 1 (1986-1995); which laid the foundation for the manufacturing sector.

The National Science Centre was set up for public awareness of STI in 1986.

The National Vocational Training Council was established for technical skills development in 1989.

Malaysia became a member of APEC in 1989.

1990s

6MP (1990-1995)

Industrial Technology Development: A National Action Plan (1990 – 2001) was launched.

Composites Technology Research Malaysia Sdn Bhd was established for Malaysia to manufacture composite products in 1990.

Vision 2020, launched in 1991, described the goal for Malaysia to become a scientific and progressive society.

Malaysia's 1st Internet Service Provider, JARING, was launched in 1992.

MASTIC was established as the national STI information resource centre in 1992.

MTDC was established to promote the development of technology businesses in 1992.

The Malaysia Industry Group For High Technology (1993) and ASM (1995) were established.

The National Telecommunications Policy (1994–2020), among others, encouraged R&D to facilitate the absorption and application of new IT and upgrade telecommunications facilities and services.

SMIDEC, now known as SME Corp, was established for SME support in 1996.

7MP (1996-2000)

The Review of National Science and Technology Policy I (2000) was conducted.

Business incubators such as Technology Park Malaysia (1996), Kulim High Tech Park (1996), and Cyberjaya (1997) were established.

The Special Economic Zone and the Multimedia Super Corridor were established in 1996 and became the hub for ICT.

The first satellite MEASAT for data transmission was launched in 1996.

Innovation-led Economy

2000s **2010s**

8MP (2001-2005)

The Second National Science and Technology Policy and Plan of Action (2002 – 2010) was launched.

The Knowledge-based Economy Master Plan (2002) was launched.

Innovation became an important focus for Malaysia with the formation of the National Innovation Council (2004), and Agensi Inovasi Malaysia (2010).

Five Regional Economic Corridors were developed with heavy focus on STI .

Malaysia focused on biotechnology when National Biotechnology Policy (2005-2020) was launched. Biotech Corp (2005), Agro-Biotechnology Institute Malaysia (2006), IPharm (2006) were among institutions formed.

National Space Agency (ANGKASA) (2002) was established. The first astronaut (2007) was sent to increase STI awareness.

In 2006, several public universities were recognised by the Cabinet as research universities, which later received significant amount of research fund.

Mathematics & Science in English Policy was introduced in 2003 and was implemented in stages.

Malaysia signed ASEAN-China Free Trade Agreement in 2002.

9MP (2006-2010)

Formation of Halal Industry Development Corporation in 2006 indicated Malaysia's commitment to become a Global Halal Hub. 20 Halal Parks, state and private-driven were established.

JARING's spinoff, CyberSecurity was established for safer cyberspace in 2007.

Mathematics & Science in English policy was reversed in 2009.

'New' agriculture and biotechnology were highlighted in 9MP.

Nanotechnology Statement (2010) indicated Malaysia's commitment to venture into the field of nanotechnology.

Targets for higher value-added manufacturing were set.
NEAC was formed to formulate NEM (2010).

Innovative Malaysia 2010 was celebrated.

Malaysia signed the ASEAN Korea Free Trade Agreement (2007), East Asia Free Trade Area (2007), Australia-Japan Free Trade Agreement (2008), ASEAN-India Free Trade Agreement (2010), ASEAN-Australia-New Zealand Free Trade Agreement (2010).

10MP (2011-2015)

NSRC which was dormant since 2006 was reactivated as inter-governmental platform in formulating national STI strategic plan in 2011.

The Global Science & Innovation Advisory Council was established in 2011 and became among the STI advisory bodies in Malaysia.

The National Policy on Science, Technology and Innovation (2013–2020) was launched.

In PISA (2012), Malaysia ranked 52 of 65 countries in math, science and reading.

National Science Year was launched in 2012.

Mathematics & Science in English Policy was reverted to Bahasa Malaysia in 2012.

The MOSTI Commercialisation Year was launched in 2014.

Sources: Akademi Sains Malaysia 2013; Economic Planning Unit 2006; Economic Planning Unit 2010; Economic Planning Unit 2012; Jabatan Penerangan Malaysia 2012; Jomo 2007; MASTIC 1998; MASTIC 2014; MOE 2004; MITI 2008; MITI 2010; MOSTE 1986; MOSTE 2003; MOSTI 2013; NEAC 2010; National Science and Research Council 2013; OECD 2013; OECD 2014; The Prime Minister's Department, Malaysia 2014; Parlimen Malaysia 2014; PEMANDU 2012; Rahman 2013; Wong 2011; Yusoff et al. 2000

Further Reading 1-3

Hansard data mining and analysis to measure the STI awareness of Members of Parliament in Malaysia

Introduction

Parliaments have a long tradition of publishing their records by transcribing parliamentary debates of politicians in parliament. Countries have now made available recent transcripts as well historical collection as citizens often have a legal right to inspect them and is considered to be a vital part of a healthy democracy (Marx & Aders 2010). The availability of these documents allows the general public to gauge their politicians' views and is useful for social science research, e.g. political science. Analysis of debates has allowed the proponents of evidence based policy making measure effectiveness in knowledge brokering, advocacy and constituency focus (van Kammen, de Savigny et al. 2006; Sheate & Partidário 2010; Martin 2011).

These debates are often the reflection of the parliamentarians capabilities to deal with public policy problems involving cutting edge S&T. It has been proposed that there is a risk where scientific literacy is low, policy-makers are more likely to be swayed by weak evidence, dogmatic party positions and media scaremongering and unable to weigh scientific evidence properly in justifying their policy choices (Henderson 2012; Goodwin 2014). A strong scientific training background would have provided the acumen and equips parliamentarians to make rational, evidence-based decisions for both science and non-science based legislation. Hence, the measure of interest on STI or related themes would gauge the situational awareness amongst parliamentarians and political circles. The aims of this analysis are: to gauge the STI awareness among the Members of Parliament; to determine the top sectors discussed in STI; to assess the intensity of discussions and quality of discussions based on the content discussed during the debate. Specific exchanges that are policy related such as recommendations, international partnerships, talent and research & development to improve STI potential for the country are of great interest.

Methodology

The Hansard is a highly structured transcript of exchanges between Members of Parliament in the august house. It is named after the publisher Thomas Curson Hansard, who printed the first proceedings of the British Parliament. Parliamentary debates are a nation's legacy, thus are uniform in format with very little modifications throughout history, making it suitable for semantic data mining efforts. Currently in most modern democracies, it is common to transcribe everything that is being said, keeping the content but making it grammatically correct and easy to read (Marx 2009). Hence, the Malaysian Hansard is available in PDF files, separated according to sessions, and are available for download from the official parliamentary portal (http://www.parlimen.gov.my/hansard-dewan-rakyat.html?uweb=dr&arkib=yes)

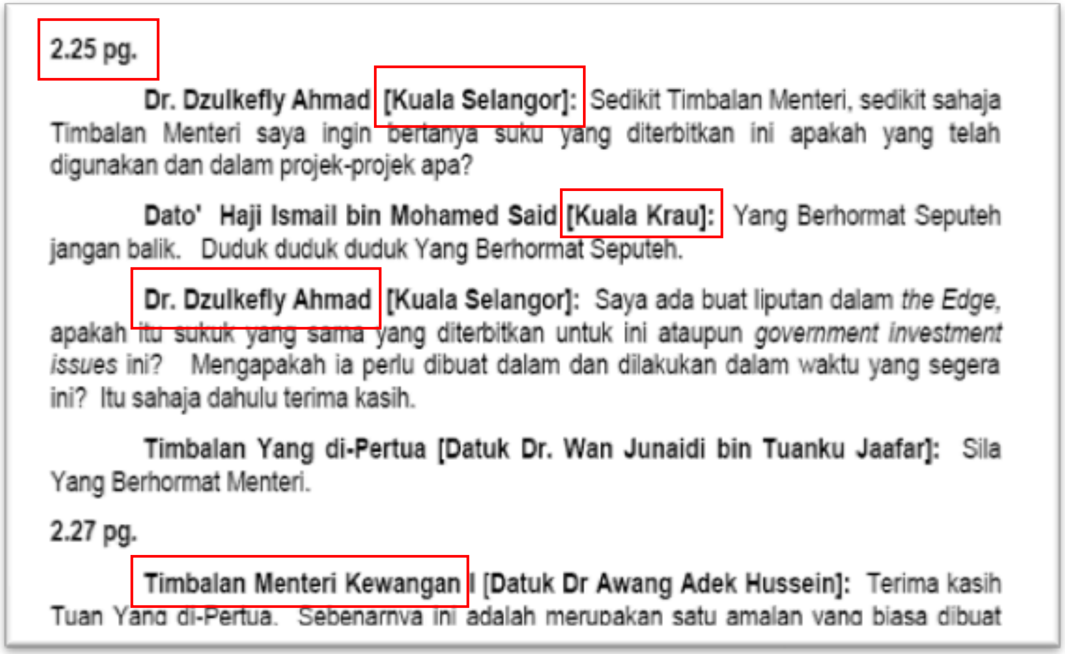
All the transcribed exchanges are downloaded according to parliamentary sessions from 2008 to 2013. Transcripts of parliamentary exchanges are a document genre characterised by a unique sequence of narrative where the essence is not only what is said, but also by who and to whom (Kaptein & Marx 2010).

These sequential exchanges between individuals are often centred on sensational aspects of topics originated from questions by parliamentarians to ministers. The Malaysian parliamentary proceedings come in the form of long documents in PDF form containing the notes of one whole day similar to most countries with modern parliamentary systems (Europe, Commonwealth). The documents are long, with at least 100 pages, in single column and can reach up to 252 pages long as in the case of the Hansard for 19th April 2012.

Every document is broken down into its constituents; basic information and the natural units of retrieval. The basic information needed is the date, number of attendees, politician names, parliamentary constituency and ministries, whose data is typically listed in the early section of the document. The natural units of retrieval are questions, speeches, interruptions and interjection that are marked with defined textual demarcation. For example, "Tuan Chua Tian Chang @ Tian Chua [Batu]" denotes the speaker and the parliamentary constituency. The constituency Batu within the square brackets is defined as the demarcation point separating different individuals within the daily exchanges [Figure (a)].

The hierarchically nature of the corpus allows partitioning of the exchanges by each identifiable person even to the minutiae of common interruptions (e.g., sarcasm, irony and digression) that most often do not have illegible verbal transcription. This allows identification of every word in the corpus is spoken by who, from which party, has certain function or role while speaking (e.g. chairman, minister of X, spokesman of party X, and the type of exchange etc.).

Parliamentary questioning is a compulsory, ubiquitous sometimes banal act that exists in all form of parliamentary democracy. As the accountability of the executive to the parliament is one of the definitive characteristics of a parliamentary democracy, the widespread institution of parliamentary questioning is also present in all parliaments (Russo and Wiberg 2010). Its function is commonly intended to influence the government or to raise awareness of a specific issue. For the purpose of this study, exchanges within the day are catalogued to determine the STI topic and to differentiate between soalan (question), soalan tambahan (additional question) and jawapan (answer). The data mining process uses specific STI related keyword and semantic search in English and Bahasa Malaysia. English words are immediately and compulsorily followed with dengan izin or with permission. Using a library of STI associated keywords, each document is mined. The identified units of retrieval are then catalogued before being clustered into similar topics or themes. Each Hansard has information on nonverbal content or actions such as the list members present and absent. The description of actions like applause by party members, sentiments and non-verbal nuances are not taken into account.



2.25 pg.

Dr. Dzulkefly Ahmad [Kuala Selangor]: Sedikit Timbalan Menteri, sedikit sahaja Timbalan Menteri saya ingin bertanya suku yang diterbitkan ini apakah yang telah digunakan dan dalam projek-projek apa?

Dato' Haji Ismail bin Mohamed Said [Kuala Krau]: Yang Berhormat Seputeh jangan balik. Duduk duduk duduk Yang Berhormat Seputeh.

Dr. Dzulkefly Ahmad [Kuala Selangor]: Saya ada buat liputan dalam *the Edge*, apakah itu sukuk yang sama yang diterbitkan untuk ini ataupun *government investment issues* ini? Mengapakah ia perlu dibuat dalam dan dilakukan dalam waktu yang segera ini? Itu sahaja dahulu terima kasih.

Timbalan Yang di-Pertua [Datuk Dr. Wan Junaidi bin Tuanku Jaafar]: Sila Yang Berhormat Menteri.

2.27 pg.

Timbalan Menteri Kewangan I [Datuk Dr Awang Adek Hussein]: Terima kasih Tuan Yang di-Pertua. Sebenarnya ini adalah merupakan satu amalan yang biasa dibuat

Figure (a). Exemplar on the use textual markers, e.g. square brackets to demarcate different parliamentarians and other information such as name, constituency, ministerial post and time stamp.

Result and Discussion

STI Awareness: Top sectors discussed in STI
Various STI sectors and their corresponding S&T constituents surfaced throughout the parliamentary debated from 2008 to 2012, as listed in Table (a).

Table (a). Sectors or themes related to STI discussed in parliamentary debates from 2008 to 2012 in no particular order

Environment (2012)	Medical and Health (2008, 2011, 2012)	Security and Safety	S&T	Nation Building	Alternative energy (2008, 2009, 2011)	Agriculture (2009, 2010, 2011, 2012)	Communication	Energy	R&D	Climate Change	Government Service / Governance
Lynas (2012)	Tuberculosis	Biometric System	Global positioning system (GPS)	Angkasawan (2008)	Nuclear energy	Veterinary science	Broadband	Coal	Research Funding	Effect of climate change (El Nino)	Government e-services
Biodiversity	HIV/AIDS	Illegal immigrants	Multimedia	Science Education (2008)	Hybrid car	Fishery	Mobile communication	Petroleum	Research Infrastructures	Flooding (2009)	Automated Enforcement System (AES)
Pollution	Acute Gastroenteritis (AGE)	Cybersecurity	ICT	Development Corridors	Biodiesel	Food Security	Agencies (SKMM)	Ministry (KETTHA)	Agencies (MDEC, etc)	Water Supply	
Waste management	Adenovirus epidemic	Advanced Passenge Screening System (APSS)	Biotechnology	Community Development	Solar energy	Agencies (MARDI)	Short Messaging Services (SMS)	Electricity power and generation	Intellectual Property		
Radioactive Waste		National Enforcement and Registration System (NERS)	Nanotechnology	Capacity Building	Renewable energy	Seaweed farming					
Marine Park conservation			DNA	*Program Galakan Sains dan Teknologi*	Electric vehicles	Aquaculture					
Sustainable Forest Management (SFM)			Transportation	Knowledge Transfer	Biothanol	Cloning of plats (rubber, timber and cocoa)					
			Radio Frequency Identification Technology (RFID)	Government policies							
			Sports Science								

Note: The top sectors discussed in their corresponding year are denoted by brackets or highlighted, e.g. Angkasawan (2008). The S&T components are listed at the bottom of each sectors or themes.

The sectors or themes on: 1) medical and health; 2) agriculture; and 3) alternative energy are of high interest among the parliamentarians. On average, more than 60% of the questions would come from non-ruling parties (PKR, PAS and DAP), whereas the answers are from ministers from respective portfolios. Certain sub themes generated significant interest and would dominate the exchanges such as Angkasawan Project (2008), Flooding (2009), science education (2008) and Lynas (2012). These sub-sectors are amplified by the media and thus would garner attention of the politicians. Other less significant media amplified sub-themes include national epidemics (Leptospirosis, Acute Gastroenteritis (AGE) and adenovirus), governance (Automated Enforcement System (AES)) and politics (DNA sampling associated with Anwar Ibrahim's trial). Overall, non-ruling parliamentarians pose more STI related questions than the government backbenchers. Notable parliamentarians between 2008 and 2012 that are considered to possess STI awareness from the ruling coalition are that of the Ledang and Rembau districts, while the non-ruling coalition member is from Hulu Langat district. While there are other parliamentarians that regularly show STI awareness such as Pontian, Kinabatangan, Lipis and Batu Gajah, their queries are consistent with current 'hot' issues at the time, constituencies dependent on nature or in response to questions posed to them due to their ministerial posts, thus does not transcend into ex-ante questions.

Quality of the questions

Parliamentary questions are classified into many different criteria. Based on procedural features of questioning, the natural starting point (Soalan) can be deduced along with subsequent questioning (soalan tambahan) along the line of the original question. The questions can also be classified according to two dimensions; the first distinguishes between those tools having the aim at influencing future actions (ex-ante oversight instruments) and those which are concerned with past actions (ex-post oversight instruments) (Maffio 2002). Ex-ante questionsare used as a means to influence future actions of the government or to modify its future behaviour, while ex-post questions is mainly aimed at reviewing the past conduct of the executive (Russo & Wiberg 2010). Examination of the type of questions associated with STI revealed that majority of the questions is ex-post questions, suggesting that parliamentarians play a passive role in charting the STI direction of the nation. Question posed are either in response to an issue at hand or following a line of questioning subsequent to a ministerial response. The analysis showed that parliamentary members either in ministerial posts or appointed senators only engaged in debate by answering questions and did not participate strongly in debates on STI. The proportion of STI questions debated in the Parliament from 2008 until 2013 that contribute to the nation's development are listed in Table (b).

Table (b): Development versus Non Development STI Questions

Year	08	09	10	11	12	13
Total STI topics	849	214	344	405	193	202
STI topics related to the nation's development	633	163	188	183	109	108
Percentage (%)	75%	76%	55%	45%	56%	53%

(i) Quality of the discussion:
Toe-ing the party line

Previous work showed that Members of Parliament with a scientific background would not behave differently from their peers that do not have any scientific training (Goodwin 2014). The allegiance to their respective parties or coalition shall prevail in every case and they would toe the party line. (Henderson 2012). The analysis showed that neither the government nor non-government Malaysian Members of Parliament would raise an issue during the debate that would jeopardise or go against the grain of their party or coalition. Compounding the problem is the actual dearth of Malaysian Members of Parliament who are trained in S&T. Within the myriad of information and multiple types of knowledge currently available, decision making may need to take account many different types of information provided by a different group of experts. These include: evidence about policy, public opinion, dynamics of party or parliament tary mood; intelligence, whether human or signals; statistics; economics; history; knowledge about civil service capacities; and government performance data (Doubleday & Wilsdon 2013). Thus, parliamentarians need to be intellectual enough in making sure issues are approached using evidence and use effective problem-solving methods to make rational decisions.

(ii) Quality of the discussion:
Topical according to media

The line of questioning of a particular STI related theme is regularly biased by topical themes that have been sensationalised by the media. For instance, the Lynas issue dominated the news in 2012 [Figure (b)]. In 2008, the Teaching of Science and Mathematics in English (PPSMI) and the Angkasawan Programme dominated the discussions.

iii) Quality of the discussion:
Constituency focus

Parliamentarians differ widely in the degree to which they devote attention to their constituency's geography. Although they are expected to champion issues at the federal level, it appears that some of them still spend time and effort to champion the interest of their constituency (Russo 2011). This phenomenon is discernible in this analysis. A majority of the ruling

Note:
a) Examples of Development Topics: *Jurang Digital, Kajian Penyelidikan, Kelajuan Internet, Kemudahan Kesihatan*, Capacity Building, Education, Green Technology, *Industri (rumpai laut), Industri Minyak Sawit, Tenaga Alternatif, Tenaga Arang Batu, Tenaga Biomass, Tenaga Boleh Diperbaharui, Tenaga Suria, Akuakultur, Automotif, Bioteknologi,* Biodiesel, Biofertiliser, Biomass Energy, *Jalur Lebar/ Komunikasi*

b) Examples of Non-development Topics: Agri-food, Ammonia Urea, Ancaman biodiversiti, Ancaman Siber, Angkasawan, Arteriosklerosis, Automated Enforcement System (AES), Bio- security/Kuarantin, CFC, CT Scan, DNA, e- Syariah, e-voting, Flying Doctor Service, GM Mosquito, GMO , GPS parliamentarians would pose questions biased towards their constituencies to ministers, which most often comes from the same political coalition. These questions, most often posed by parliamentarians from East Malaysia, commonly focused on technologies and pertinent industries that may bring development to their constituencies. Most of the questions can be categorised as rural, community and development, as well as on development corridors such as SCORE and SDC. In contrast, non-ruling parliamentarians would dominate the queries by asking ex-ante questions regarding STI related sectors that affect the nation as a whole. The participation of ruling parliamentarians into similar ex-ante exchanges are limited to passive participation in the form of answers given by the ministers of their respective portfolios.

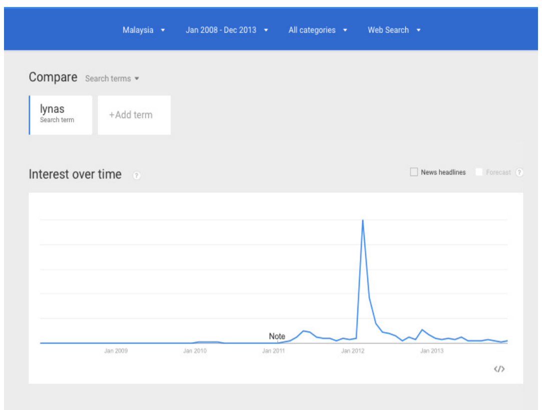


Figure (b). A Screenshot from Google Trend analysis showing the peak of interest by the public with respect to sensational topic, e.g. the Lynas issues are reflected in the interest of parliamentarians to include its discussion in their debates.

Further Reading 1-4

Review of STI regime in select countries

United States

The key features of the STI regime in the US are as follows:

- While there are national priorities, which translate into funding, planning is decentralised and the emphasis is on a bottom-up approach. This is facilitated by a mechanism that is dynamic and participatory.
- Support exists to inform decision-makers in legislature and judiciary branches of government.
- An agency that provides competitive funding has a systematic national database of experts who perform national S&T evaluation.

Latin America

Outside of Brazil, STI planning in most Latin American states is still at its infancy stage. However, with the liberalisation of trade and political links, and the success of the Brazilian STI, the regional growth of STI is expanding with the primary mechanisms such as:

- Increased participation by various actors in the STI system; and
- Introduction of coordinating structures.

Brazil's investment in aerospace STI would be an instructive example that should shape Malaysia's own approach. Brazil began investing in aerospace STI in the 1940s and 50s. Despite numerous political changes in the country, the imperative was undiminished, and in 1969, the Empresa Brasileira de Aeronáutica (Embraer) was created as a government-owned corporation. The company began with an assembly of single engine turboprops, and moved on to more sophisticated aircraft after that. Today, Brazilian aerospace STI has advanced to the point that it is on par with Canada as the third largest manufacturer of aircraft in the world, after US and Europe.

Given the small scale and size of some government research institutions, clustering the institutions would be a viable option to pool resources and expertise. For example, EMBRAPA, a successful agricultural research institutional innovation in Brazil. This public corporation features very distinct characteristics and a model organisation, with a scale of operation at national level which is spatial decentralisation. It has specialised research units, enhanced training and remuneration of human resources and a vision of agricultural success based on STI. Some of the successful features of EMBRAPA are as follows:

1: Continuous support from the Federal Government: in terms of budget and by recognising EMBRAPA as a strategic organisation;
2: Diversified R&D portfolio: EMBRAPA always had priority on short-term goals coupled with attention to the dissemination of existing results;
3: Timing and social support: There was enough pressure and understanding to reform public research in agriculture; a typical case of institutional reform;
4: Option for a public corporation model: Bold decision of the government in 1972 to release EMBRAPA from the bureaucratic rules practised in the public administration. It provides the flexibility to administer resources and personnel, to plan, assess performance, implement the budget, disseminate results and achieve transparency;

5: Scale, interactivity and decentralisation: The success of a national R&D organisation would depend on its size, diversity of talents and level of decentralisation. EMBRAPA established its presence throughout the national territory, developed a network with a critical mass of researchers capable to engage in active cooperation with universities, State research institutes, private sector and overseas organisations;
6: A concentrated organisation model for the research units: EMBRAPA research units are spread throughout the nation and are specialised in products, resources and themes. Farmers and other stakeholders know where to go for information and results, giving them ownership of the centre, providing help to the political leadership and the economic management of the government;
7: Human resources: HR policy is based on several factors, among them: the establishment of a career that stimulates the desire to study and progress; a salary that allows the researcher to live comfortably; a retirement plan, voluntary membership; a health plan paid by EMBRAPA and the employees; opportunities and stimuli for all employees to accumulate knowledge and experience; a system of a merit-based promotion, focused on individual, group and research unit´s performance; a training programme at post-graduate and post-doctoral levels that meets the interests of the corporation and researchers; among others;
8: Professional relations and co-existence with power: Politicians represent Brazilian society and EMBRAPA considers it important that they take part in the organisation´s activities, especially in aspects related to definition of priorities for research and institutional development. Hiring its top managers by an open selection process became an instrument promoting co-existence and professional relations with the political power. Therefore, EMBRAPA has been able to develop productive relations with the political world, while safeguarding its independence and retaining competent leaders;
9: Independent reviews and evaluations of impact. Over the years EMBRAPA has used diversified set of instruments to demonstrate its importance in the modernisation of agriculture and the agribusiness sector in Brazil. The independent reviews and evaluation are publicised to the public.
10: Communication with society: EMBRAPA adopts strategies to communicate effectively with the society. It also demands talents to establish links between media and the organisation. EMBRAPA invests in professionals who are able to create strong ties with the media, making its results well publicised, both in Brazil and abroad.
11: Foresight and institutional flexibility: EMBRAPA invests heavily in foresight, strategic planning and institutional processes. During its 36 years of existence, the organisation experienced three different models of R&D management, in response to changing times, innovation trends and methods.

Europe

A major feature of the European model is the presence of the European Commission (EC), which has enabled a regionalisation of strategies, where member states translate European Union (EU) targets to national strategies, following cohesive actions in politics and trade. High performers in S&T, attributed to structured top-down system with a coordinator.

However, this has not discouraged innovation at a local level, even where there is a significant level of institutional fragmentation. For instance, the absence of a single dedicated ministry/department does not hinder S&T progress in the case of Finland.

STI strategies in Europe are future-oriented to maintain socio-economic competitiveness. The EU STI mandate has also not floundered on the artificially contrived boundary between basic and applied research. There has been an appreciation that applied research is not possible without understanding of the basic sciences. A case in point has been the construction of the Large Hadron Collider (LHC), the world's largest and most powerful particle collider, built by the European Organization for Nuclear Research from 1998 to 2008. The LHC was built in collaboration with over 10,000 scientists and engineers from over 100 countries, as well as hundreds of universities and laboratories, at a price tag of €7.5 billion.

Middle East and Africa

STI does not have a long history in the Middle East and Africa, where poverty, political instability and entrenched religious and cultural traditions have pre-empted investment in the area. However, some countries such as South Africa, are exceptions to this rule, while oil-rich nations such as the UAE and Saudi Arabia have begun allocating substantial funds to STI.

South Africa invested heavily in STI during the apartheid years in reaction to global isolation. STI was a national imperative, although the focus was on several major areas including defence, water management, medicine and food production. The investment has paid off and the country is now a global STI hub in several fields such as:

- The world's first heart transplant was in South Africa, and the country continues to lead in biopharmaceuticals;
- South Africa manufactures among the most sophisticated field cannon and radars in the

world. When the radar system in Subang was destroyed by fire a few years ago, it was South African field radar that was used to resume and sustain flight operations; and
- South Africa continues to lead in biodiversity and ecological research.

Other African countries have a less impressive resume, though Kenya has made significant advances in anthropology, hominid palaeontology and lake ecology. However, although these represent important scientific advances, they have not been translated into innovative modalities that have wealth creation dimensions.

The key constraints to STI in the region are as follows:

- Although a coordination body has been established, there is little pooling of resources or sharing of information among various countries, even where there is an ethnic, linguistic or religious similarity (such as in the Middle East).
- Because of the newness of STI, the focus has been on catching-up with major STI players with emphasis on research mobility. This means that much of the current funding is channelled into developing the necessary human and physical STI infrastructure.

As a consequence of these constraints, the STI ecosystem is maturing gradually.

Asia
Japan, India and China have a long standing tradition in STI development stretching back to the early part of the 20th century. In Japan, STI was a central tenet in the administration of the Meiji Emperor (1852 - 1912). The half-century of STI meant that Japan still had sufficient resources to bounce back after the devastation suffered during World War Two to become a global technological power.

China has had a similar history where its STI development was interrupted by World War Two, the Great Leap Forward and Cultural Revolution. However, in recent years, massiveinvestments were channelled into STI, resulting in major innovations in defence, space, railway engineering and renewable energy.

India has also seen investments in STI from the early 20th century, particularly in medicine and agriculture. Consequently, India became one of the world's largest producers of pharmaceuticals. Current STI focuses on IT and the country ranks as one of the leading software producers in the world. The sustained development efforts in STI in South Korea and Taiwan since the 1960s made both countries leaders in consumer electronics, agriculture (Taiwan) and automobiles (South Korea).

Summary

Current regional trends point to the following:

- A greater autonomy of universities and research institutes to pursue technology and research goals.
- National research institutes dedicated to cottage industries and national specialities.
- Policy goals towards increasing GERD and strengthening basis of collaborations.
- Institutionalisation of basic research.
- National strategies that emphasises the development of creativity industry as a source of wealth creation.
- Popularisation of S&T law to promote the enculturation of S&T from the top.

Sources: Lopez & Arcuri 2010; OECD 2012

Further Reading 1-5

National STI policies evolution and achievements

STI Landscape before NSTP	Policy Measures NSTP (1986–1989)	Achievements under NSTP	Policy Measures NSTP2 (2002-2010)	Achievements under NSTP2	Policy Measures NPSTI (2013-2020)
STI Governance					
Substantial institutional base already existed, such as the Ministry of Technology, Research and the Local Government (1973), National Council for Scientific R&D (1975). The first Science Adviser to the Prime Minister was appointed in 1984. There were 71 academies established globally prior to NSTP.	The NSTP was incorporated into the 5MP. The Malaysian Industrial Master Plan 1 (1986-1995) was also launched. NSTP calls for S&T to be fully integrated into national development plans and other policies. It also emphasised on the need to collect data on S&T in and outside Malaysia for analysis and policy planning. NSTP encouraged the establishment of a Centre of Excellence like ASM.	A dedicated chapter on S&T appears in the subsequent Malaysia Plans. To illustrate, MASTIC (1992), MIGHT (1993), and ASM (1996) were established. However, there is a lack of resource devoted to S&T policy analysis and diffusion of responsibilities through the government bodies	The NSTP2 targeted to strengthen the institutional framework for S&T and monitor of the implementation of this policy. The NSTP2 aimed at strengthening MOSTE by endowing it with necessary resources and to review the role of National Council for Scientific Research and Development. Also, the management of intellectual property rights including patent advisory, trademarks, and industrial designs was to be enhanced.	The knowledge –based Economy Master Plan (2002) was launched. The National Council for Scientific Research and Development which ceased to operate in 2006 was reinstated in 2011. The National Innovation Council (2004), National Innovation Agency (2010), five Regional Economic Corridor (2006) were established. The NEM (2010), National Biotechnology Policy (2005) and Nanotechnology Statement (2010) were launched.	The NPSTI aims to: • Formulate and enhance STI Act for implementation of the national agenda in 2013; • Transform existing S&T information centres to become more effective; e.g. MASTIC; and • Provide greater autonomy to public and private IHLs and PRIs to spur industry collaboration and entrepreneurship.

STI Landscape before NSTP	Policy Measures NSTP (1986–1989)	Achievements under NSTP	Policy Measures NSTP2 (2002-2010)	Achievements under NSTP2	Policy Measures NPSTI (2013-2020)
Research, Development, and Commercialisation					
Scientific research started in the 1900s by R&D institutions such as IMR (1900), DOA (1905), FRI (1926), & RRI (1926). Plantation houses were also establishing research institutions. *Pejabat Cap Dagangan dan Jaminhak/Paten* (now MyIPO) (1983) and the Malaysian Institute of Microelectronic Systems (now SIRIM) (1985) were established before the NSTP was launched. In 1980s, the GERD/GDP for Japan was more than 2.5%, UK more than 2%, US more than 2.5%. In 1994, GERD/GDP for Malaysia was 0.33% vs. Singapore 1.13% and Japan at 3%.	The NSTP emphasised on R&D and technology development for agriculture, health and others. It also targeted for research management system and research infrastructure to be established. Computerisation, technology transfer and incentives for industry to encourage R&D were promoted in the NSTP. The NSTP also mentioned that the Government will increase the allocation of GERD gradually to 1.5%.	The intensification of Research in Priority Areas was initiated in 1988. MyIPO and SIRIM were corporatised. In 2000, the GERD/GDP for Malaysia was 0.5%. So the target was not achieved. Increasing GERD/GDP to 2 % by 2010 was recommended by ASM in the Strategic Policy Architecture and Recommended Policy Instruments Report (2000).	The NPST2 targeted to increase the GERD to at least 1.5% of GDP by 2010. It also targeted to invest in upgrading infrastructure for S&T development including establishment of new major research/technology development institutions/facilities/initiatives, e.g. the Biovalley Initiative in the Multimedia Super Corridor. Research and technology development programmes including basic research in the new and emerging technologies were to be prioritised regularly through initiatives like Technology Foresight/Technology Mapping.	Malaysia recorded an estimated GERD/GDP of 0.79% in 2008 and 1.07% in 2010. Setting a GERD/GDP target closer to the OECD average of 2.3% was suggested in the MASTIC Indicators Report 2013.	The NSTPI aims to: • Increase GERD to at least 2.0% of GDP by 2020; and • Enhance the performance of public private R,D&C funding.

STI Landscape before NSTP	Policy Measures NSTP (1986–1989)	Achievements under NSTP	Policy Measures NSTP2 (2002-2010)	Achievements under NSTP2	Policy Measures NPSTI (2013-2020)
STI Talent					
In the 1970s, several universities were established to undertake research which resulted in the rising enrolment and graduation from the local universities in science and engineering. There was an increase of science and engineering graduates trained abroad. However, there were constraints in funding for both teaching and research, shortage of experienced staff and low enrolment in graduate studies. Student enrolments in Science Degree course has increased by 400% within duration of 15 years (2,408 students in 1970, 12,505 students in 1985).	The NSTP targeted training, appropriate environment for R&D, incentives and awards that are appealing to be given and skilled workers to be retained in the public sector. Long term manpower planning needs to be formulated and examined periodically to increase human resource in fulfilling national S&T requirement. The education system also gives attention to the application of new approach to the scientific field with advancement in modern S&T, including consideration on morale, ethical and social implications.	In 1989, 13,605 personnel, either full or part time were involved in R&D activities. A total of 5,537 were research scientists and the rest were supporting staff. The MASTIC Indicators Report 2013 recorded a ratio of 15.6 per 10,000 workforce in 2000. 32.4% of students graduated in S&T in 2000 from public educational institutes, short of the desired 60%.	The ratio of RSEs per 10,000 workforce was to be increased to at least 60 by 2010. A 60:40 ratio of students for S&T to non-S&T was to be adopted at SPM level and university. The NSTP2 targeted to increase the number of post-graduate students in science to at least 10% of undergraduate population by 2005.	MASTIC Indicators Report 2013, shows the number of RSEs tripled from 2008 to 2011, which is 58.2 researchers per 10,000 labour force. The target ratio was achieved in 2011 but still lower to the average of OECD countries, which is 76 RSEs per 10,000 labour force. Students enrolment in science at the SPM level, increased yearly. Yet, the registration for science dipped from 2008 to 2011 for STPM. The report also shows that the ratio 60:40 was not met. The percentage of postgraduates in science over undergraduates reached 16.5% in 2005. The number of PhD holders surged from 7,001 (2006) to 33,272 (2011) and those with Master's soared from 5,337 (2006) to 24,691 (2011). Two out of 10 Malaysians with degrees migrated to OECD nations or Singapore in the last 20 years. (The World Bank 2011)	The NSTPI aims at: • Increasing the ratio of RSEs per 10,000 workforce to at least 70 by 2020; • Developing higher order cognitive skills, analytical, creative and innovative skills among school children, tertiary level students and teachers; • Promoting STI among school children, professional bodies and science-oriented societies; • Enhancing talent management system to track human capital; • Promoting the participation of women at all levels and sectors; and • Increasing skilled and competent technical workforce to handle highly specialised equipment including infrastructure.

STI Landscape before NSTP	Policy Measures NSTP (1986–1989)	Achievements under NSTP	Policy Measures NSTP2 (2002-2010)	Achievements under NSTP2	Policy Measures NPSTI (2013-2020)
Energising Industries					
Pioneer Industry Ordinance (1958), Investment Act (1968) were enacted to promote investments. Export-related incentives and the establishment of Free Trade Zones (1972) were introduced.	The NSTP targeted for private sector involvement in R&D activities to increase, and collaboration and consultation between the government and the private sector to be enhanced. Transfer of technology (including foreign) and development of indigenous technology were to be introduced and promoted actively.	The MTDC (1992), Technology Park Malaysia (1996), Kulim High Tech Park (1996), and Cyberjaya (1997) were established. The Industrial Technology Development: A National Action Plan (1990–2001) was launched. The Special Economic Zone and Multimedia Super Corridor (1996) were established. The R&D Expenditure Survey (1990) shows a low level of R&D spending and innovation among domestic firms supported by Federation of Malaysian Manufacturers Manufacturing Survey 1989/90. Since the Asian Financial Crisis (1997-1998), Malaysia experienced a major change in aggregate investment trends. While nations such as Indonesia recovered in its investment levels, Malaysia's aggregate investment levels as a percentage of GDP continued to dip. This contraction was mostly due to a decline in private investments.	Private sector investment in R&D development was to be stimulated through various means, e.g. enlarged allocations for industry grant schemes, e.g. Industry R&D Grant Scheme (IGS), MGS, DAGS.	Private sector R&D investment (BERD/GERD) decreased from 84.9% in 2006 to 70.5% in 2008 to 56.7% in 2011.	The NSTP aims to: • Maintain a minimum of R&D expenditure between public and private sector of 30:70; • Stimulate and facilitate the private sector to undertake R,D&C; and • Initiate extensive review of fiscal and financial incentives to promote industry innovation.

STI Landscape before NSTP	Policy Measures NSTP (1986–1989)	Achievements under NSTP	Policy Measures NSTP2 (2002-2010)	Achievements under NSTP2	Policy Measures NPSTI (2013-2020)
STI Enculturation					
The National Science Centre was established in 1986.	Approach to be taken to educate and expose the public to the importance of science as a discipline and a way of life.	Contests such as the national science essay, poetry and fiction writing, quizzes, new inventions, computer software and graphic designs were promoted among students as part of the annual National S&T Week. The National Planetarium was set up in 1994 due to lack of awareness of S&T. In 2000, the public's perceived knowledge of S&T continued to drop from 2.29 (1996), to 2.23 (1998) and 2.18 (2000) with the index scale of four as the maximum.	The NSTP2 aimed at rising S&T awareness and appreciation by introducing S&T culture in the education system through initiatives like introducing research grants to schools, redesigning the syllabus and increasing S&T language competence to facilitate the flow of information.	On the GCI 2011-2012, Malaysia ranked 23rd on innovation and 25th on competitiveness out of 144 countries. Innovative Malaysia 2010 was launched. The teaching of Maths & Science in English policy was reversed in 2009, MOSTI and its partners continued to lead and implement programmes to stimulate innovation and creativity.	The NPSTI aims to: • Establish advisory body to guide STI public awareness and promotions; • Expand and empower science centres to popularise and sensitise STI in society; and • Conduct outreach programmes to raise awareness of ethics and humanities in society.
Strategic International Alliance					
Malaysia became a member of ASEAN in (1967)	An independent and continuous mechanism to assess the progress of technology transfer, especially on the foreign companies' role and the local firms capability to absorb new technology will be introduced. In the process, requirements for the transfer will be prioritised, e.g. scanning, evaluation and appraisal of the technology to be developed.	Malaysia is a member of various organisations and has participated in many forums at regional and international levels such as the UNESCO, APEC (1989).	The NSTP2 targeted to enhance exposure to international developments in the new technologies, and exploit of foreign research expertise where necessary.	Malaysia has signed a number of MoUs in S&T cooperation and FTAs on bilateral and multilateral levels. It includes 152 STI related agreements and memorandums with 88 nations such as ASEAN & Korea Free Trade Agreement (AKFTA) (2007), ASEAN & Japan Free Trade Agreement (AJFTA) (2008), Science and Technology Policy Asian Network (STEPAN), and Federation of Asian Chemical Societies.	The NPSTI aims to: • Develop partners, allies and channels in key destination countries; and • Intensify domestic and international networks for research collaboration, strategic partnerships and business relationship.

Sources: Day & Muhammad 2011; MASTIC 1998; MASTIC 2014; MOE 2004; MITI 2008; MOSTE 1986; MOSTE 2003; MOSTI 2010; MOSTI 2013; NEAC 2010; NSCRC 2013; OECD 2010; Rahman 2013; World Economic Forum 2014

Research, Development and Commercialisation

Further Reading 2-1

Challenges in commercialisation and impact assessment

Various interviews conducted suggest that commercialisation activities of the universities and research institutions are weak due to:

- TTO established in each of the respective institutions is weak given the lack of expertise, resources and is mainly managed by academics.
- Resources are limited due to the fragmented arrangements where each university and research institution undertakes its commercialisation efforts on its own. A consortium approach would better pool all the limited resources to be utilised in a more effective manner.

Other challenges in commercialisation include the existing weaknesses of the Venture Capital (VC) industry, among others comprise of:

- The VC industry is predominated by government funding whereas in Australia, Thailand, and Japan, private sectors participation is high as shown in Figure (a).
- A recent study on 39 VC-backed companies shows that only nine of these companies manage to perform well in the Malaysian stock exchange. A combination of lack of human capital and the requisite VC practice (risk-taking environment) has restricted VC industries to advance entrepreneurial activities.
- Low institutional involvement, e.g. pension funds – in Asia Pacific, those funds account for an average of 17% of VC investment.
- Low average participations by individuals.
- GLCs and foreign corporations tend to concentrate on large-cap blue chip companies, sidelining smaller-cap companies.
- Commercialisation involves various stages, and funding is concentrated more at the end stage, value realisation stage, due to the risk-averse nature of the funding institutions, e.g. banks and others.

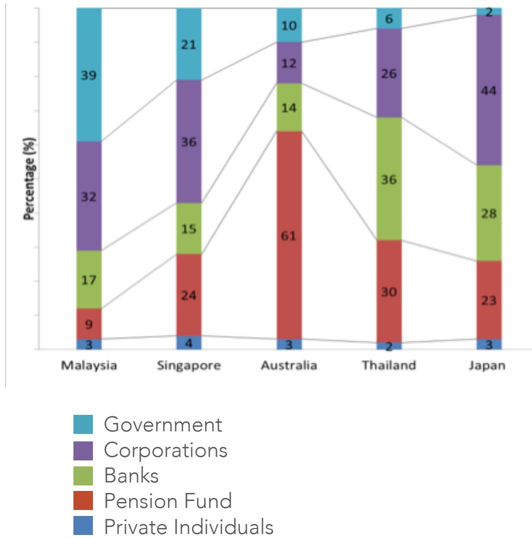


Figure (a). Malaysian VC Funding is dominated by the government
Source: ScienceSnap 2014

Russel group of universities commercialisation impact assessment provides variety of lessons about commercialisation efforts.

The lessons include:

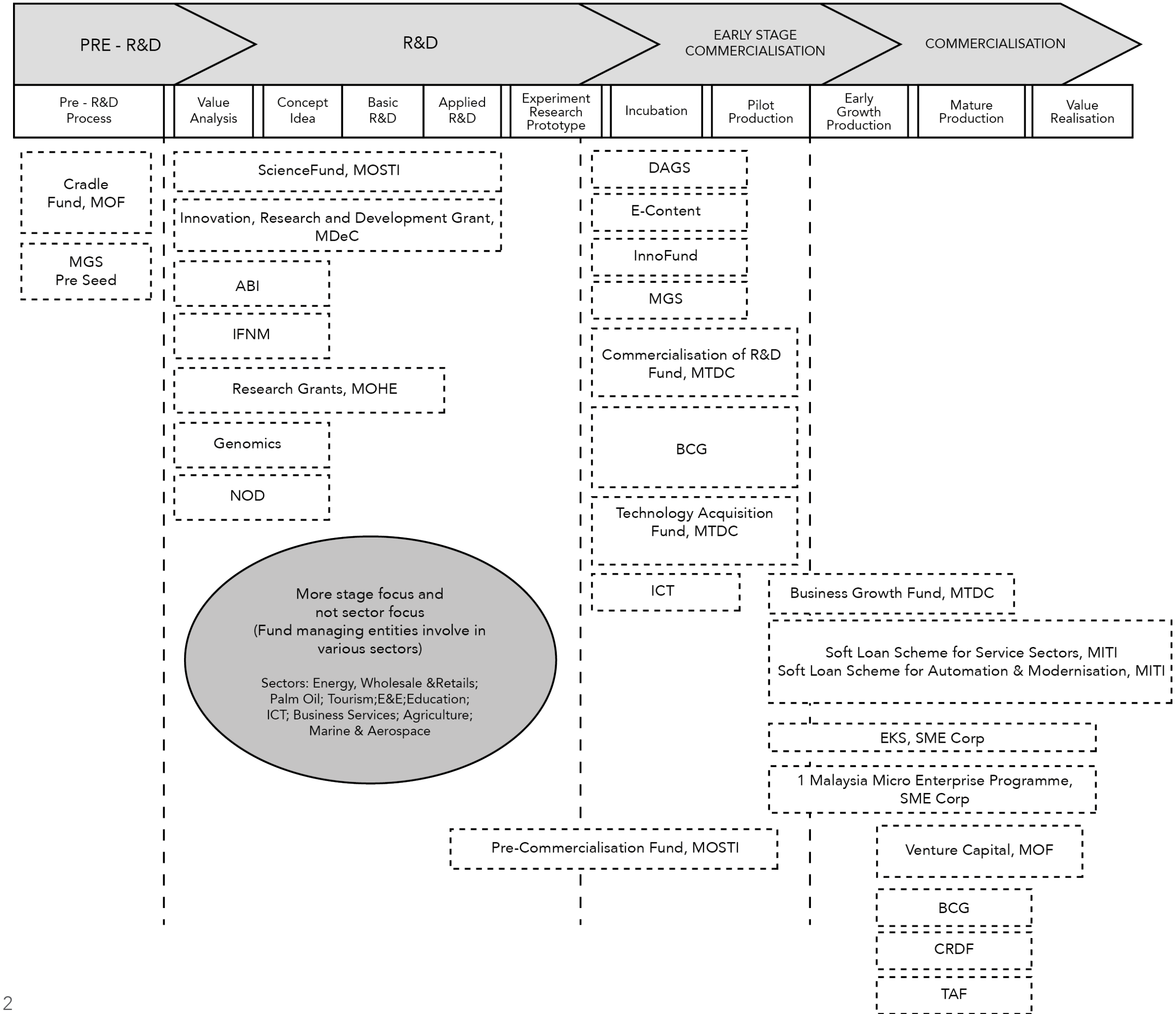
- Universities can benefit the economy by exploiting research through licences and spin-off companies.
- Professional knowledge transfer, staff and processes within universities are critical to create benefit for the economy.
- Many of the highly successful licences and spin-off companies are from the long-term curiosity driven research.
- Successful commercialisation requires sustained long-term investment in research, often over many years or even decades. It took 8.5 years for revenue generation after a license is granted and an average 17 years for research to realise its first commercial return.
- It is misleading to consider the impact of technology transfer only through its direct and quantifiable economic impact, e.g. commercialisation. In many cases the evidence is found to benefit the wider society. Positive effects are reflected on policy-making, healthcare, the environment, and improvements in quality of life.
- Commercial exploitation of research often involves long-term, strategic partnerships and collaborations with business and industry.
- TTO played significant role and having effective TTO is important.

The lessons suggest that the definition of commercialisation should be expanded and viewed as a long-term strategy that requires continuous support and linkages, especially with industry. Effective patenting strategy is required to ensure that money is not wasted on inventions that have no potential.

Source: Russel Group Papers 2010

Further Reading 2-2

Governance of R,D&C



Source: EPU 2012

Further Reading 2-3

Correlation analysis on the drivers of publication and patent output

Correlation analysis

1. There is a high correlation between outputs (publications and patents) and amount of research funding and number of researchers with PhD qualification. The contribution of amount of R&D funding is greater for publications than patents.

   Every 1% increase in the amount of R&D spending increases publication by about 2%, while for patent it is only 0.7%. On the other hand, every 1% increase in human capital contributes nearly 7% increase in publication and 0.9% for patent.

   This shows that the ROI on R&D investment is greater for publications than patents. However, this is understandable, given that patent application and granted requires time to materialise. Comparatively, the costs of increasing patents are greater than publications.

2. As for the patent outputs, there is no clear distinction between research universities (RUs) and non-research universities (non-RUs). However, there is a strong positive correlation between the amount of funding and patent outputs. Based on the panel regression analysis, the threshold amount seems to be RM14 million.

3. For both publications and patent outputs, the contribution of human capital (number of researchers with PhDs) is greater than the amount of R&D funding.

It suggests that human capital development is a crucial part of policy instrument to improve the performance of the universities. More emphasis should be given to training and skills upgrading among researchers. Recent micro level study indicates the following:

a) Human capital plays a more important role for publications and patents than funding; and
b) Researchers with applied research, consulting experience and spin-off experience are more likely to patent, license technology and get involved in start-ups.

As a whole, the drivers of performance in the university, e.g. publications and patents, indicates the relative contribution of human capital is larger than R&D expenditure. In other words, having quality researchers and scientist have greater impact on the outputs compared to amount of R&D spending.

Source: Chandran et al. 2014

Further Reading 3-1

The impact of technical/technology upskilling on industry and economic growth in Malaysia

Background

It is common to think that investing in STI will lead to economic growth through productivity search of all factors used to produce economic outputs. Such presumption suggests more outputs can be generated using the same amount of inputs. From the technical and economic perspective, such technological change is known as total factor productivity, where the ratio of input used by the various industries in the economy remains the same (i.e. the ratio of skilled labour to unskilled labour, or labour to capital ratio).

Yet, in Malaysia's case, there are arguments that technical change may be biased towards skilled labour. For instance, most national policy on R&D and STI have been directed towards the creation and utilisation of more skilled manpower relativeto unskilled labour. Over the decades, Malaysia has also witnessed improvements in higher education infrastructure, attainment of tertiary education, along with the development of skills, technology and innovation. So we may presume that capital deepening and associated technologies are complementary with the employment of skilled labour not with all inputs. The literature describes any improvements in production technology results in increases in relative demand for skilled (higher education, more productive and efficient) over unskilled manpower as skill-biased technical change (SBTC).

This section appraises the economy and region-wide effects of SBTC in Malaysia using the general equilibrium, multiple country Global Trade Analysis Project (GTAP) model. The analysis is aimed at obtaining quantitative insights on which sectors are relatively more impactful to the Malaysian economy in terms of selected macroeconomic indicators such as industrial outputs, demand for skilled labour, trade balance, GDP and welfare. The use of the multiple country models enabled the analysis of impact on SBTC to not only be conducted in Malaysia but also other economies, particularly ASEAN countries.

However, this study did not attempt to ascertain whether there has been any technical change in the Malaysian economy due to STI. The study presumes that STI in Malaysia results in SBTC and appraises its impact in the economy and other regions.

Application of the GTAP Model

For this study, 118 nations in the GTAP8 database were aggregated into 11 regions. For a detailed exposition of the results, Malaysia is modelled as a single, separate country whereas the aggregated regions are:

1. Oceania
2. East Asia (encompassing Japan, South Korea and China)
3. Malaysia
4. South East Asia (All ASEAN member countries except Malaysia)
5. South Asia (encompassing India, Pakistan, Bangladesh)
6. North America (encompassing USA, Mexico and Canada)
7. Latin America
8. EU-25
9. MENA (Middle East and North Africa)
10. SSA (Sub Saharan Africa)
11. Rest-of-the World (Rest of the World Aggregate)

The GTAP8 database carries 57 commodity sectors. This study aggregates them into 10 major sectors as shown in the following table. The table shows the mapping of the aggregated sectors with 11 out of the 12 NKEAs in Malaysia. Note that it is not a one-to-one mapping as the GTAP commodity aggregates were based on standardised international commodity groups drawn from CPC and ISIC. Some NKEA sectors particularly oil, gas and energy appear in more than two commodity aggregates (i.e. extraction; heavy manufacturing; and utility and construction). This is due to the nature of the sector itself, which has both upstream and downstream linkages, as well as services sector within the utility industry.

Commodity Aggregates	Commodity Components (GTAP labels/codes)	Malaysia NKEA Sectors
1. Grains Crops (*GrainsCrops*)	Paddy rice; Wheat; Cereal grains nec; Vegetables, fruits and nuts; Oil seeds; Sugar cane and beets; Plant-based fibres; Crops nec; Processed rice	Agriculture
2. Meat and Livestock (MeatLstk)	Meat: Cattle, sheep, goats, horses; Animal products nec; Raw milk; Wool, silk-worm, cocoons; Meat: ; Meat products nec	
3. Extraction	Forestry; Fishing; Coal; Oil; Gas; Minerals nec	Oil, gas and energy
4. Processed Food (ProcFood)	Vegetable oils and fats; Dairy products; Sugar; Food products nec; Beverages and tobacco products	Palm oil; Agriculture
5. Textiles and Apparels (TextWapp)	Textiles; Wearing apparel	
6. Light Manufacturing (LightMnfc)	Leather products; Wood products; Paper products/ publishing; Metal products; Motor vehicles and parts; Transport equipment nec; Manufactures nec	Rubber
7. Heavy Manufacturing (HeavyMnfc)	Petroleum, coal products; Chemical, rubber, plastic products; Mineral products nec; Ferrous metals; Metals nec; Electronic equipment; Machinery and equipment nec	Oil, gas and energy; Electrical and Electronics; Palm oil and rubber
8. Utility and Construction (Util_Cons)	Electricity; Gas manufacturing, distribution; Water distribution; Construction	Oil, gas, and energy
9. Transportation and Communication (TransComm)	Trade (retails); Transport nec; Sea transport; Air transport; Communication	Communication and infrastructure; Wholesale and Retail
10. Other Services (OthServices)	Financial services nec; Insurance; Business services nec; Recreation and other services; Public Admin/Defence/Health/Education; Dwellings	Financial services; Business services; Education; Health care; Tourism

Policy Simulations and Results

We presume that there was a 3% improvement in technological efficiency within the major economic sectors, leading to an increase in demand for skilled labour in Malaysia. Such technical improvement as aforementioned maybe due to capital deepening along with the adoption of better production technologies, including innovation and advancement in information technology. We performed seven simulation scenarios. Each scenario examined the effects of a 3% SBTC within the following seven aggregate sectors separately (ceteris paribus):

1. Heavy Manufacturing
2. Light Manufacturing
3. Extraction
4. Transportation and Communication
5. Utilities and Construction
6. Other Services
7. Processed Food.

Note that sectors 4, 5 and 6 above are categorised as services sectors. To allow meaningful comparison of economic effects on industry outputs and demand for labour inputs, the simulation is done individually for the selected sectors. The effects on GDP, welfare and trade balance of Malaysia and other regions were also examined. Table 1 shows the implication of SBTC on demand for labour and industrial outputs in Malaysia, which are expressed in percentage changes. Table 2 depicts the results on trade balance, GDP and welfare of Malaysia and other regions. GDP is in the form of percentage change, while trade balance and welfare are expressed in US$ million.

Effects on Demand for Labour in Malaysia

As expected, demand for skilled and unskilled labour for most sectors increases and decreases, respectively. The rate of change varies across sectors. For skilled labour, it ranges from 0.23% to 1%, while for unskilled workers it drops between -0.28% and -0.04%. These results denote the elasticity of substitution between skilled and unskilled labour for the respective sectors has been inelastic (less than 1).

Given a 3% rise in own sector's SBTC, demand for skilled labour within the transportation and communication sector (Scenario 4) is poised to soar most by 1%. Note this sector contains the NKEAs on communication and infrastructure, and wholesale and retail.

The only sector that will see considerable decline in the demand for skilled labour given a SBTC is the extraction sector (Scenario 3). This sector includes the extraction of forestry products, fishing, coal, oil, gas and minerals. In an economy-wide modelling framework, as utilised by this study, it is important to note that the decline in demand for skilled labour in this sector will be outweighed by increases in the demand for unskilled labour. This suggests high substitution elasticity (greater than 1) between skilled and unskilled labour within the extraction industry.

The effects on demand for labour in all sectors due to SBTC resulting from any individual sector is also provided in Table 1. Generally, the demand for skilled labour in other sectors increased while unskilled labour decreased, as the former and other primary production factors are drawn towards the sector that experienced increases in SBTC.

Effects on Industrial Outputs in Malaysia

Industrial outputs for all sectors are expected to increase with the other services sector showing the largest change. This sector comprises of the financial services, insurance, public administration and education subsectors. It also encompasses the NKEAs of financial services; business services; education; health care; and tourism.

Increases in SBTC in the individual services sectors (scenarios 4, 5 and 6) will induce substantial increases in industrial outputs in most other sectors. On the other hand, increases in SBTC in any manufacturing sector tend to reduce industrial outputs of other manufacturing sectors. This is attributed to the decline in relative demand for skilled labour in the respective sectors. However, as expected, the outputs of the services sectors are projected to rise, given increases in SBTC in the manufacturing sectors. In particular, the outputs of the utility and construction, and transportation and communication sectors will rise more pronouncedly given increases in SBTC in the heavy manufacturing sector, as compared to a similar technical change in the light manufacturing sector.

Effects on Trade Balance

SBTC in the various economic sectors in Malaysia is likely to produce a positive impact to the country's trade balance, except in Scenario 5 (SBTC in the Utility and Construction services sector). Note that this particular analysis does not consider whether Malaysia would eventually face a trade deficit or surplus after the technical change. The emphasis has been on whether or not the overall trade balance would improve or decline.

The study found that Scenario 1 (SBTC in the Heavy Manufacturing sector) and Scenario 4 (SBTC in Transportation and Communication services sector) would yield comparable benefits of some US$10 million per year.

Results show the trade balance for most ASEAN member countries (SEAsia) will be made worse off except in Scenario 7 (SBTC in Processed Food) where their combined trade balance will improve marginally. In general Scenario 1 (SBTC in Heavy Manufacturing), followed by Scenario 4 (SBTC in Transportation and Communication) produce more adverse trade balance effects in other countries, particularly EU-25, East Asia, North America, and other ASEAN countries (SEAsia).

Effects on GDP

The GDP for Malaysia will either improve marginally or no change at all under any SBTC scenario. Scenario 6 Scenario 4 (SBTC in Services) is likely to produce the highest marginal impact of 0.13%, followed by Scenario 1 (SBTC in Transportation and Communication) at 0.06%.

Effects on Welfare

The welfare impact of any exogenous policy change or economic shocks such as freer trade or technical change, as in this study, is examined by estimating the welfare change indicator. Note that the GDP yardstick has never been an adequate measure of welfare change. This study uses the Equivalent Variation criterion to measure the change in welfare within each country. In a nutshell, the Equivalent Variation estimates the amount of income needed to compensate all economic sectors in Malaysia should the SBTC does not occur. Technically, it encompasses the monetary value of changes in resource allocation efficiency, terms of trade, and other sources of welfare change.

Interestingly, results indicate Scenario 6 (SBTC in other services) would lead to the largest gain in welfare, worth some USD220 million per year. As discussed earlier, this sector largely comprises the financial services, insurance, public administration, and education subsectors. The next largest welfare gain for Malaysia is likely to be realised under Scenario 4 (SBTC in transportation and communication), followed by heavy manufacturing and again the services sector (utility and construction).

It is also interesting to note that SBTC in either sector in Malaysia may lead to considerable welfare gain in other ASEAN countries, while all other countries may experience either a small gain or loss. A SBTC in the transportation and communication sector, in particular, will see other ASEAN countries enjoying a welfare gain of US$6 million in aggregate.

Summary, Policy Implication and Conclusion

Capital deepening, human resource development, technology augmentation and innovation in Malaysia may induce a rise in technical change which is biased towards skilled labour. A presumed increase in SBTC in Malaysia will induced greater relative demand for skilled labour over unskilled labour within the sector experiencing the efficiency gain, except the extraction sector. Results from the comparative analysis of sectors indicate the demand for skilled labour is most pronounced for transportation and communication services sector.

Results suggest the industrial outputs for the sector experiencing SBTC will rise, with the other services sector having the biggest impact. This sector comprises the financial services, insurance, public administration, and education subsectors. Generally, a SBTC within the non-services sectors would induce a rise in industrial outputs in the services sectors, particularly the utility and construction, and transportation and communication sectors. Furthermore, SBTC would result in an improved trade balance for Malaysia. SBTC in heavy manufacturing, and transportation and communication may produce more adverse trade balance effects in other countries, particularly EU-25, East Asia, North America and other ASEAN countries.

While the impact of SBTC on Malaysia's GDP would be minute, from the welfare perspective, SBTC in the services sectors, particularly their services, transportation and communication, as well as utility and construction would likely to produce substantial welfare gain to Malaysia. Other ASEAN countries (SEAsia), in particular, will also benefit from a SBTC in Malaysia.

Based on the welfare criterion, overall results suggest Malaysian industrial policies may be directed towards inducing a technical change within the services sectors (all services sector within the NKEAs), particularly the other services sector which comprises the financial services, insurance, public administration, tourism and education subsectors [Figure (a)]. The next area of focus is the transportation and communication services followed by heavy manufacturing, and utility and construction. It is imperative to ensure that genuine capital and technological advances are taking place in these sectors. Note that the heavy manufacturing sector here largely utilises Malaysia's own natural resources as inputs such as crude oil, palm oil and rubber products, which maximises the local value added content, as well as minimises leakages in the economy.

It is important to note that this study only examined the economy-wide effects of SBTC in the individual economic sector separately, presuming no change in all other sectors. In a general equilibrium framework, as utilised in this study, the economy-wide effects are likely to be more pronounced and the direction of impacts may be significantly altered should all the SBTC occur simultaneously in all economic sectors. Such analysis is, however, beyond the scope of this study.

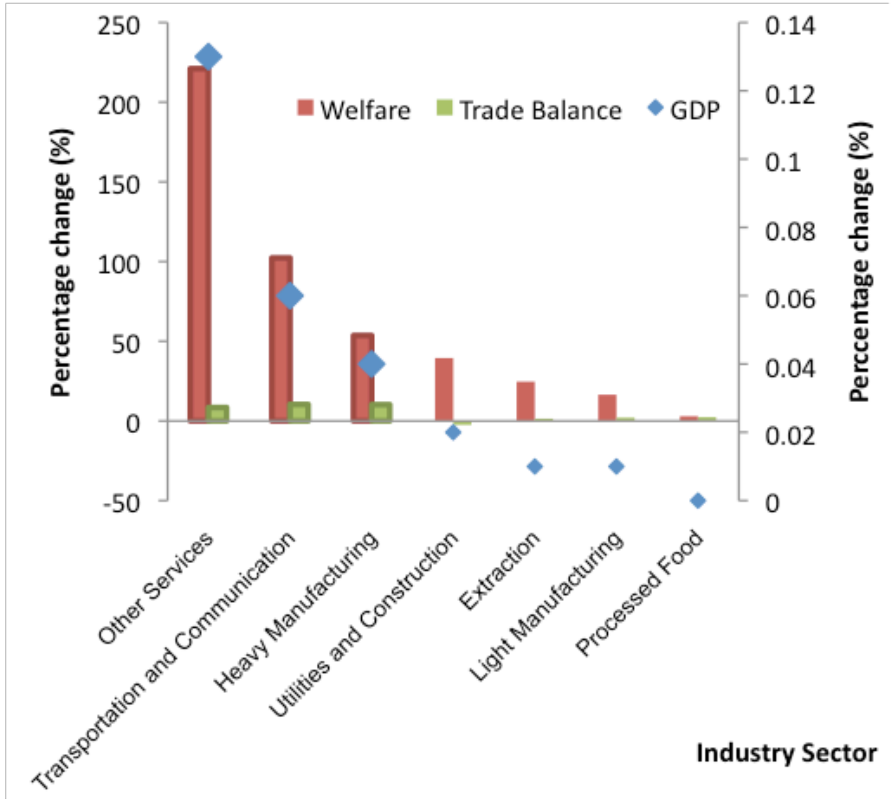


Figure (a). The impact of technology upskilling on industry and economic growth in Malaysia

Table b1. Effects of a 3% SBTC on demand for labour and industrial outputs (percentage change).

Scenario / Sectors	Heavy Manufacturing			Light Manufacturing			Extraction			Transportation & Communication		
	Skilled Labour	Unskilled Labour	Industrial Output	Skilled Labour	Unskilled Labour	Industrial Output	Skilled Labour	Unskilled Labour	Industrial Output	Skilled Labour	Unskilled Labour	Industrial Output
1	-0.046	-0.022	-0.012	-0.01	0	0	0.02	0	0	-0.06	0.04	0.02
2	-0.059	-0.013	0	-0.01	0	0	0.04	0	0	-0.1	0.07	0.04
3	-0.037	-0.032	-0.014	-0.01	0	0	**-2.27**	**0.05**	**0.05**	-0.06	0.01	0
4	-0.129	-0.03	-0.028	-0.03	0	0	0.09	-0.01	0	-0.32	0.06	0.03
5	-0.211	-0.099	-0.098	-0.04	-0.01	-0.01	0.1	-0.01	-0.01	-0.35	0.08	0.05
6	-0.134	-0.022	-0.023	**0.7**	**-0.04**	**0.17**	0.11	0	0	-0.33	0.1	0.06
7	**0.589**	**-0.069**	**0.165**	-0.03	0	-0.01	0.1	-0.01	0	-0.3	0.14	0.09
8	-0.083	-0.039	0.035	-0.02	-0.01	0.01	0.12	0	0.01	-0.36	0.11	0.06
9	-0.093	0.052	0.043	-0.03	0.01	0.01	0.14	-0.01	0.01	**1.01**	**-0.28**	**0.14**
10	-0.103	0.009	-0.011	-0.02	0.01	0	0.1	-0.01	0.02	-0.3	0.13	0.02
11	-0.013	0.076	0.058	-0.01	0.02	0.01	0.09	0	0.02	-0.18	0.16	0.07

Table b2. Effects of a 3% SBTC on demand for labour and industrial outputs (percentage change).

Scenario / Sectors	Utilities & Construction			Other Services			Procesed Food		
	Skilled Labour	Unskilled Labour	Industrial Output	Skilled Labour	Unskilled Labour	Industrial Output	Skilled Labour	Unskilled Labour	Industrial Output
1	-0.01	0	0	-0.05	0.01	0	0.02	0.02	0.01
2	-0.02	0.01	0.01	-0.08	0.03	0.02	0.01	0.01	0
3	-0.01	0	0	-0.06	-0.02	-0.01	0	0	0
4	-0.07	0	0	-0.23	0.01	0	**0.25**	**-0.1**	**0.04**
5	-0.05	0.03	0.02	-0.23	0.05	0.03	-0.01	-0.01	0
6	-0.06	0.02	0.02	-0.22	0.06	0.04	0	0	0
7	-0.06	0.02	0.02	-0.25	0.02	0	0	0	0
8	**0.73**	**-0.26**	**0.08**	-0.12	0.18	0.15	0	0	0
9	-0.08	0.03	0.02	-0.23	0.12	0.08	0	0	0
10	-0.05	0.04	0.02	**0.23**	**-0.26**	**0.5**	0	0	0
11	-0.01	0.05	0.04	-0.08	0.13	0.08	-0.01	0	0

Legend

1 GrainsCrops
2 MeatLstk
3 Extraction
4 ProcFood
5 TextWapp
6 LightMnfc
7 HeavyMnfc
8 Util_Cons
9 TransComm
10 OthServices
11 CGDS (capital goods)

Table c1. Effects of a 3% SBTC on certain variables for regions and Malaysia (% change except trade balance and welfare) (in US$ million).

Scenario / Country	Heavy Manufacturing			Light Manufacturing			Extraction			**Transportation & Communication**		
	Trade Balance	GDP	Welfare	Trade Balance	GDP	Welfare	Trade Balance	GDP	Welfare	Trade Balance	GDP	Welfare
1	-0.5	0	1.274	-0.21	0	0.51	-0.03	0	-0.37	-0.44	0	1.11
2	-2.667	0	-0.085	0.09	0	-0.49	-0.4	0	4.16	-2.92	0	-0.71
3	**10.223**	**0.04**	**53.649**	**2.07**	**0.01**	**16.43**	**1.41**	**0.01**	**24.66**	**10.35**	**0.06**	**102.31**
4	-1.304	0	7.34	-0.45	0	1.26	-0.37	0	0.3	-0.92	0	5.71
5	0.297	-	-0.97	0.11	0	-0.21	-0.2	0	1.12	0.3	0	-0.72
6	-2.188	0	3.806	0.07	0	-0.61	0.75	0	1.02	-2.18	0	3.11
7	-0.281	0	0.751	-0.11	0	0.45	-0.07	0	-0.63	-0.37	0	0.99
8	-3.528	0	-4.022	-1.23	0	-1	0.86	0	2.45	-3.96	0	-0.29
9	-0.157	0	0.69	-0.11	0	0.78	0.12	0	-0.89	0.11	0	0.89
10	-0.244	0	0.734	-0.22	0	0.7	0.16	0	-1.09	-0.29	0	1.41
11	0.35	0	3.275	-0.03	0	3.73	0.99	0	-4.45	0.3	0	4.15

Table 2b. Effects of a 3% SBTC on selected variables for regions and Malaysia (% change except trade balance and welfare in US$ million).

Scenario / Country	**Utilities & Construction**			**Other Services**			**Procesed Food**		
	Trade Balance	GDP	Welfare	Trade Balance	GDP	Welfare	Trade Balance	GDP	Welfare
1	-0.02	0	0.14	-0.26	0	1.35	-0.01	0	0.03
2	0.44	0	-2.4	-2.54	0	1.9	-0.56	0	0.58
3	**-2.49**	**0.02**	**39.45**	**8.43**	**0.13**	**221.07**	**2.37**	**0**	**2.96**
4	-0.2	0	1.39	-0.11	0	2.61	0.06	0	0.3
5	0.18	0	-0.54	0.51	0	-1.34	-0.01	0	0.24
6	1.02	0	-0.79	-0.77	0	-0.32	-0.64	0	0.26
7	0.16	0	-0.07	-0.93	0	2.46	-0.09	0	0
8	0.56	0	-1.35	-2.8	0	11.74	-0.89	0	0.16
9	0.04	0	0.2	-0.17	0	1.8	-0.03	0	0.07
10	-0.09	0	0.35	-0.76	0	2.5	0	0	0.22
11	0.4	0	0.61	-0.6	0	10.43	-0.19	0	0.28

Legend

1 Oceania
2 East Asia
3 Malaysia
4 SE Asia
5 South Asia
6 North America
7 Latin America
8 EU-25
9 MENA
10 SSA
11 Rest of the World

Further Reading 3-2

Brain drain and the role of TalentCorp

1. Brain drain is a common phenomenon among middle-income countries. Such countries experience the highest migration rates as talent has both the means and incentives to migrate. The incentive to migrate is driven by the attractiveness of income levels, career opportunities and the quality of life in other countries.
2. The outflow of Malaysian talent is increasing. It is estimated that about 4% of the country's population resides overseas, approximately 40% in Singapore. More than 300,000 Malaysians – many of whom possess tertiary qualifications – have migrated in recent years. In 2010, there were approximately one million Malaysians living and working in other countries (a third of whom comprised skilled individuals aged 25 years and above with tertiary-level education).
3. Malaysia's brain drain intensity is high. Although other countries in the region have seen a more rapid increase in their respective diaspora over the period 1990-2000, relative to the domestic skills base, Malaysia ranks high in the chart on brain drain intensity. This suggests that, despite slower emigration than elsewhere, Malaysia's stock of human capital domestically has not grown as fast as other nations. While the brain drain intensity has fallen in Malaysia, as it has elsewhere in the world, it still remains high [Table (a)].

Table (a). Brain drain scenarios in selected countries (figures in thousands)

	1990 High-Skill at Home	1990 High-Skill Overseas	2000 High-Skill at Home	2000 High-Skill Overseas	1990 Brain Drain Intensity (%)	2000 Brain Drain Intensity (%)
China	11,593	359	19.893	783	3.0	3.7
Hong Kong	379	182	696	292	32.5	29.5
Japan	17,399	233	22,128	278	1.3	1.2
Korea	3,083	335	7,565	613	9.8	7.5
Malaysia	222	79	818	96	26.2	10.5
Singapore	84	28	279	47	25.3	14.4

Source: The World Bank 2011

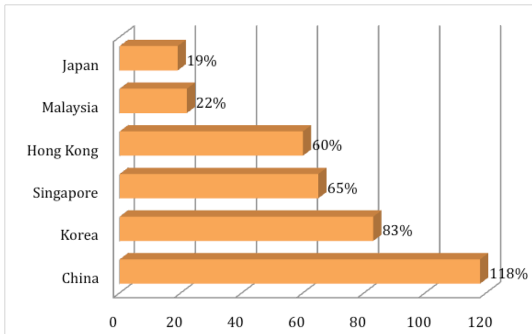


Figure (a). Decade-on-decade growth foreign-born high-skill migrant stock (%), 1990-2000
Source: The World Bank 2011

4. To remedy brain drain, TalentCorp was established in 2011 to retain talent and attract skilled Malaysians from abroad to fill the country's growing deficit in skilled manpower. In 2011, 680 applications were approved under the Returning Expert Programme (REP) scheme, which was more than double the previous year.
5. On top of bringing back talent, TalentCorp is also partnering with the Government to enhance the skills level of the workforce and ease transition from school to work place. Responding to calls for greater exposure to careers in NKEA sectors, the Government – in collaboration with MOE and TalentCorp – opened up 12,000 internship positions in companies of relevant industries in 2011. To promote internships, Budget 2012 offers double deduction tax incentives for approved internship programmes.
6. Together with EPU, TalentCorp coordinates upskilling programmes for graduates to ensure resources are invested on priority areas. The programmes are projected to benefit close to 10,000 graduates yearly, mainly engineers, involving an allocation worth about RM200 million per annum across various ministries.
7. TalentCorp, JPA, is providing scholarships for students who have gained entrance to top universities of the world. In 2011, JPA and TalentCorp introduced the Scholarship Talent Attraction and Retention (STAR) and Talent Acceleration in Public Service (TAPS). Those attaining 9A+ plus and above in their 2011 SPM exams will receive bursaries and funded to enter university, conditional on gaining entrance to a top global university.

Source: The World Bank 2011

Further Reading 3-3

Is the poor performance on various rankings and scores instrumental in dissuading the public away from STEM and related subjects?

1. When Malaysia first participated in the TIMSS in 1999, the average student score was higher than the international average in both Mathematics and Science. By 2011, in the last published cycle of results, the performance had slipped to below international average. Critically, 35% and 38% of our students failed to meet the minimum proficiency levels in Mathematics and Science, up from 7% and 13% respectively in 1999.

2. The number of top-performing students is also low in comparison to other countries, meaning that Malaysian students, in general, are under-performing. A breakdown of student performance in the TIMSS 2011 results shows that only 1%-2% of Malaysian students perform at the highest benchmark level, such as complex problem-solving, compared to more than 40% of students in Singapore.

3. Results for the PISA are also discouraging. In 2009, the first time Malaysia participated in PISA, the country was placed at the bottom third of 74 participating countries, below the international and OECD average. Almost 60% of the 15-year-old Malaysians who participated failed to meet the minimum proficiency level in Mathematics, while 43% did not meet the minimum proficiency levels in Science. Our performance was not driven by urban-rural disparities, as students from large cities similarly under-performed relatively to peers in other East Asian cities.

4. Malaysia's performance shows a minimum three-year lag vis-à-vis higher performing regional countries. A comparison of scores shows that 15-year-olds in Singapore, South Korea, Hong Kong and Shanghai are performing as though they have had three or more years of schooling than 15-year-olds in Malaysia. Data as of 2010 indicates that Malaysia's performance lags behind other countries that have similar or lower levels of expenditure per student, such as Thailand, Vietnam, Chile and Armenia.

Source: The World Bank 2013

Further Reading 3-4

The Vietnamese experience

In seeking to improve the performance of Malaysian students, it is worth looking at changes that were implemented in the educational system in Vietnam, which was a star performer in the 2012 PISA, scoring higher than the OECD average in all three components of Science, Mathematics and English. Some of the changes made to the education ecosystem in the country which could explain its outstanding results are listed below:

1. Improvements in teaching quality: In 2013, nearly 60% of all primary school teachers in Vietnam held a college or university degree, double the percentage from 2006. The Vietnamese education system is also highly equitable: few teachers, including those working in disadvantaged neighbour hoods, perform poorly in assessments of their knowledge for teaching. In addition, teacher attendance is very high.
2. National-level exams are mixed with school-based assessments: Classroom assessments with written and oral tests, as well as marked assignments and homework are used to provide real-time feedback on students' performance to inform teaching, while after grade 12 (equivalent to Malaysia's Upper 6), national examinations are used to inform high-stakes decisions about students' progression to the next level in the system.
3. Full-day schooling: The government embarked on an expansion of full-day schooling. About 51% of schools provide full-day schooling to all pupils, with 40% on a pro-bono basis. Schools use the additional time for strengthening of Mathematics and Vietnamese; subjects that would otherwise be limited under the half-day school such as music, arts, foreign languages and IT; and remedial programmes for weak performing students.
4. Modern curriculum and greater parent participation: Vietnam has adapted a Colombian teaching model called Escuela Nueva, which emphasises group learning and problem solving over rote memorisation and copying. Students are taught at their own pace, and parents have the opportunity to be a part of the learning process as well as contribute to learning content. The latter is particularly meaningful in ethnic minority regions, where parents are encouraged pay a visit to schools to share their cultural traditions. The government is now scaling up the original pilot of 24 schools in six provinces to 1,500 schools in all 63 provinces.

Source: The World Bank 2013

Further Reading 3-5

Approaches implemented in STEM teaching

Approach	Description	Pros	Cons	Adaptations
Inquiry	Originated in the USA. Involves the use of scientific inquiry to help students make connections between ideas and facts through; • Discussion • Open questioning • Higher order conceptual explanation	• Decrease in teacher-directed activities. • Increase in student-centric activities.	• Limits the interrelationship between conceptual ideas, investigative methods and societal applications. • Science ideas are not explored in local contemporary contexts.	1. Australia 2. Canada 3. France 4. Germany 5. UK 6. USA
Practical	Comprises activities such as: • Demonstrations; and • Experimental investigations linked to the development of ideas.	Students get to learn STEM through hands-on application.	Contents are organised as discrete factual information or problem solving algorithms, rather than as a connected set of ideas.	1. Australia 2. France 3. USA
Theoretical	• Involves the use of comprehensive and structured textbooks; • Aligns learning processes to the contents of the textbooks; and • Requires a great deal of memorising of materials and work through exercises.	Curriculum is more structured and uniform across the nation.	Does not place sufficient attention on other useful skills in science learning such as: • problem solving; • application of principles to novel situations; and • interpreting and predicting.	1. China 2. Malaysia

Source: International Gas Union 2012

Further Reading 3-6

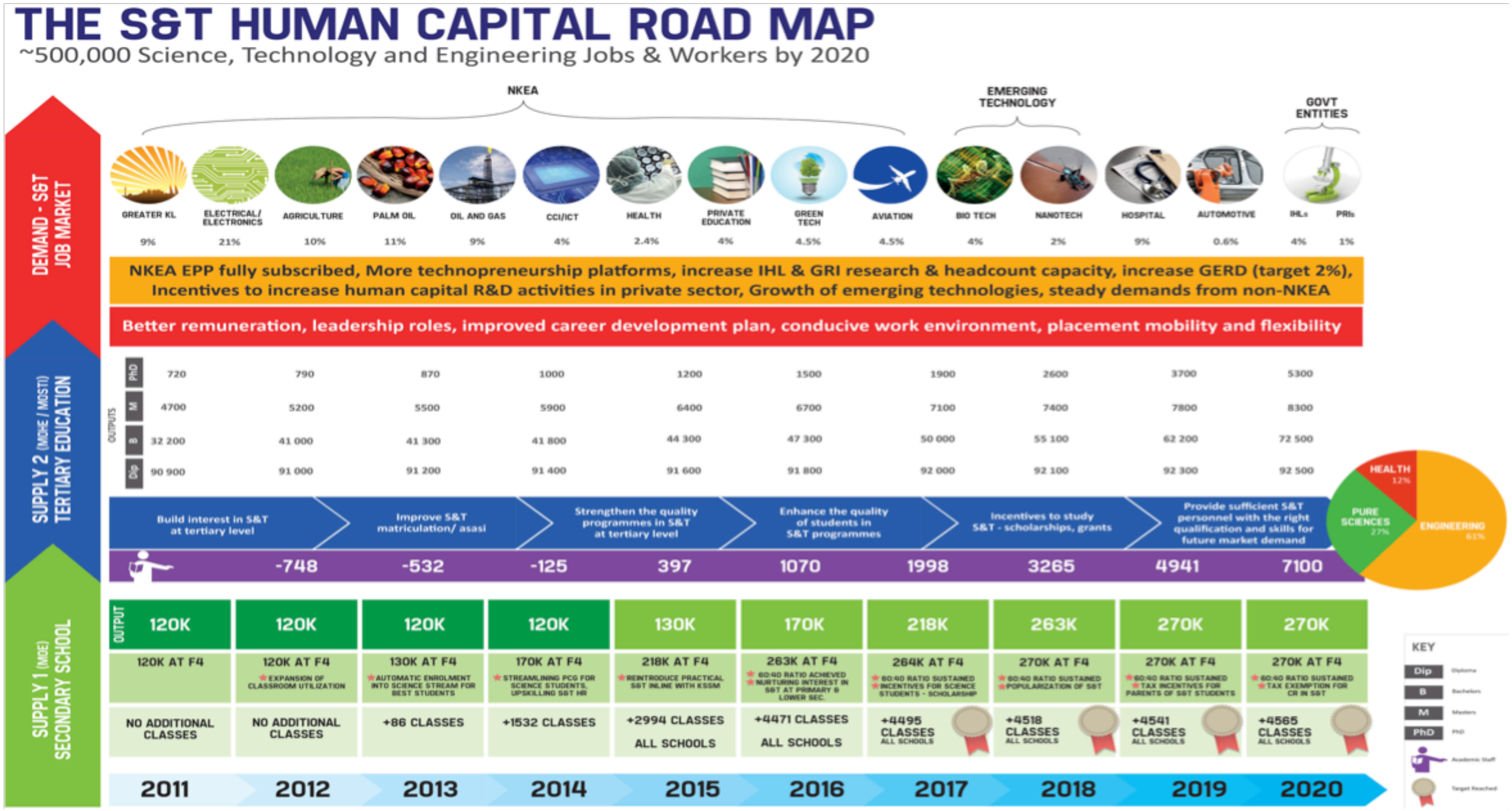
Critical skill shortage, 2002 and 2007

Skill	Percentage of respondent (%)	
	2002	2007
IT skills	4.1	20.4
Technical or professional skills	3.2	18.0
English language proficiency	47.5	16.5
Creativity and innovation skills	4.1	10.0
Professional communication skills	14.0	6.4
Team-working skills	6.6	5.9
Leadership skills	4.4	5.5
Time management skills	3.8	5.0
Adaptability skills	1.9	4.2
Problem-solving skills	1.4	4.0
Social skills	8.8	2.5
Numerical skills	1.1	1.6

Source: Innovation in Southeast Asia, Malaysia: Innovation Profile (OECD 2013)

Further Reading 3-7

Human Capital Roadmap for Science and Technology 2012–2020



Source: MOSTI 2012

Further Reading 4-1

Industry perception audit key findings

Demographics and Methodology

The Industry STI Perception Audit reflects the viewpoints of 49 industry leaders in Malaysia and was conducted from May to November 2014. Purposive sampling technique was used to cover stakeholders that most influence or are influenced by the STI industry.

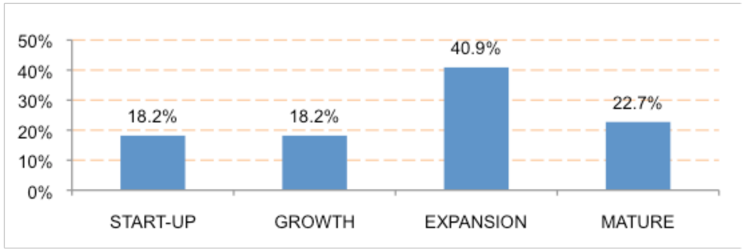


Figure (b). Business life cycle
Note: Only 45% of respondents shared their company business life cycle stage

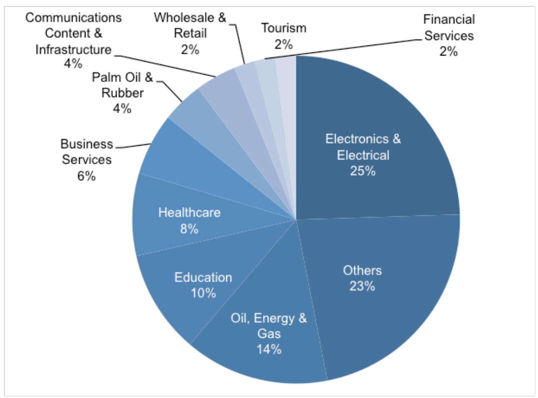


Figure (a). Industry sector

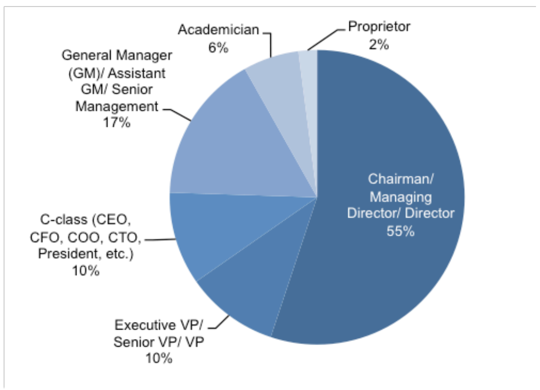


Figure (c). Title / position

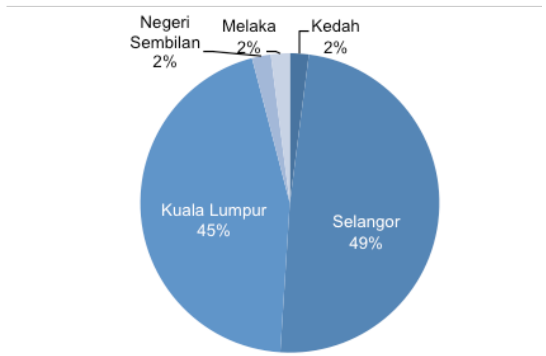
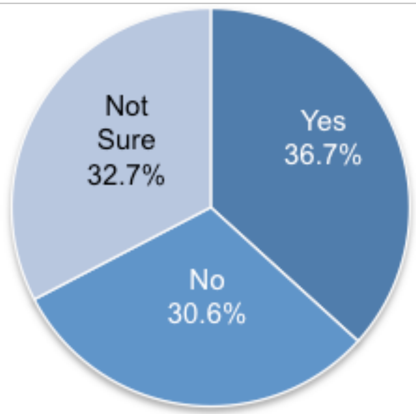


Figure (d). Location

Key Findings

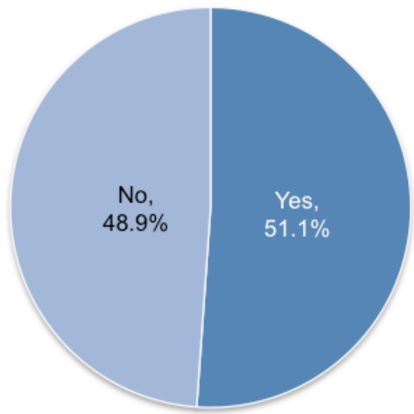
Q1. Are you aware of any national policies/ or and infrastructure that supports SMEs and the industry to achieve local, regional and global growth?



Top Three Mind Reads

- 30.6% of respondents are not aware of any national policies and do not know where to obtain the information.
- 36.7% of respondents are aware and have provided some examples such as National Science and Policy 2, MOSTI ICT Security Policy and National Biotech Policy. However, some of them felt that the policies lack in clarity in terms of direction.
- 32.7% of respondents were unsure of the policies related to them as they have not been consulted or informed on any policies that support their growth.

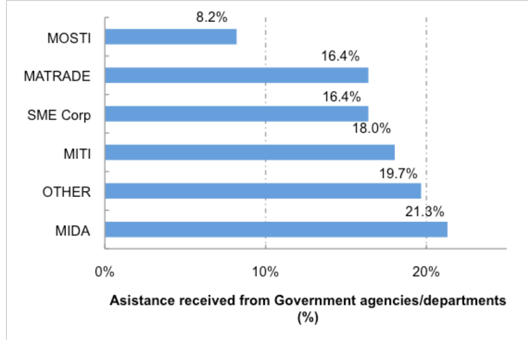
Q2. Have you previously received or currently receiving any assistance (financial/technical/training/programme) under the auspices of any government agency or department)?



Top Three Mind Reads

- 51.1% of respondents previously received or are currently receiving assistance (financial/ technical/training/programme) under the auspices of Government agency or department.
- 48.9% of respondents do not receive any assistance and remain independent. In regards to finance, most of them are self-funded.
- Some listed their top source of assistance as Malaysia Electricity Supply Trust Account (MESITA), SME Bank, Multimedia Super Corridor (MSC), Human Resource Development Fund (HRDF), Malaysian Debt Ventures Berhad, CISCO, Ministry of Finance, SOCSO, MITI & TERAJU.

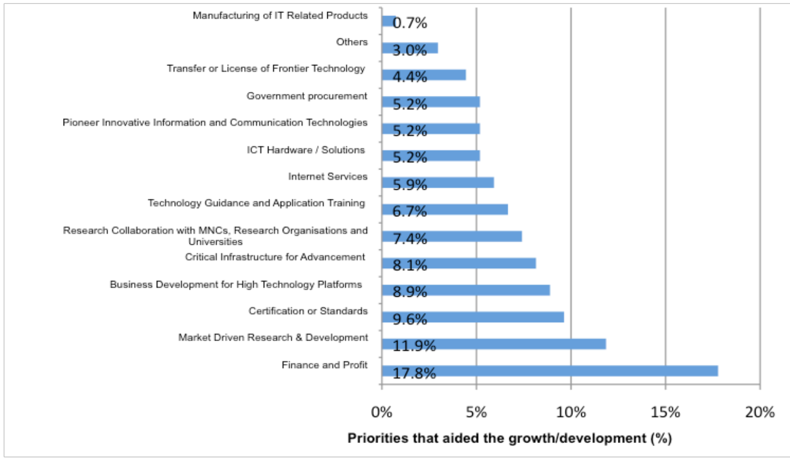
Q2 (a). List of Government Agencies and/or Departments



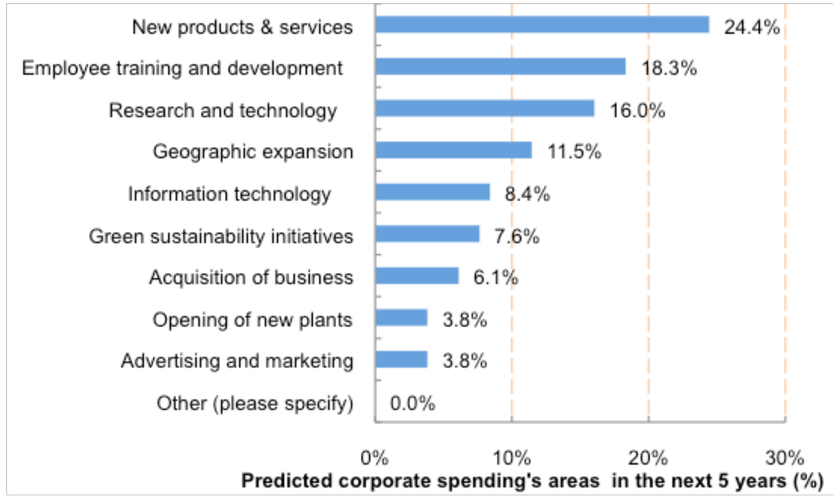
Top Three Government Agencies/Departments

- 21.3% of respondents selected MIDA as the source of assistance.
- As many as 19.7% respondents listed other sources of assistance such as HDRF, MSC, MOF and many more.
- 18.0% of respondents selected MITI as their source of assistance.
- Some respondents shared that it was challenging to get approval for funding due to the processes involved. They also feel that there should be less bureaucracy in the funding process.

Q3. What were the top three priorities that aided the development or growth of your business in the past three years?



Q4. In which areas do you foresee an increase in your overall corporate spending in the next five years?



Top Three Priorities That Aided Growth/Development

- 17.8% of respondents chose Finance and Profit as the factor that aided the development or growth of their business.
- 11.9% of respondents chose Market Driven Research & Development as one of their priorities that aided their development and growth.
- As many as 9.6% of respondents chose Certification or Standards as a top priority which aided their development or growth, because they helped enhance the quality of their products/services as well as help level the playing field for them to compete on the global stage.

Top Three Priorities Areas for Corporate Spending

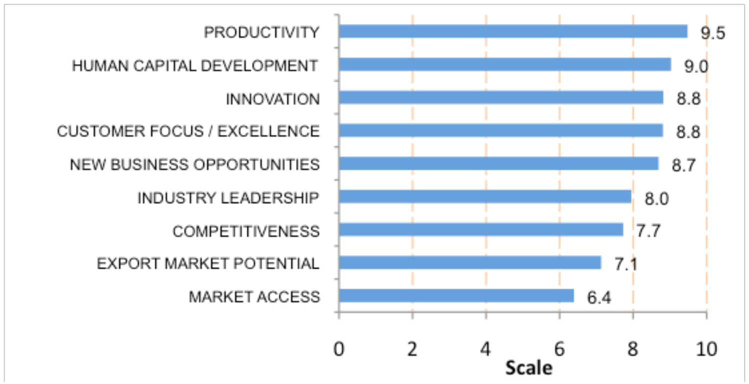
- 24.4% of respondents foresee an increase in overall corporate spending in New Products & Services. Respondents spend on technology to produce innovative products and enhance their services.
- 18.3% of respondents foresee an increase in overall corporate spending in Employee Training and Development. Respondents feel that they have to constantly invest in Human Capital Development to retain skilled workers.
- 16.0% of respondents foresee an increase in overall corporate spending in research and technology. Respondents feel the need to invest in research and technology as they need to ensure that they produce products with high quality. In addition, technology will help them increase productivity and save cost.

Q5. Can you share the top three issues, challenges and opportunities in your line of business [STI perspective]?

Top Issues, Challenges and Opportunities

- Lack of funds
- Lack of STI talent
- Lack of awareness on STI policies and infrastructure
- Lack of policy implementation/enforcement

Q6. How much does technology / ICT contribute in furthering your objectives?



*The scale is from 0-to-10. Scale 0 refers to no contribution and scale 10 refers to very extensive.

Top Three Parameters with Highest Score

- 9.5% of respondents chose productivity. Technology helps respondents complete their tasks at a faster rate. It also helps them save more time.
- 9.0% of respondents chose human capital development. Respondents use technology to enhance the skills of their workforce.
- 8.8% of respondents chose innovation. Respondents use technology to innovate their products to remain competitive.

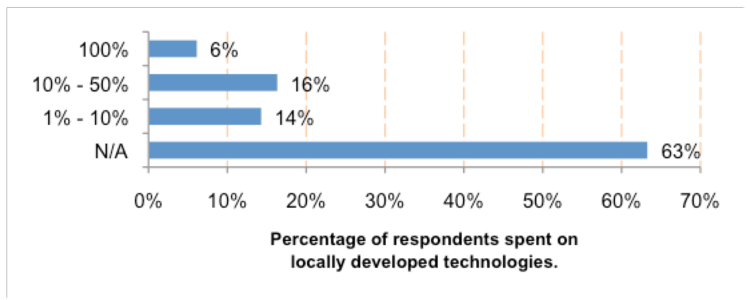
Q6(a). What has been the company's average annual spending for technology/ICT (e.g. license, procurement, maintenance)?

The highest average annual spending for technology/ICT is RM2 billion and the lowest is RM5,000-RM10,000.

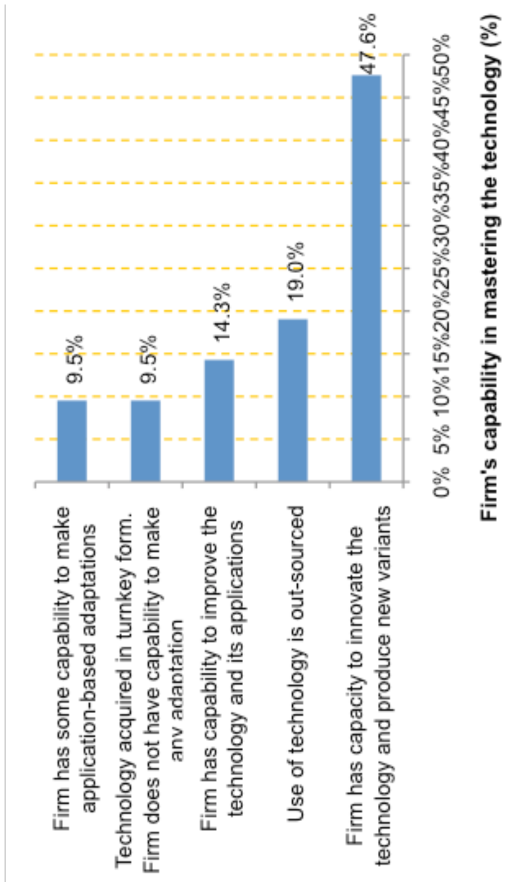
Company average annual spending for technology/ICT	Total respondents
Less than 0.1 million	2
Between 0.1 – 1 million	9
Between 1.1 – 10 million	7
Between 10 -100 million	2
More than 1 billion	3

*Note: 53% of respondents were reluctant to share figures due to company regulations.

Q6(b). Roughly what percentage of the expenditure is spent on locally developed technologies?



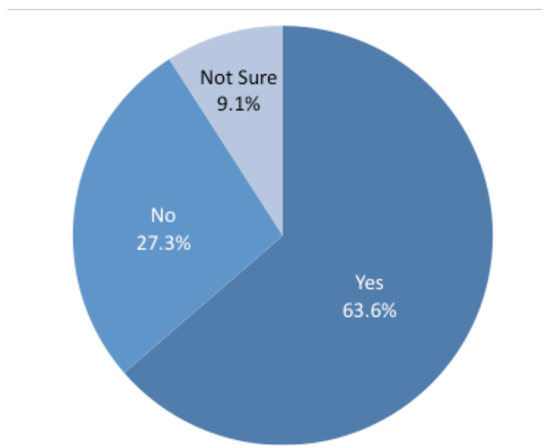
Q6(c). Please describe your firm's capability in mastering the technology?



Top Three Description of Firm's Capability in Mastering Technology

- As many as 47.6% respondents chose firm that has capacity to innovate the technology and produce new variants.
- As many as 19.0% respondents chose use of technology is out-sourced.
- As many as 14.3% of respondents chose firm that has capability to improve the technology and its applications.

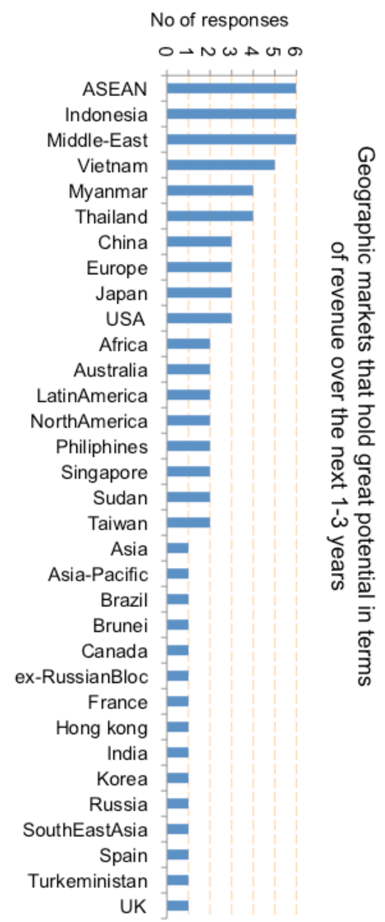
Q7. Are you currently also targeting international markets to grow your business?



Top Three Mind Reads

- As many as 63.6% respondents are targeting international markets to grow their business. They are targeting countries in the Asia Pacific, Middle East and Europe.
- As many as 27.3% respondents chose to focus on domestic markets to grow their business instead of targeting international markets.
- As many as 9.1% of respondents were not sure if they will target international markets any time soon.

Q7(a). Which geographic markets hold great potential in terms of revenue contributions over the next 1-3 years?



Q7(b). What are the top three challenges that you face in export markets?

- Lack of funds
- The pricing pressures
- Tough competition in market
- Lack of understanding the local law requirements, tax and regulatory compliance and local business culture
- Lack of talent
- Lack of international recognition of Malaysian products and services
- Regulatory compliance cost

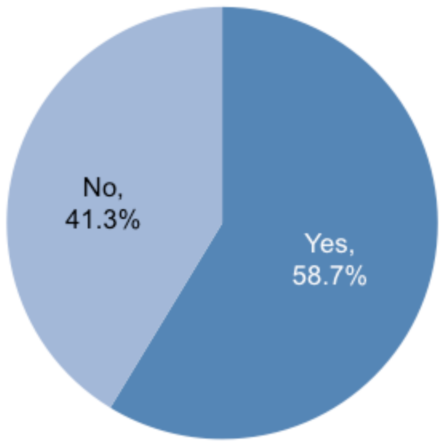
Q7(c). How do you fund your expansion currently and what are your sources?

- Self-funding
- Loans – private, government
- Internal profit
- Cess fund
- Leasing and partnering

Q7(d). How do you use STI to support your expansion plan?

- Relationships management
- Timely communication with clients, internal and external stakeholders
- Online training
- Marketing and sales support tool
- Product and facilities improvement -through R&D

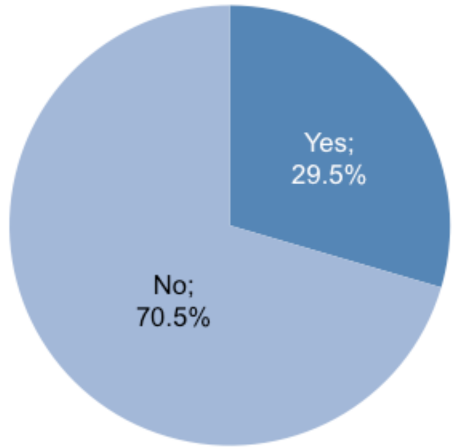
Q8. Does your company have a section/unit/ division/department devoted to R&D?



Top Two Mind Reads

- As many as 58.7% of respondents have a section/ unit/ division/ department. However, most of them do not own patents or R&D facilities.
- 41.3% of respondents do not have a section / unit/ division/ department because of lack of funds and R&D is not top priority.

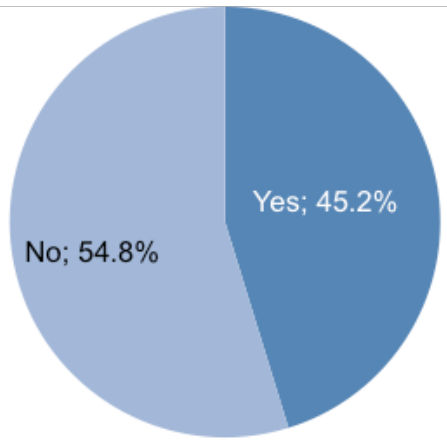
Q8(a). Do you have any existing partnership with any R&D institute or university that help you with product innovations etc.?



Top Two Mind Reads

- 70.5% of respondents chose the answer "No". Most companies felt that universities are not able to commercialise their products.
- 29.5% of respondents chose the answer "Yes". They had/have partnerships with universities such as USM, UKM. UTM, UITM, UPM, MMU, UNITEN and University Teknologi PETRONAS.

Q8(b). Do you have sufficient funds to engage in or outsource R&D?



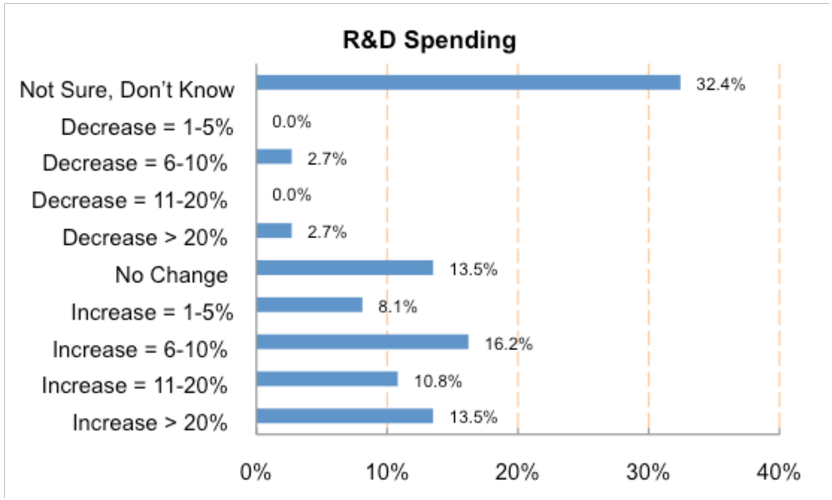
- 54.8% of respondents chose the answer "No". Most of the respondents felt that it is costly to engage in or outsource R&D and do not consider R&D as a top priority.
- 45.2% of respondents chose the answer "Yes" because they believe that engaging in R&D will benefit them in the long run.

Q8(c). What has been the company's/ organisation's R&D spending (annual average) in terms of % of turnover?

R&D spending in terms of % of turnover	2	4	5	10	15	20	30	50	90	300
Percentage of respondent (%)	11	5	5	11	16	11	16	16	5	5

*Note: 59% of respondents were either not at liberty to disclose their company's R&D expenditure, or the question was deemed not relevant to them.

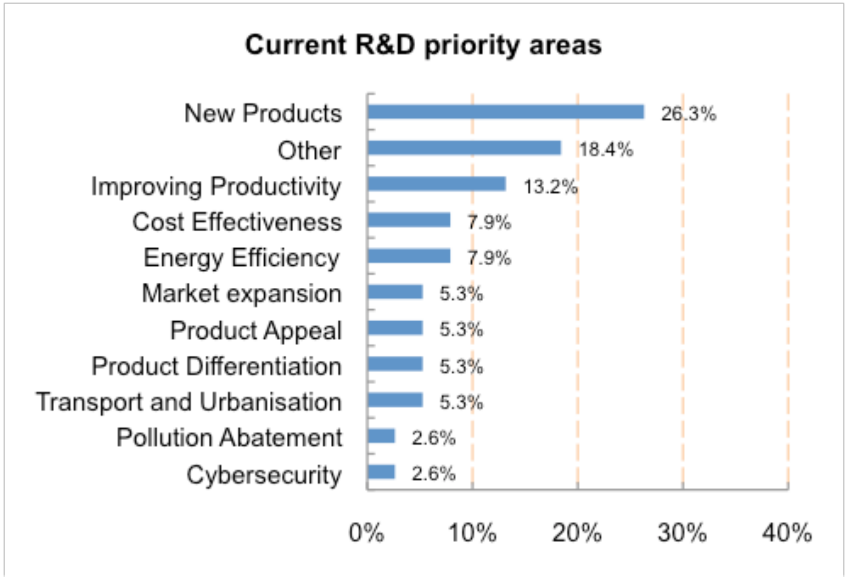
Q8(d). What do you expect your R&D spending to be like one year from now?



Top Three Expectations of R&D Spending

- 32.4% of respondents are not sure on what to expect for R&D spending for the following year.
- 16.2% of respondents expect an increase of 6-10% in R&D spending.
- 13.5% of respondents predict no change in their R&D spending. Another 13.51% expect an increase by 20%.

Q8(e). What are your company's current research & development priority areas?

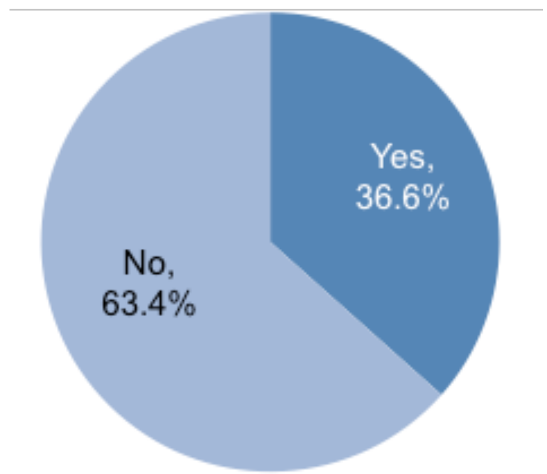


Top Three Research and Development Areas

- 26.3% of respondents chose new products.
- 13.2% of respondents chose improving productivity.
- 7.9% of respondents chose cost effectiveness and another 7.9% chose energy efficiency

Note: 18.4% do not have a current research and development priority area.

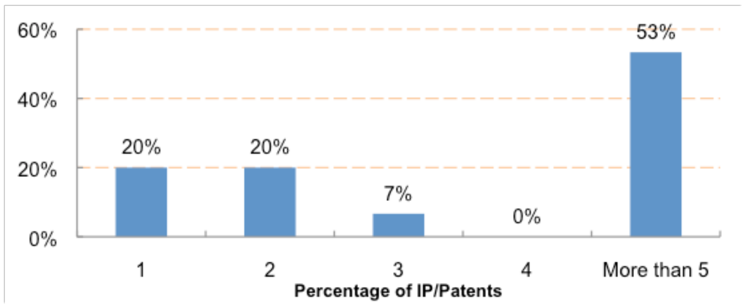
Q9. Do you have any registered patents or IP or trademark applications in the process?



Registered Patents or IP or Trademark Applications

- As many as 36.6% of respondents have registered patents or IP or trademark applications in the process.
- As many as 63.4% of respondents do not have them as they find it costly.

Q9(a). If you have answered YES in the previous question, how many IPs/ patents that are currently registered and/or patent pending in your organisation?

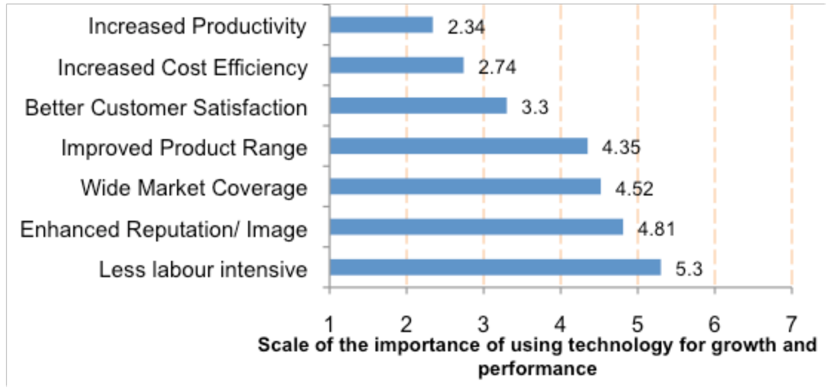


Q10. Which of the following clusters of adjectives would you use to express your views on R&D, adoption of new technologies, promoting technopreneurship and commercialising innovations?
(You may select up to three options)

Clusters	Total*	Percentage
Profitable, performance-drive	28	21.05%
Market advantage, brand differentiation	23	17.29%
Expensive, lack of funds, not a priority	14	10.53%
Industry and market relevance, growth	14	10.53%
Export potential, global competitiveness	11	8.27%
Lack of local R&D - industry linkages	10	7.52%
Long pay-off period	9	6.77%
Capable, reliable, results-oriented partners	8	6.02%
Politically motivated, government-linked	7	5.26%
Bureaucratic, difficult to manage	4	3.01%
Lack of opportunity for cooperation with local R&D institutions	4	3.01%
Innovation too easy to replicate	0	0.00%
Others	1	0.75%

*Note: Frequency of clusters selected by respondents.

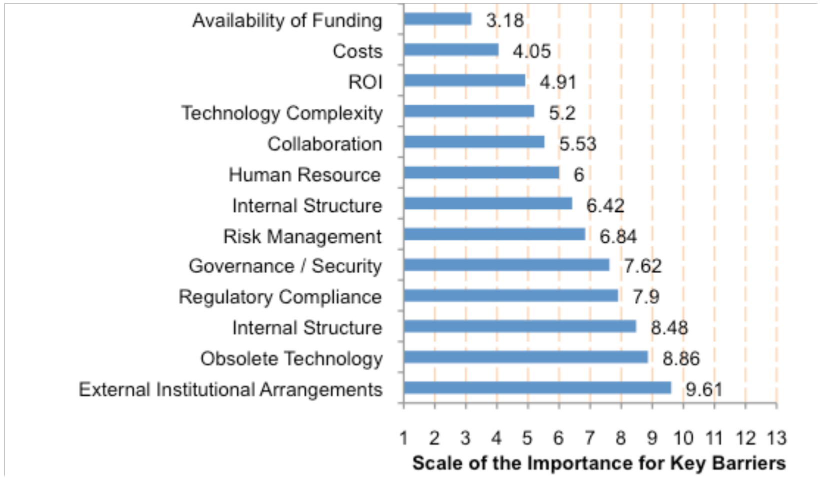
Q11. In your opinion, what are the key advantages of using technology for growth and performance of your businesses?



*Note: The scale is from 1-to-7. Scale 1 refers to being the most important and scale 7 refers to being the least important.

Scale rank / Frequency	1	2	3	4	5	6	7
Increased Productivity	18	11	4	7	1	3	0
Increased Cost Efficiency	9	16	6	4	6	1	1
Better Customer Satisfaction	9	7	10	7	6	1	4
Wide Market Coverage	5	2	9	5	5	8	10
Enhanced Reputation/ Image	1	1	4	9	13	14	1
Improved Product Range	4	4	5	9	7	9	5
Less Labour Intensive	0	5	7	2	4	6	19

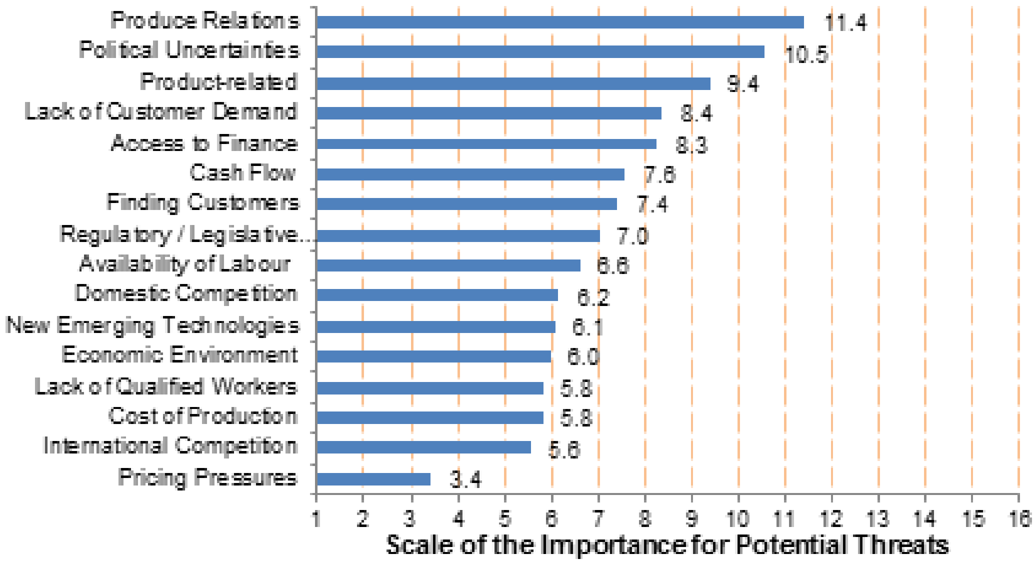
Q12. What are the key barriers to adopting, developing and commercialising new technology?



*Note: The scale is from 1-to-13. Scale 1 refers to being the most important and scale 13 refers to being the least important.

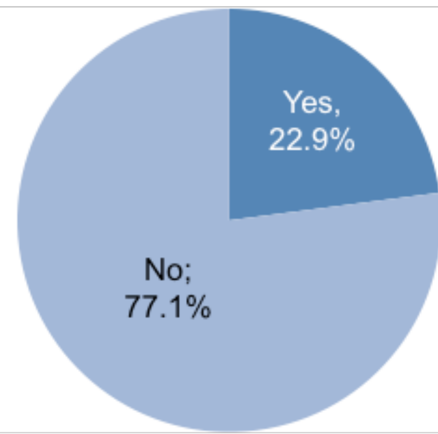
Scale rank / Frequency	1	2	3	4	5	6	7	8	9	10	11	12
Availability of Funding	17	3	3	3	1	1	2	1	1	0	2	0
Costs	3	10	5	8	2	2	3	3	0	0	0	0
ROI	7	4	4	2	3	2	2	4	2	3	1	0
Technology Complexity	7	4	4	1	2	7	1	1	2	1	4	1
Collaboration	3	6	1	3	4	3	3	1	5	1	0	1
Human Resource	5	2	7	3	2	2	1	1	1	1	2	0
Internal Structure	2	0	4	3	3	5	3	5	1	1	0	4
Risk Management	2	1	1	4	4	0	4	6	4	3	2	1
Governance / Security	1	2	1	3	4	1	2	2	0	5	3	3
Regulatory Compliance	1	3	1	2	2	4	0	1	2	4	2	7
Internal Structure	0	1	2	0	0	2	3	3	4	2	1	2
Obsolete Technology	1	0	2	0	4	1	3	1	2	1	2	7
External Institutional Arrangements	1	0	2	1	1	0	1	1	2	4	6	3

Q13. What would be the potential threats for your company as a whole in the next 1-3 years?



*Note: The scale is from 1-to-16. Scale 1 refers to being the most important and scale 16 refers to being the least important.

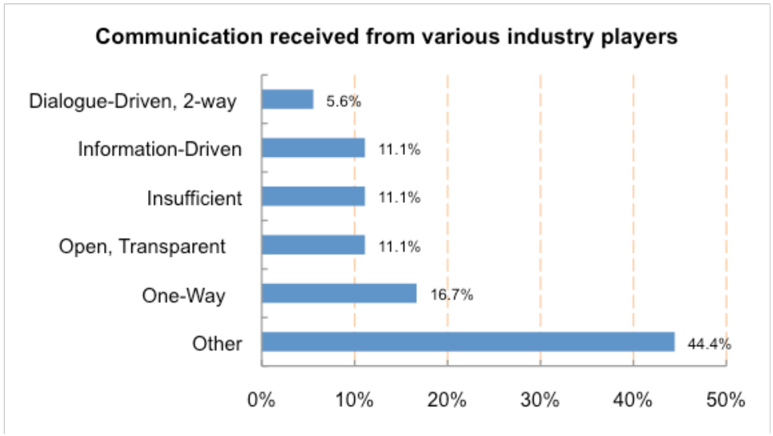
Q14. Has your company/organisation been consulted or informed on any policies regarding S&T?



Top Two Mind Reads

- 77.1% of respondents chose the answer "No". Most of the respondents have not been consulted or informed of any policies regarding S&T. They feel that there is lack of implementation of the policies.
- 22.9% of respondents chose the answer "Yes" have been briefed or consulted on the policies.

Q15. If you have answered YES in the previous question, which of these best describe the communication you receive from various industry players in your line of business or technology?



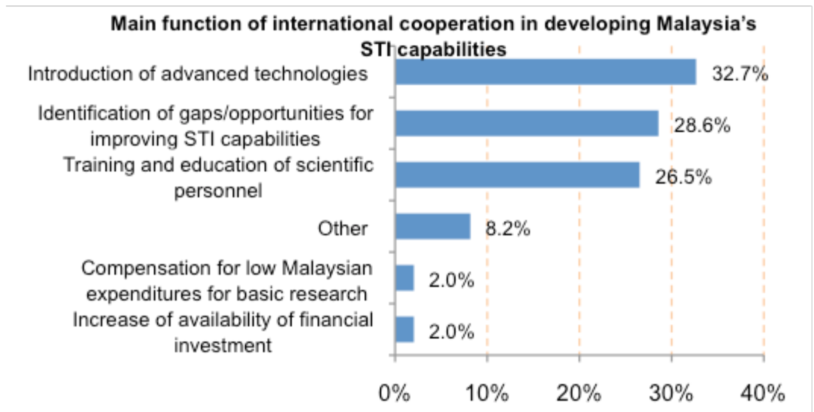
Top Two Mind Reads

- 44.4% of respondents chose the option ''Other''. Some respondents feel that most industry players are not open with information.
- 16.7% of respondents chose the answer "One-Way". They feel that the communication is usually one-way and that it does not give them the opportunity to express their views regarding the policies that affect them.

Q16. Have you had any challenges receiving information or communicating with your stakeholders? Please elaborate.

- Respondents that answered 'no' have well-established communications systems in place
- Those who answered 'yes' felt that there is a need for stakeholders such as industry, government, MNCs to be more open with information

Q17. What should be the main function of international cooperation in developing Malaysia's STI capabilities?

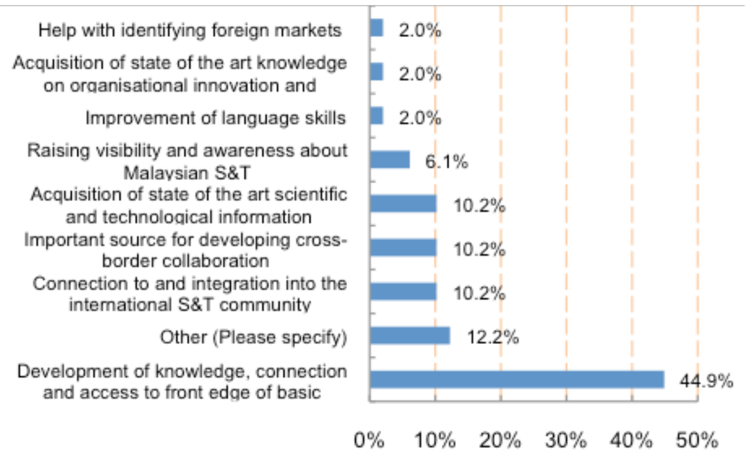


Top Three Main Functions of International Cooperation

- As many as 32.7% of respondents chose "introduction of advanced technologies".
- As many as 28.6%of respondents chose "identification of gaps/ opportunities for improving STI capabilities".
- As many as 26.5% of respondents chose "training and education of scientific personnel".

Q18. What should be the main forms of international research/innovation cooperation for Malaysian public and private stakeholders (research organisations and firms) in Malaysia?

Q19. What should be the main impact of Malaysian researchers' mobility in acquiring scientific and technological information?



Top Three Main Forms of International Research / Innovation Cooperation

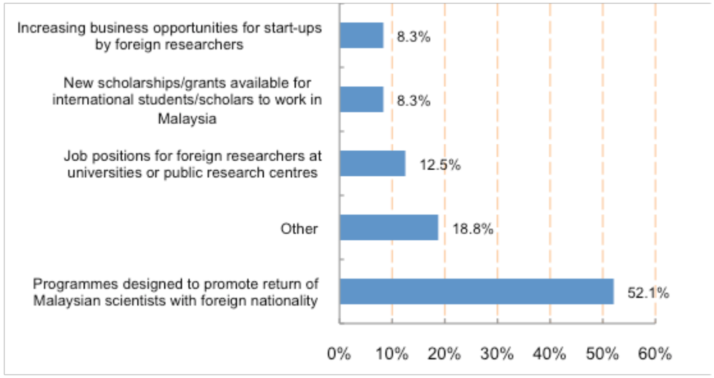
- As many as 43.5% of respondents chose "setting up joint ventures with foreign organisations".
- As many as 28.3%of respondents chose "participating in international collaboration projects and fellowships".
- As many as 19.6% of respondents chose "sending personnel abroad for scientific education and research collaboration".

Main Impacts of Malaysian Researchers' Mobility

- As many as 44.9% of respondents chose "development of knowledge, connection and access to front edge of basic research".

- Others (12.2%) felt that Malaysia needs to identify the gaps between industry and academia.

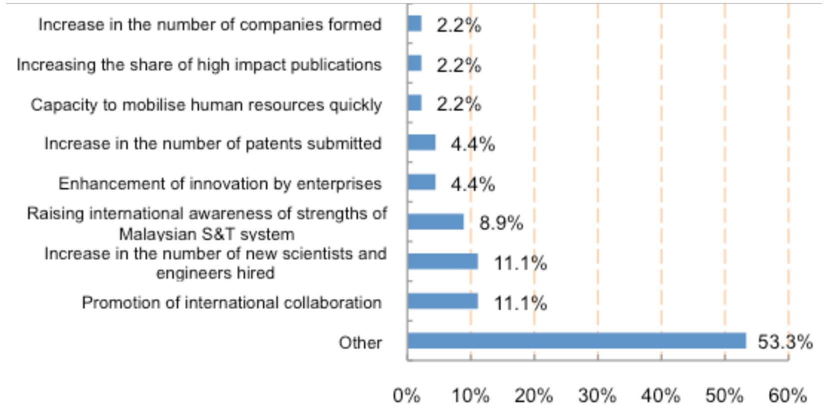
Q20. What should be the main forms of Malaysian research and technology infrastructure opening to foreign researchers?



Main Forms of Malaysian Research and Technology Infrastructure Open to Foreign Researchers

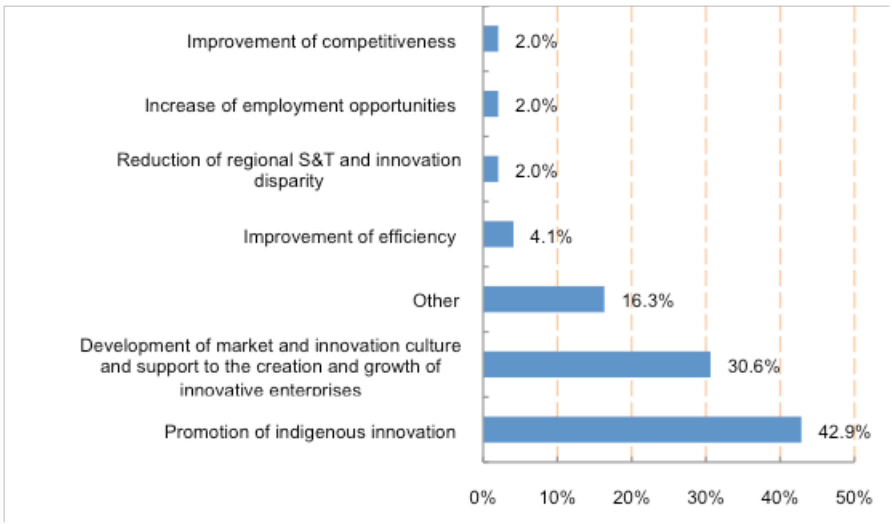
- As many as 52.1% of respondents chose "programmes designed to promote return of Malaysian scientist with foreign nationality". Some felt that there should be incentives to promote the return of Malaysian scientist.
- 12.5% felt that there should be more "job positions for foreign researchers at universities or public research centres" as they will be able to share their knowledge and expertise.

Q21. From your perspective, in which of the following areas are Malaysian STI plans and programmes are most successful?



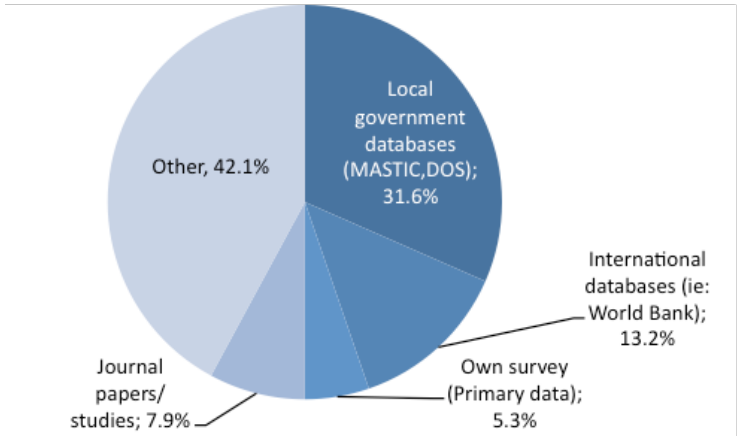
- 11.1% of respondents chose "increase in the number of new scientists and engineers hired" and another 11.11% chose the "promotion of international collaboration".
- 53.3% of respondents feel that the STI plans and programmes are not successful.

Q22. What is the major challenge you expect of Malaysian STI plans and programmes?



- 42.9% of respondents feel that "promotion of indigenous innovation" is a challenge for Malaysian STI plans and programmes.
- 30.6% of respondents feel that "development of market and innovation culture and support to the creation and growth of innovative enterprises" is major challenge.
- 16.3% of respondents had other opinions.

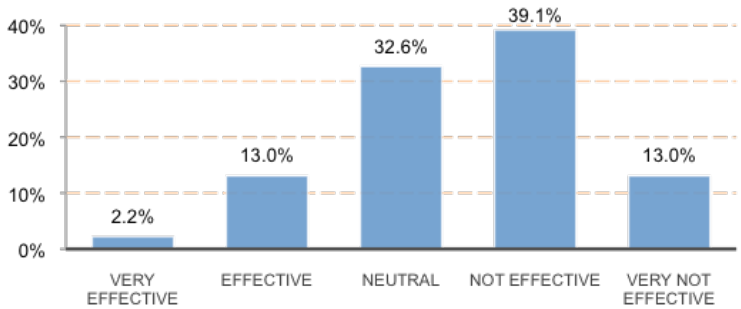
Q23. What resources do you use to get data on STI development (e.g. commercialisation rate)?



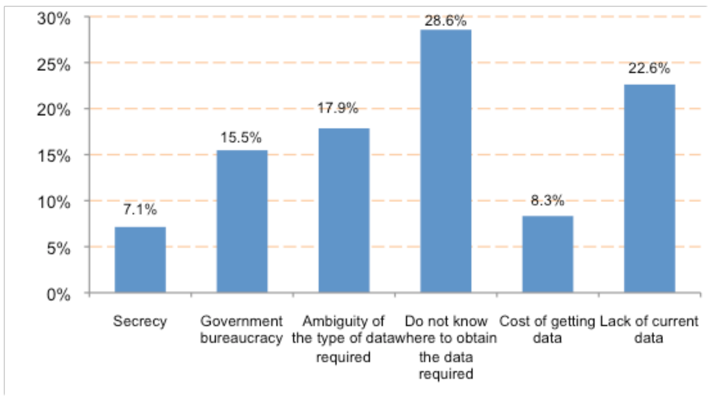
Top Three Resources

- 42.1% of respondents "read newspapers, consult consultants and participate in industry forums to obtain data on STI development".
- 31.6% of respondents use "local government databases" to get data on STI development.
- 13.2% of respondents use "international databases".

Q24. What do you think of the current public institutional arrangement of STI in Malaysia? Is it effective in developing STI for nation-building?



Q25. What are the main challenges in obtaining data for STI?



Top Three Main Challenges in Obtaining Data

- 28.6% of respondents "do not know where to obtain the data required".
- 22.6% of respondents feel that there is "lack of current data".
- 17.9% of respondents feel that there is "ambiguity on the type of data required".

Q26. What do you think is the main issue in STI governance in Malaysia?

- There is lack of awareness, cohesion and clarity/ focus in policies
- There is also lack of efficiency and commitment in implementation/coordination/enforcement.
- Lack of talent and skills for STI project management
- Fragmented STI development
- Weak ecosystem for R&D and innovation

Q27. Do you believe science and technology are relevant today in the development of the nation's ICT economy? In which areas, in particular?

- STI is the engine of development for the nation
- Need to improve in the areas such as education and intra-collaboration between industry players and inter-collaboration between Malaysia and other countries

Q28. If there is one thing that could be done or implemented immediately to rectify any of these, what would it be?

- Provide public STI support and financial aid
- Increase cohesion/clarity/focus in the STI initiatives
- Inculcate a STI culture/orientation and increase public STI awareness
- Connect between industries, academia and government
- Provide quality education and focused training
- Promote meritocracy, and equality across all sectors.

Further Reading 4-2

Industrial policy interventions in China, India, Japan and Korea

China and India

- Direct State ownership; Selective credit allocation; Favourable tax treatment to specific industries; Tariff and non-tariff barriers to imports;
- Restrictions on FDI; Local content equirements; Special IPR policies; Government procurement; Promotion of large domestic firms; Avoiding permanent infant industries especially by trying to develop indigenous ones; Developing broad and sophisticated industry for the long term; Encourage SMEs: Legally reserving certain products to small industries.
- Other interventions and programmes complemented: Huge investment in higher education (China); Investment in a select group of elite engineering & management schools (India); Manufacturing hub of the world (China); Major offshore service centre (India) through outsourcing of knowledge-based services.
- Strategies for tapping into global knowledge: Trade, FDI, technology licensing, copying and reverse engineering; Foreign education and training; Accessing information in print and internet; Large market pull; and technology parks that attract the diaspora back.
- R&D expenditure: There has been an increase in R&D expenditure needed for MNCs to do R&D locally to adapt their goods and services to the domestic market; MNCs increasingly set-up R&D centres aimed at developing products and services for the global market.

Japan

- Public financial support: Its support to the business sector is limited as firms self-finance 98% of their R&D activities. Tax incentives are the main funding instrument but direct funding has increased in relative terms since 2005. In 2009, grants, loans and contracts accounted for an estimated 35% of public support to business R&D.
- A new strategic regional innovation support: In 2011, a new strategic regional innovation support programme was launched for regional revitalisation through knowledge transfer between universities and industry. It capitalised on prior cluster initiatives such as the Knowledge Cluster Initiative, which ended in 2010. The Reconstruction Agency is also contributing to invigorate local industry.
- Knowledge flows and commercialisation: The commercialisation of scientific research has been a priority of Japanese STI policy in recent decades as reflected in the number of measures taken since the mid-1990s to foster technology transfer from academia to industry. For example, the A-step programme (Adaptable and Seamless Technology Transfer Programme through Target-Driven R&D) defines overall objectives to facilitate medium- and long-term collaboration on R&D and combines several funding programmes to enable technological development at various stages of commercialisation. The New Growth Strategy also encourages the use of intellectual property rights. In the context of increasingly open innovation, a new patent licensing and patent co- ownership system will be in force in 2012.
- Globalisation: The New Growth Strategy has set an objective of doubling the flow of people, goods and money to Japan within 10 years. Today, with Korea, it has the lowest share of GERD funded by abroad in the OECD area (0.4%). In 2010, the Inward Investment Promotion Programme suggested accelerating FDI through a cut in the corporate tax rate and deregulation of investment procedures. It also includes a broader series of initiatives to attract R&D facilities and global companies' regional Asian headquarters to Japan. Incentives, such as tax treatment and subsidies, are also to be developed under the corporate certification system.
- Green innovation: It is a priority for Japan. A Comprehensive Green Innovation Strategy was announced to develop environmental and energy technologies. It aims at creating over US$468 billion of new demand and 1.4 million jobs in the environment sector by 2020, and to reduce greenhouse gas emissions by 25% relative to 1990 using Japanese private- sector technology. After the Great East Japan Earthquake in 2011, the Japanese government decided to draw up a Green Growth Strategy.

South Korea

- Recent changes in STI expenditures: Korea's GERD was 3.74% of GDP in 2010 and has grown by a robust 9.3% annually in the past decade and by 10% a year in the five years to 2010. In 2010, 72% of GERD was funded by industry, 27% by government and only 0.2% from abroad.
- Overall STI strategy: Korea's 577 Initiative aims at increasing GERD to 5% of GDP by 2012, nurture seven strategic technology areas, and become the world's seventh "S&T power". To meet these targets, the Government has increased its expenditure on R&D and has used various tax incentives to encourage more private investments. In line with a decade-long trend, government support has continued to shift away from large firms towards SMEs.
- Business R&D and innovation: The structure of business expenditure on R&D (BERD) shows that R&D is mainly conducted by large manufacturing conglomerates. Small and young firms have contributed relatively little to innovation, though there are signs of improvement. Much government support to the business sector goes to SMEs. The Small and Medium Business Administration's R&D investments for start-ups will increase by 33% in 2012, and the Ministry of Trade, Industry and Energy (previously known as Ministry of Knowledge Economy) has announced that the share of its R&D budget allocated to SMEs will reach 40% of the total by 2015.
- Clusters and regional policies: The Seoul Metropolitan Area is the focus of much S&T and innovation activity and this has led to quite unbalanced regional growth. In response, the government has introduced a number of schemes over the years. As a result, Korea had 105 regional innovation centres and 18 techno-parks in 2010, as well as seven programmes to strengthen the competitiveness of industrial cluster programmes.
- Schemes: There are several schemes aimed at improving commercialisation and knowledge transfer from the public sector research, namely: the Technology Holding Company system, which promotes the establishment of venture businesses by universities and research institutes; the Leaders in Industry University Programme (LINC) and the Brain Korea Programme (BK), both which seek to improve industry-academia collaboration.

Source: Akademi Sains Malaysia 2013

Further Reading 4-3

STI funds under MOSTI

Science Fund

Agency

MOSTI

Sector

Agriculture and Forestry, Biotechnology, Engineering &Technology, ICT, Medical and Health Sciences, Natural Sciences & Social Sciences.

Fund Objective

1. To support research that can lead to the innovation of products or processes for further development and commercialisation; and/or
2. To generate new scientific knowledge and strengthen national research capacity and capability.

Description / Scope

ScienceFund covers preliminary research leading to laboratory proof of concept or towards the development of new products or processes. The quantum of fund approved will be determined based on the merit of each application.

Quantum of Funding: RM500,000

Phase

Applied R&D

Eligibility

This fund is open to all research scientists and engineers who are employed on a permanent or contractual basis from the following organisations:

- GRIs;
- Government STI agencies; and
- Public and private IHL with accredited research programmes.

Pre-Commercialisation Fund (InnoFund)

Agency

MOSTI

Sector

Agriculture and Forestry, Biotechnology, Engineering &Technology, ICT, Medical and Health Sciences, Natural Sciences & Social Sciences.

Fund Objective

InnoFund is a grant scheme which funds the development or improvement of new or existing products, processes or services with elements of innovation. The project must have economic value and improves the societal well-being of the community. InnoFund can be categorised into:

- Enterprise InnoFund (EIF)
- Community InnoFund (CIF)

Description / Scope

- Specialised Equipment.
- Pre-Clinical/ Clinical Trial/ Field Trial (if applicable).
- IP (intellectual property) Preparation and Registration in Malaysia only (excluding maintenance).
- Market Testing and Regulatory and Standard Compliance.

Quantum of Funding: RM500,000

Phase

Pre-Commercialisation

Eligibility

- EIF: This fund is open to individuals, sole proprietors and small and micro enterprises
- CIF: Registered associations/NGOs, registered cooperatives and community groups

Pre-Commercialisation Fund (TechnoFund)

Agency

MOSTI

Sector

Agriculture and Forestry, Biotechnology, Engineering &Technology, ICT, Medical and Health Sciences, Natural Sciences & Social Sciences.

Fund Objective

1. The development of new or advanced technologies or further develop/ value add existing technologies/ products in specific areas for the creation of new businesses and creating economic wealth;
2. Promote market driven R&D towards commercialisation of R&D outputs;
3. Encourage institutions, local companies and investors to capitalise their IP registration; and
4. Stimulate growth, capability and capacity of Malaysian technology based enterprise, GRIs and IHL through local and international collaborations.

Description / Scope

- The acquisition of technology (foreign and/or local).
- Applicants to provide the acquisition agreement or to provide details of the technology if an agreement is non-existent.
- The upscaling of laboratory-scale prototype or the development of commercial ready prototype; and
- Pre-clinical testing/clinical testing/field trials. The funding can be used for: pilot plant/prototype – equipment and supporting infrastructure which is directly related to the pilot plant; IP Preparation and registration in Malaysia only (excluding maintenance) - existing and new IP; market testing/assessment and/ or evaluation; regulatory and standards compliance; expenditure for services (consultancy/testing) not exceeding 20% of project cost; contract expenditure applicable to IHLs and GRIs only (research assistant); raw materials/consumables; and technology/IP acquisition (if applicable).

Quantum of Funding: RM1.5 - RM3 million

Phase

Pre-Commercialisation

Eligibility

Researchers and individuals from:

• SMEs; • IHL; and • STI agencies.

Commercialisation of Research & Development Fund (CRDF).

Agency
MTDC

Sector
Agriculture and Forestry, Biotechnology, Engineering and Technology, ICT, Medical and Health Sciences & Natural Sciences.

Fund Objective
Promoting commercialisation of locally developed technologies (public and private universities, GRIs undertaken by Malaysian owned company).

Description / Scope
For the commercialisation of R&D output from public and private university/GRIs by a spin-off company:

- Maximum funding of RM500,000 or 90% of the eligible expenses; and
- Activities covered are purchase of equipments (QC & production), administration and overhead, technology and services costs (raw material, advertisement and promotion, certification and standard, IP registration & protection and production outsourcing)

Quantum of Funding: RM500,000

Phase
Commercialisation

Eligibility
- The company is incorporated in Malaysia;
- The company must be at least 51% owned by Malaysian;
- The proposed technology to be commercialised must be from one of the Priority Technology Clusters identified by MOSTI, excluding ICT;
- The R&D must have been completed successfully and the commercially-ready prototype is available;
- The proposed project must be tangible or can be incorporated into tangible product;
- Significant paid-up capital which commensurates the total project cost (proof of the availability of the fund to finance the project);
- Licenses from relevant authorities; and
- Proposed project is recommended by industrial expert.

Biotechnology Commercialisation Fund (BCF)

Agency
Malaysian Biotechnology Corporation (MBC)

Sector
Biotechnology & Medical and Health Sciences

Fund Objective
- To facilitate ongoing commercialisation of biotechnology products and services; and
- To facilitate expansion of existing biotechnology business.

Description / Scope
- The BCF Facility is a term loan/financing facility that will be offered based on conventional principles primarily for the financing of working capital and capital expenditure;
- Hybrid loan & grant facility; and
- Maximum of RM3 million, based on ratio 2:1 between loan and grant.

Quantum of Funding:
RM500,000 - RM3 million

Phase
Commercialisation

Eligibility
1. The applicant must be a BioNexus status company;
2. Majority ownership by Malaysians, i.e. at least 51% of the equity is owned by Malaysians; and
3. Minimum paid-up capital of RM250,000.

Business Start-Up Fund (BSF)

Agency
MTDC

Sector
Agriculture and Forestry, Biotechnology Engineering and Technology, ICT, Medical and Health Sciences & Natural Sciences

Fund Objective
- To support and encourage entrepreneurship and creation of new strategic businesses that are important, and potentially scalable; and
- The funding of supporting companies within a technology ecosystem.

Description / Scope
- A seed funding of technology-based start-ups.
- The maximum funding is RM5 million or 90% of the total eligible cost; whichever is lower.
- Redeemable Convertible Cumulative Preference Shares (RCCPS) with fixed interest rate of 3.5%
- The maximum tenure is eight years, inclusive of a three years grace period (repayment shall commence on the 1st month of the fourth year on monthly basis over five years.
- The activities covered are operational expense (OPEX) & capital expenditure (CAPEX) excluding purchase of land & purchase of building

Quantum of Funding: RM5 million

Phase
Commercialisation

Eligibility
A spin-off company incorporated under the Companies Act 1965;

- A minimum 70% owned by a Malaysian entrepreneur or group of entrepreneurs;
- The proposed technology to be commercialised must be from one of the Priority Technology Clusters; and
- The product must be significant in novelty /innovation.

Technology Acquisition Fund (TAF)

Agency
MTDC

Sector
Agriculture and Forestry, Biotechnology, Engineering and Technology, ICT, Medical and Health Sciences & Natural Sciences.

Fund Objective
Facilitating local companies to acquire foreign technologies for immediate inclusion into the company's manufacturing activity. TAF's partial grant helps companies to avoid expensive and risky technology development stages.

Description / Scope
- Technology acquisition cost (a cap of RM 2.8 million or 70% of total cost, whichever is lower).
- Cost of technology acquisition + acquisition of M&E (a cap of RM2.4 million for IP or 70% of total cost, whichever is lower and a cap of RM1.6 million for M&Es or 50% of total cost whichever is lower).
- Engagement of foreign individual within a specific area of expertise on process or product improvement (a cap of RM200, 000 per application for travelling and lodging for six months)
- Training (a cap of RM250,000 or 70% of total cost whichever is lower)

Quantum of Funding:
RM250,000 - RM2.8 million

Phase
Commercialisation

Eligibility
- The company is incorporated in Malaysia;
- The company must be at least 51% owned by locals;
- The technology acquired must be a registered IP (Patent/Copyright/Industrial Design) with significant sales volume;
- The technology acquisition must be from one of the Priority Technology Clusters identified by MOSTI;
- The technology provider must not hold any equity in the applicant's company;
- The proposed project must be tangible or can be incorporated into tangible product;
- The company must be involved in the production, fabrication and manufacturing of the products; and
- Significant paid-up capital commensurating total project cost (proof of the availability of the fund to finance the project).

Business Growth Fund (BGF)

Agency
MTDC

Sector
Others

Fund Objective
To provide support for successful grants of recipient companies until they can generate sufficient commercial value to attract VC financing and other forms of financing.

Description / Scope
- Hybrid (combination of grant + equity)
- The maximum funding is RM4 million (up to 25% of total funding or maximum of RM1 million in the form of grant and RM3 million in the form of Redeemable Convertible Preference Shares (RCPS) excluding the grant portion)
- Exits within three to five years through initial public offering (IPO), buyback, trade sale, etc.

Quantum of Funding: RM150 million

Phase
Commercialisation

Eligibility
All Malaysian grant recipient companies.

Bioeconomy Transformation Programme (BTP)

Agency
MBC

Sector
Biotechnology & Medical and Health Sciences

Fund Objective
- To complement and accelerate the implementation of Bioeconomy Trigger Projects (BTP);
- To attract more high impact FDIs and Domestic Direct Investments (DDIs) to participate into local Agro-biotechnology, Bio-industrial, and bio-medical industries; and
- To emphasise Government's commitment in developing a high income, inclusive and sustainable bio-economy for the nation.

Description / Scope
- To support the implementation of BTP under the Bioeconomy Transformation Programme.
- To support the implementation of NEM
- BTP comprises of three main subsectors;
- Agro-biotech
- Bio-industrial
- Bio-medical for commercialisation of bio-economy projects using a loan mechanism.

Quantum of Funding: RM10 million
or 10% of its total project cost, whichever is lower

Phase
Commercialisation

Eligibility
The 10 shortlisted EPPs include the following:
- Industrial bio-inputs;
- Bio-chemicals;
- Bio-materials;
- Bio-based farm inputs;
- High value bio-ingredients;
- High value food varieties;
- Bio-similars;
- Drug discovery;
- Molecular screening;
- Stem cells; and
- Regenerative medicine in Malaysia.

Source: Agensi Inovasi Malaysia 2014

Further Reading 5-1

Funds promoting enculturation of STI

Fund	Funding Quantum (RM)	Objective
MSC Malaysia Pre-Seed Fund Programme	RM150,000 for 12 months maximum	Boost the development of commercially viable ICT projects and stimulate a chain reaction in the creation of new local K-SMEs in ICT.
Online Education Content Creation Grant (ICONedu)	RM100,000 conditional funding up to 8 months	For local SMEs and technopreneurs who want to be innovative and commercially focused on putting their educational projects up for online consumption.
Online Social and Community Content Creation Grant (ICONity)	RM100,000 conditional funding up to 8 months	For the development of social and community content platforms and ecosystems by Malaysians.

Source: Abdullah 2011

Further Reading 5-2

Public awareness of STI

Interest in STI

Overall, Malaysians are interested in STI and only a small percentage were unsure or unaware about STI.

- Most respondents (84%) stated that they were *interested* or very interested in "the use of new inventions and technologies", followed by "new medical discoveries" (79%), "innovation" (78%) and "new scientific discoveries" (76%).
- In contrast, 25% of respondents were *not interested* in "environmental pollution", followed by "renewable energy" (22%) and "new scientific discoveries" (21%).
- STI interest level is positively related to the education level of the respondents.
- Compared to 2008 findings, the percentage of *very interested* responses in selected STI related issues had doubled in 2014.
- Compared to the US and EU, local respondents showed the lowest level of interest in STI. On average, 78% of local respondents were interested STI compared to 89% in the US and 83% in the EU.

Knowledge of STI

Less than half of all respondents (46%) were able to correctly answer the factual knowledge questions in the 2014 survey.

- The public's average knowledge levels of STI hovered below 50% over the past 16 years (1998 till 2014).
- Most Malaysians correctly answered "the earth travel around the sun" (85%) and "the centre of the earth is very hot" (75%).
- In contrast, very few Malaysians correctly answered "antibiotics kill viruses as well as bacteria" (16%) and "all radioactivity is man-made" (20%).
- More urban respondents (48%) answered the factual knowledge questions correctly compared to rural respondents (39%).
- Male respondents (49%) had a higher percentage of correct answers than female respondents (43%).
- The youth group (51%) had a higher percentage of correct answers than adult (46%) and children's group (36%).

- There is positive correlation (Pearson's R = 0.299) between educational attainment and correct answers to the STI statements.
- Malaysia's public knowledge of STI is lower than US (as of 2014), EU (as of year 2005), Japan (as of 2011) and South Korea (as of 2004).
- Nevertheless, Malaysia is on par with India (as of 2004) and marginally better than China (as of 2010).

Attitudes towards STI

Public attitudes towards STI were seen to be more positive in 2014 than in 2008. More than half of all respondents (53%) in the 2014 survey commented that scientific research was more beneficial than harmful.

- About 33% said it was equally beneficial as well as harmful, 4% thought that scientific research did more harm than good, while 10% were not sure.
- Compared to 2008, the percentage of respondents who agree that scientific research has done "more good than harm" declined from 74% to 53% while the response of "more harm than good" had always remained at below 10%. Most respondents have either become more sceptical or less sure that scientific research had generated more positive or more negative effects.
- The percentage of Malaysians who believe that scientific research had greater benefits was relatively lower than the percentage of respondents in the US and EU, but, it was about the same with the UK.
- Compared to the US (42%), more Malaysians (81%) agreed that "science caused our lifestyles to change too fast". Similarly 95% of Malaysians agreed with the statement "STI are very important for the progress of our nation" while only 42% of the US respondents and 62% of EU respondents shared the same view.
- There are no notable differences between Malaysia (42%), the US (42%) and EU (39%) relating to the statement "we depend too much on science and not enough on faith."
- Most of the respondents believed science have more positive effects over the negative for the issues of "public healthcare" (79%), "job creation" (78%), "working conditions"(70%), "lifestyle" (68%), "food security" (66%), "environment" (66%), "cost of living" (63%) and "world peace" (54%).

STI Information Sources

Television was the most popular media in Malaysia. 89% of respondents used it as the source of information for learning about STI.

- The next most popular media for information related to STI was print newspapers (63%), followed by internet (53%), radio (43%), books (39%) and print magazines (24%).
- In terms of the most reliable source of information for STI, about half of the respondents (49%) picked television, followed by internet (19%), print newspapers (13%) and books (9%).
- Surveys in the EU, UK and Taiwan indicated television to be the primary source of STI information for the public, except for the US where the primary source of STI information was the internet.

Zoos (31%) and museums (23%) were the two most popular STI related places.

- About 13% of respondents had made at least one visit in last 12 months to aquariums, 10% of respondents had visited Petrosains , 7% had visited the National Science Centre and 7% had visited planetariums.
- Malaysian public engagement with informal STI venues are comparable to countries like the UK and South Korea, but were lower than the US, China and Taiwan.

Awareness of STI related Government Programmes and Policies

At least one in four of respondents had heard of STI related government programmes.

- Most of the programmes had a low participation rate of below 2%.
- About one third of the respondents felt the government spend too little to support scientific research.

Source: MOSTI 2014b

Further Reading 5-3

Strategy Report on achieving 60:40 Science / Technical: Arts Stream (60:40 Report)

The 60:40 Report suggested the following as a measure to increase scientific literacy and interest in S&T:

No.	Subject	Focus	Discussion	Recommendation
1.	Designed or Structured Informal Science Learning	Informal science learning institutions or environments that have well designed or well-structured pedagogical and learning approaches that are, research-based, credible and have clear learning outcomes.	Modest investment can make formal education more effective. The infrastructure is already in place in Malaysia. Many available offerings of different size, scale, and reach.	Provide recognition Leverage further — MOE ACTION: Designed or structured informal science learning institutions
2.	General Informal Science Learning	All informal science learning opportunities.	Highly diverse range of offerings that although support science learning, are often too various to manage or control.	Support — MOE ACTION: Informal science learning institutions
3.	Mass Media	All mass media platforms.	Has the potential to popularise science. Numerous quality offerings already available but not often accessible. No broader governing or directing body in terms of content production, delivery, or reach. No strategic framework in place for science popularisation.	Incentivise production — MOE ACTION: MOE, others ministries Encourage collaboration — MOE ACTION: MOE, others ministries Platform for scientists and technologists — MOE ACTION: MOE, others ministries

Source: Kementerian Pendidikan Malaysia 2012

Further Reading 5-4

Petrosains' Volunteer Scheme

Introduction

Petrosains' Volunteer Scheme is an exemplary demonstration of enculturation and how science based graduates and professionals, students, and school-leavers can work with the public including children, and engage them with science.

Objective

The key objective of this scheme is to encourage Malaysians (minimum age of 17) to be involved with Science learning and communication, through a more structured approach. Meanwhile, participants are able to build their confidence in understanding science and gain a greater appreciation for science as a culture.

Volunteer Induction Training Programme

Petrosains volunteers go through proper recruitment and training process before they are rostered "on the floor". The current volunteer induction training programme focuses on:

1. Overview of Petrosains business principles and key operational areas;
2. Health, safety and environment awareness;
3. Overview of departmental functions;
4. Science communication criteria and approaches;
5. Customer service and visitor engagement approaches; and
6. Having the right mindset as a Petrosains volunteer through self and team development activities.

Once they are selected, they are given specific assignments and help to facilitate exhibition areas and interact with visitors just like a permanent staff. A considerable amount of resources are spent to continuously mentor, coach and train the volunteers during their tenure in Petrosains.

In addition to a minimal honorarium, added experiential values for Petrosains' volunteers are countless as there are many programmes and activities implemented for their enhancement, giving them a rich work and life experience. Activities such as fundamental skills training, educational visits to similar industries, collaborative opportunities as well as sports and recreational activities are also carried out to enhance output and teamwork.

To date, Petrosains has 1,371 active volunteers and 2,626 ex-volunteers who are now enrolled as Petrosains Volunteers Alumni members. The Alumni contribute back to Petrosains as catalysts to inspire existing and future volunteers. Some of the former volunteers are now employed by Petrosains as permanent staff, or working in oil and gas companies such as PETRONAS, Schlumberger, Exxon Mobil; while others have found jobs in the government agencies and other renowned companies.

Source: Petrosains Sdn Bhd 2014

Further Reading 5-5

Inquiry Based Science Education (IBSE)

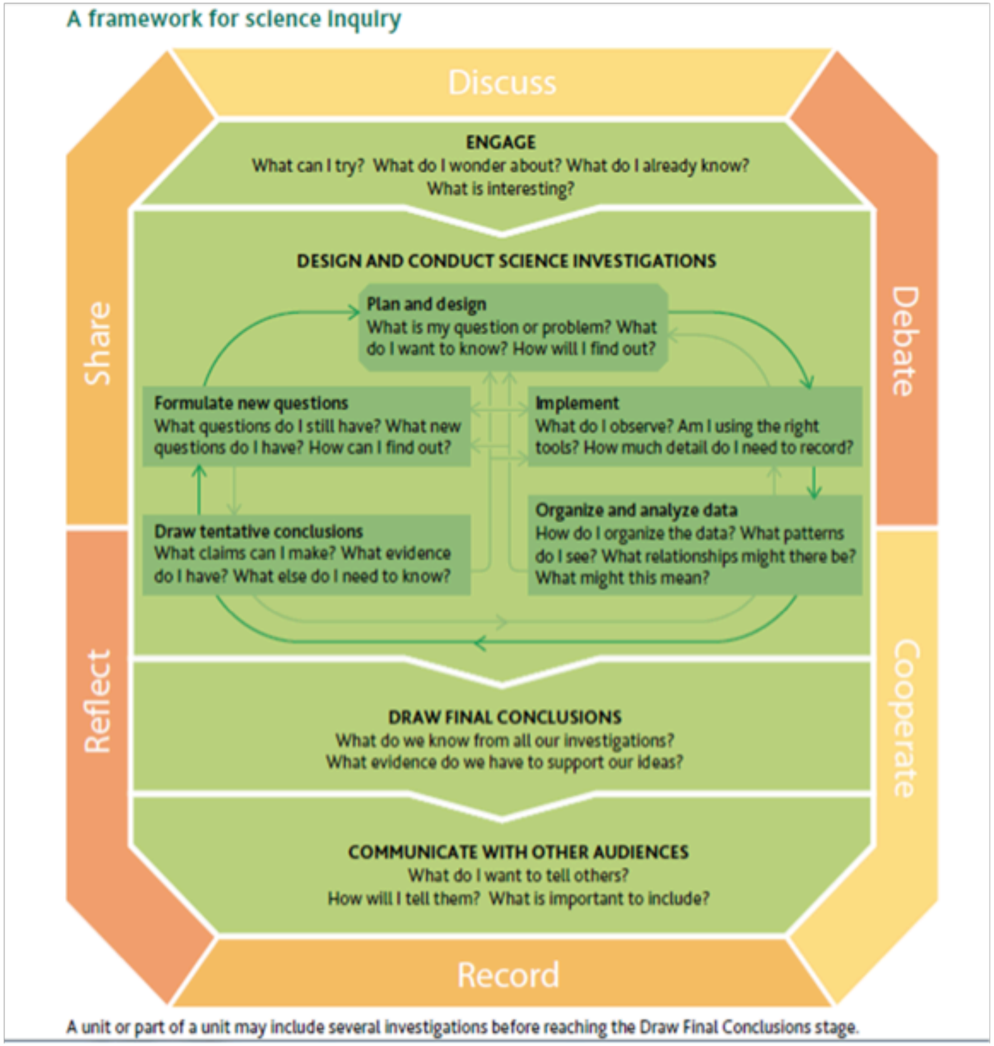


Figure (a). A framework for Science Enquiry
Source: OECD 2014

Further Reading 5-6

Sustainable CSR initiatives

PINTAR for underprivileged children

The Promoting Intelligence, Nurturing Talent and Advocating Responsibility programme (PINTAR), launched in 2006, by Khazanah Nasional and the Putrajaya Committee on GLCs High Performance Project, is to provide access to quality education to all Malaysians, especially the needy. In the initiative, GLCs and other corporations adopt schools and run various programmes to help students aspiring for excellence, and teachers to adopt effective methodologies to improve students' performance. From 44 schools supported by 13 GLCs in 2006, PINTAR now involves 309 schools and 31 firms, including 15 non-GLCs.

Supporting firms enjoy autonomy to run the programmes but most focus on helping students perform well in national examinations via remedial classes and workshops. This is achieved through enhancing the pedagogy of teachers, in addition to promoting sports talents and general knowledge on important issues such as conservation.

Since its inception, there has been notable improvements in academic performance among students in PINTAR schools in national examinations. In 2012, 71.71% of PINTAR pupils passed the UPSR compared to the national average of 56.94%, while the pass rate for the Lower Secondary Assessment PMR examination was at 68.9% among PINTAR students, on par with the national average; 1.82 percentage points more than in 2011. Meanwhile, 90.93% of PINTAR students received the SPM certificate in 2012, 0.33 percentage points more than in 2011.

Source: PINTAR Foundation 2014

Strategic International Alliances

Further Reading 6-1

Types of STI-centric international strategic alliance

A strategic alliance involves at least two partner organisations, countries and/or firms that:

1 Remain legally independent after the alliance is formed;
2 Share benefits and managerial control over the performance of assigned tasks; and
3 Make continuous contributions in one or more strategic areas, such as technology or products.

These three criteria imply that strategic alliances create interdependence between autonomous economic units, bringing new benefits to the partners in the form of intangible assets and obligating them to make continuous contributions to their partnership. Different alliance forms represent different approaches that partner firms adopt to control their dependence on the tie-up and on other partners. Table (a) below describes the various alliances practised globally that can be considered by ASEAN STI stakeholders. The following are prospective purposes for strategic alliance and collaboration:

- Market seeking
- Acquiring means of distribution
- Gaining access to new technology, and converging technology
- Learning & internalisation of tacit, collective and embedded skills
- Obtaining economies of scale
- Achieving vertical integration, recreating and extending supply links to adjust to environmental changes
- Diversifying into new businesses
- Restructuring, improving performance
- Cost sharing, pooling of resources
- Developing products, technologies, resources
- Risk reduction & risk diversification
- Developing technical standards
- Achieving competitive advantage
- Cooperation between potential rivals and pre-emptying competitors
- Complementarity of goods and services to markets
- Co-specialisation
- Overcoming legal / regulatory barriers

Prospective Engagement & Collaboration Strategies and STI Sectorial Impact

1

Model: Hierarchical Relations

Engagement Strategy

Through acquisition or merger, one firm takes full control of another's assets and coordinates actions by the ownership rights mechanism.

STI Sectoral Impact

Merger of smaller companies to achieve greater economies of scale and availability of resources to pursue R&D activities

2

Model: Joint Ventures

Engagement Strategy

Two or more firms create a jointly owned legal organisation that serves a limited purpose for its parents, such as R&D or marketing.

STI Sectoral Impact

Invite suitable technology/knowledge transfer companies to participate in the local economy

3

Model: Equity Investments

Engagement Strategy

A majority or minority equity holding by one firm through a direct stock purchase of shares in another firm.

STI Sectoral Impact

Venture funding from STI focused investment funds in local companies

4

Model: Cooperatives

Engagement Strategy
A coalition of small enterprises that combine, coordinate, and manage their collective resources.

STI Sectoral Impact
Private medical practitioners working together to access expensive plant and machinery

5

Model: R&D Consortia

Engagement Strategy
Inter-firm agreements for research and development collaboration, typically formed in fast-changing technological fields

STI Sectoral Impact
ICT firms developing communications and social outreach platforms

6

Model: Strategic Cooperative Agreements

Engagement Strategy
Contractual business networks based on joint multi-party strategic control, with the partners collaborating over key strategic decisions and sharing responsibilities for performance outcomes

STI Sectoral Impact
Agency to agency agreements on the development of human capital

7

Model: Franchising

Engagement Strategy
A franchiser grants a franchisee the use of a brand-name identity within a geographic area but retains control over pricing, marketing, and standardised service norms.

STI Sectoral Impact
Access to knowledge and technology through franchising of foreign businesses

8

Model: Licensing

Engagement Strategy
One company grants another the right to use patented technologies or production processes in return for royalties and fees.

STI Sectoral Impact
Licensing of technology to boost economic output rates

9

Model: Subcontractor Networks

Engagement Strategy
Inter-linked firms where a subcontractor negotiates its suppliers' long-term prices, production runs and delivery schedules.

STI Sectoral Impact
Blanket access to advanced technology is provided to industry in a bid to improve efficient and effective use of capital and other resources

10

Model: Industry Standards Groups

Engagement Strategy
Committees that seek the member organisations' agreements on the adoption of technical standards for manufacturing and trade.

STI Sectoral Impact
Setting of uniform STI standards and derivatives throughout ASEAN to ease collaboration projects

11

Model: Action Sets

Engagement Strategy
Short-lived organisational coalitions whose members coordinate their lobbying efforts to influence public policy making.

STI Sectoral Impact
Joint communication and awareness programmes for STI initiatives among the ASEAN community. Collaboration between governments reduces the overall cost of disseminating the message

12

Model: Market Relations

Engagement Strategy
Arm's-length transactions between organisations coordinated only through the price mechanism.

STI Sectoral Impact
General inter-company relations

Further Reading 6-2

List of STI-related multilateral treaties adhered by Malaysia

Agriculture

International Treaty on Plant Genetic Resources for Food and Agriculture
Signatory: 12
Ratification-Accession: 129

Food and Agriculture Organization of the United Nations (FAO)

Atmosphere and Outer Space

Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies
Signatory: 25
Ratification-Accession: 103

Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space
Signatory: 24
Ratification-Accession: 94

United Nations Office for Outer Space Affairs (UNOOSA)

Environment

Vienna Convention for the Protection of the Ozone Layer
Signatory: 28
Ratification-Accession: 197

United Nations Environment Programme (UNEP)

International Convention on Oil Pollution Preparedness, Response and Cooperation
Signatory: 24
Ratification-Accession: 94

International Maritime Organization (IMO)

Intellectual & IP

Convention for the Protection of Industrial Property and Revision
Signatory: 8
Ratification-Accession: 175

Convention establishing the World Intellectual Property Organisation
Signatory: 50
Ratification-Accession: 187

World Intellectual Property Organization (WIPO)

Transport & Communication

Convention on International Civil Aviation
Signatory: 190
Ratification-Accession: -

International Civil Aviation Organization (ICAO)

Disarmament

Treaty Banning Nuclear Weapons Testing in the Atmosphere in Outer Space and Underwater
Signatory: 106
Ratification-Accession: 115

Nuclear Threat Initiative (NTI)

Treaty on the Non Proliferation of Nuclear Weapons
Signatory: 93
Ratification-Accession: 189

Treaty of the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Seabed and the Ocean Floor and in the Subject thereof
Signatory: 83
Ratification-Accession: 115

Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological)and Toxin Weapons and on the Destruction
Signatory: 110
Ratification-Accession: 178

United Nations Office for Disarmament Affairs (UNODA)

Convention on Early Notification of Nuclear Accident
Signatory: 69
Ratification-Accession: 110

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
Signatory: 68
Ratification-Accession: 115

International Atomic Energy Agency (IAEA)

Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction
Signatory: 160
Ratification-Accession: 192

Organisation for the Prohibition of Chemical Weapons (OPCW)

Comprehensive Nuclear-Test-Ban Treaty
Signatory: 183
Ratification-Accession: 165

Preparatory Commission for the CTBT Organization (CTBTO)

Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction
Signatory: 183
Ratification-Accession: 165

United Nations (UN)

Source: CTBTO Preparatory Commission 2014; IAEA 2014a; IAEA 2014b; International Civil Aviation Organization (ICAO) 2014; International Maritime Organization (IMO) 2014; The International Treaty on Plant Genetic Resources for Food and Agriculture 2014; NTI 2014; UNEP Ozone Secretariat 2014;UN 2014a; UN 2014b; UN 2014c; UN 2014d; UN 2014e; UNOOSA 2014a; UNOOSA 2014b; World Intellectual Property Organization (WIPO) 2014a; World Intellectual Property Organization (WIPO) 2014b

Further Reading 6-3

A summary of multilateral treaties by regions

Region: ASEAN

Countries	Signatory	Ratification-Accession	Signatory + Ratification-Accession	Total
Brunei	0	4	4	8
Cambodia	0	6	6	12
Indonesia	1	5	8	14
Lao PDR	0	7	6	13
Myanmar	2	6	3	11
Philippines	2	5	9	16
Singapore	0	9	5	14
Thailand	2	6	7	15
Vietnam	1	8	3	12
Malaysia	4	6	7	17
Region: MIST				
Mexico	0	5	10	15
Indonesia	1	5	8	14
South Korea	1	7	1	9
Turkey	0	7	9	16
Region: BRICS				
Brazil	1	5	11	17
Russia	0	5	8	13
India	0	7	7	14
China	1	8	5	14
South Africa	0	6	9	15

Source: CTBTO Preparatory Commission 2014; IAEA 2014a; IAEA 2014b; ICAO 2014; IMO 2014; The International Treaty on Plant Genetic Resources for Food and Agriculture 2014; NTI 2014; UNEP Ozone Secretariat 2014;UN 2014a; UN 2014b; UN 2014c; UN 2014d; UN 2014e; UNOOSA 2014a; UNOOSA 2014b; World Intellectual Property Organization (WIPO) 2014a; WIPO 2014

Further Reading 6-4

ASEAN Framework Agreement on Services (AFAS) and Mutual Recognition Arrangements (MRAs)

ASEAN Framework Agreement on Services (AFAS)

AFAS is aimed at forging closer economic integration and increasing the region's competitive advantage as a single production unit. It is the vision of the ASEAN leaders that by 2020, ASEAN as an Economic Community (AEC) will be a stable, prosperous and highly competitive region; a single market and production base with free flow of goods, services, investment and skilled labour; freer flow of capital; equitable economic development and reduced poverty and socio-economic disparities. The AFAS was signed on 15 December 1995 in Bangkok, Thailand.

The key objectives of AFAS are:

a) To enhance cooperation in services amongst member states to improve efficiency and competitiveness, diversify production capacity and supply and distribution of services of their service suppliers within and outside ASEAN;
b) To eliminate substantially restrictions to trade in services amongst member states; and
c) To liberalise trade in services by expanding the depth and scope of liberalisation beyond those undertaken by member states under the General Agreement on Trade in Services (GATS), aimed at realising a free trade area in services.

Malaysia has offered market-opening measures in the form of allowing establishment of equity ownership and presence of professionals from ASEAN countries. The concessions under the AFAS Eighth Package are better than the commitments under the World Trade Organization (WTO), which covers:

a) Accounting, auditing and bookkeeping services up to 49-51 % equity ownership;
b) Taxation services up to 49% of foreign equity;
c) Advertising Services up to 51% of foreign equity;
d) Research and Development Services up to 70 % foreign equity; and
e) Telecommunication Services up to 70 % equity.

Mutual Recognition Arrangements (MRAs)

MRAs are among the more recent developments in ASEAN cooperation on trade in services. MRAs enable the qualifications of professional services suppliers to be mutually recognised by signatory member states; hence, facilitating easier movement of professional services providers in the ASEAN region.

At present, ASEAN has concluded seven MRAs:

a) MRA on Engineering Services signed on 9 December 2005 in Kuala Lumpur, Malaysia;
b) MRA on Nursing Services signed on 8 December 2006 in Cebu, the Philippines;
c) MRA on Architectural Services and Framework Arrangement for the Mutual Recognition of Surveying Qualifications both signed on 19 November 2007 in Singapore; and
d) MRA on Medical Practitioners, MRA on Dental Practitioners, and MRA Framework on Accountancy Services all signed on 26 February 2009 in Cha-am Hua Hin, Thailand.

Source: ASEAN Secretariat 2009

Further Reading 6-5

Network of collaboration in publications and patents in ICT and biotechnology

ICT

The analysis indicates:

1. The maturity of the ICT industry indicates that the research landscape is dominated by universities working on fundamental research related to ICT.
2. The Malaysian ICT research map shows strong tie-up between local universities. However, the network lacks global exposure (international partners) which may limit its potentials [Figure (a)].
3. In the patent network landscape, local varsities also undertake patenting works in joint effort with local firms [Figure (b)] but the tie-up is small and limited to a few entities. Many productive firms, both foreign and local SMEs, were excluded in the process of innovating system development. In contrast, university presence in the network is absent in Taiwan. The conjecture is that the industry maturity in Taiwan is different, with firms leading the change in contrast to Malaysia, where university research is still skewed towards patenting.
4. Taiwan's ICT scientific research is localised, with high density of networks, indicating Taiwan's success in developing a strong national innovation system conducive for scientific activities. Nearly 30 of its top institutions have strong links with various universities and PRIs. The Academica Sinica and Industrial Technology Research Institute (ITRI) emerged at the core of the network, playing a key role in bridging joint efforts between universities, industry and research institutions. This element is missing in Malaysia.

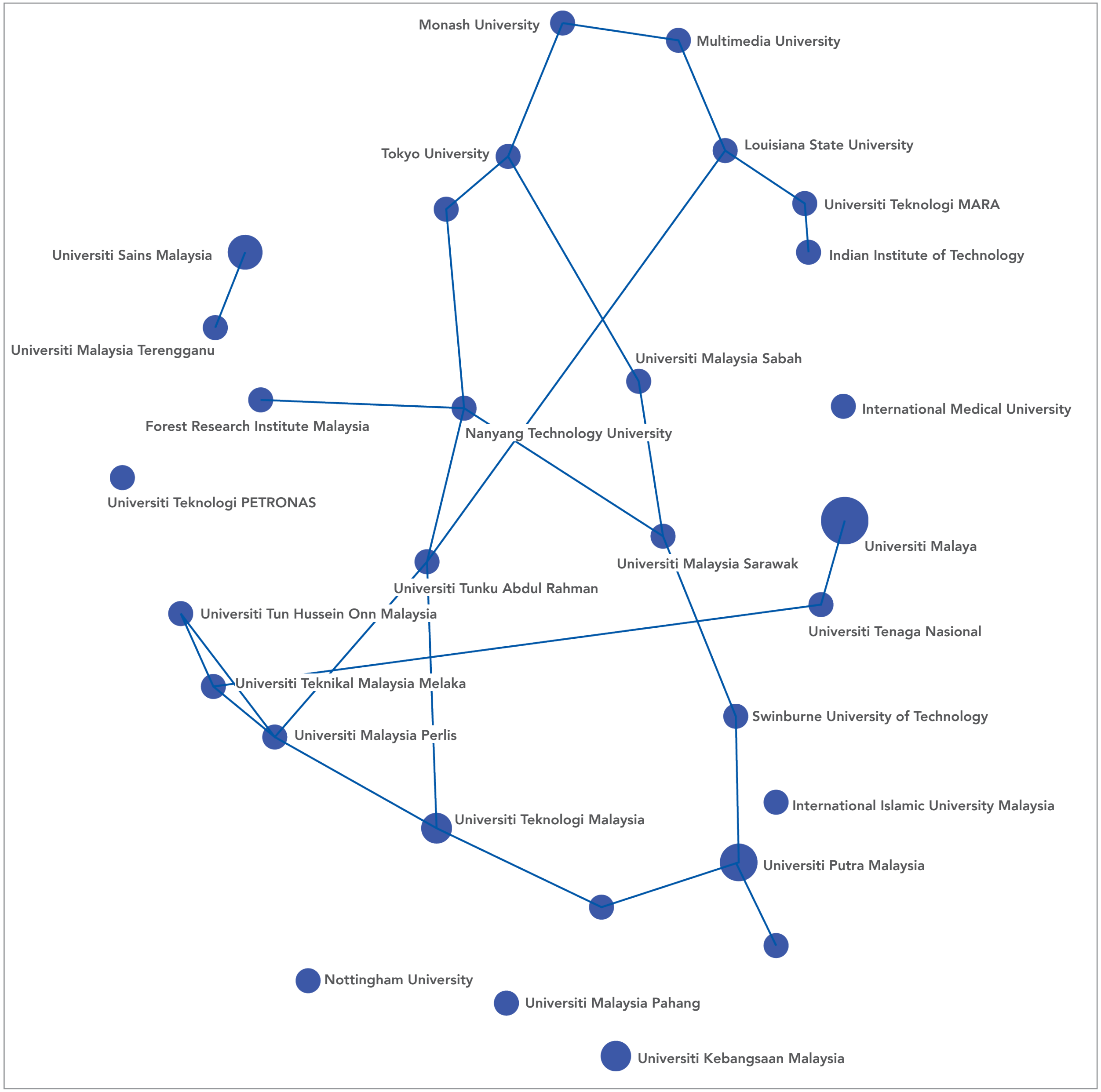


Figure (a). Malaysia ICT Publications Network - Auto-Correlation Map

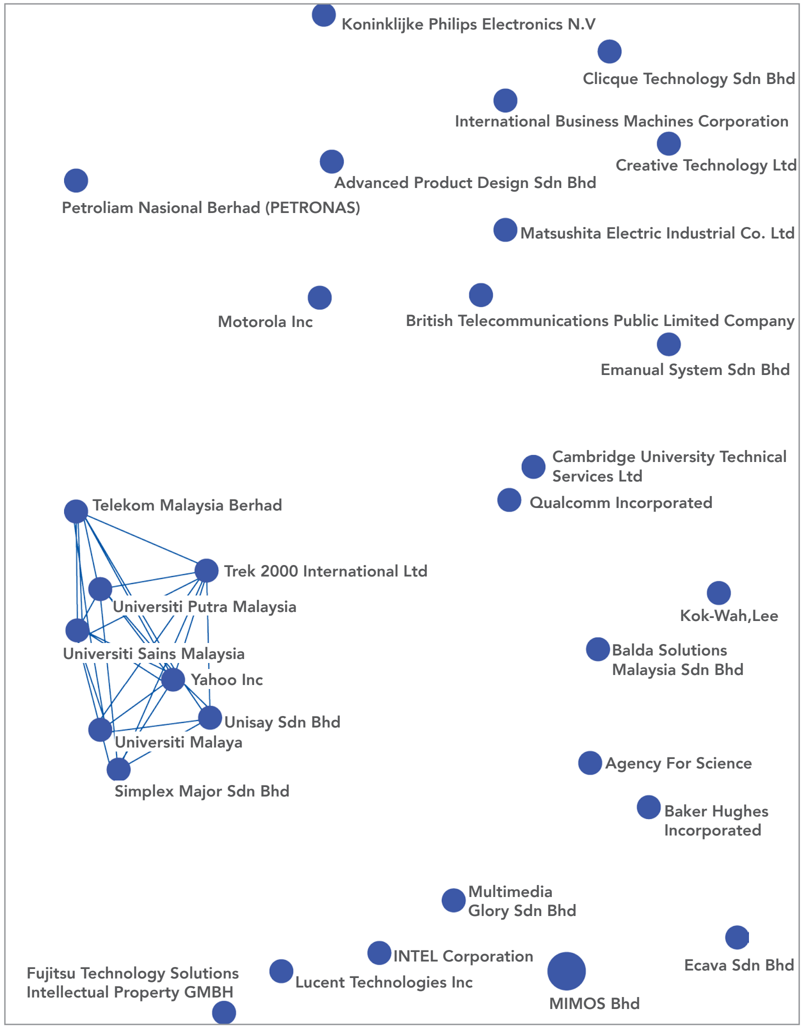


Figure (b). Malaysia ICT Patents Networks - Cross-Correlation Map

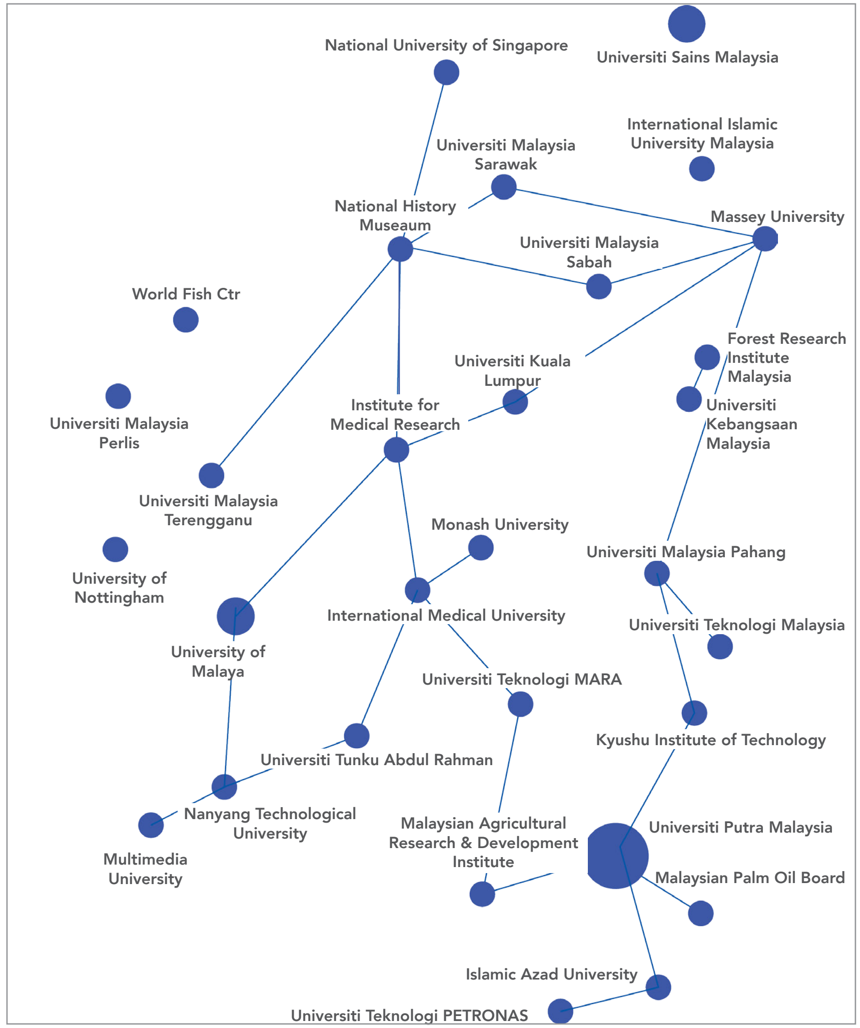


Figure (c). Malaysia Biotechnology Publications Networks - Auto-Correlation Map

Biotechnology

1. R&D in biotechnology is heavily dominated by universities, with GRIs supporting the research network in several key positions with specific universities [Figure (c)]. Proximity is a major factor as most collaboration happens within specific clusters that are physically close to each other. Universiti Putra Malaysia (UPM, formerly known as Universiti Pertanian Malaysia), is relatively the highest contributor with strong collaboration with the Malaysian Agriculture Research and Development Institution (MARDI) and Malaysian Palm Oil Board (MPOB), as well as foreign universities.

2. Several foreign universities are within the network, indicating significant international collaboration but confined to Asian universities or branch campuses of Western universities in Malaysia. Thus, the patent landscape in biotechnology is weak [Figure (c)].

3. Given that Malaysia is similar to Singapore where universities drive the research agenda, the study benchmarks Malaysia's biotechnology landscape with Singapore. Singaporean biotech landscape is dominated by its two largest universities, National University of Singapore (NUS) and Nanyang Technology University (NTU). However, the key difference is the fact that Singapore taps into a highly developed research network in the US and UK, leveraging heavily on inter-university collaboration.

Source: World Intellectual Property Organization 2013 (using Vantage Point Analytic Tools)

Further Reading 6-6

ASEAN – Areas of strengths in STI issues, challenges and advantages for Malaysia to explore alliances

A. The World Economic Forum (WEF) Global Competitiveness Report 2014-2015

The WEF Global Competitiveness Report 2014-2015 had separated the stages of development into five stages as shown in Figure (a) as below. The chart shows the Malaysia's performance in the 12 pillars of the Global Competitive Index (GCI) (blue line), measured against the average score of the group to which the economy belongs, using the same classification as in the GDP per capita (grey line).

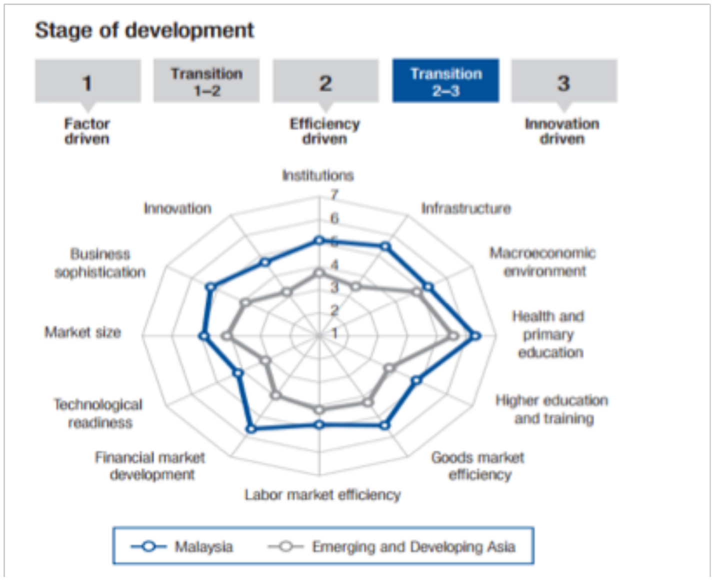


Figure (a). Stage of development for Malaysia
Source: The Global Competitiveness Report 2014-2015 (World Economic Forum 2014

B. The ASEAN Community of Science and Technology (COST) Report

The ASEAN Community of Science and Technology (COST) Report (2014) highlights the following areas of strengths for ASEAN countries, which present an opportunity for Malaysia as the AEC takes shape. Malaysia is well-positioned to forge meaningful and strategic international alliances with these countries for two main outcomes:

1. Development of Capabilities: With countries in transition from efficiency -driven stage of development to innovation-driven, or which have matured and are already innovation driven economies.

ASEAN Member
Singapore
Areas of Strength in S&T
Electronics;
Biomedical sciences;
ICT & Media;
Engineering; and
Clean Technology.

2. Reverse Linkages: With countries that are factor-driven or in transition towards efficiency-driven stage of development

ASEAN Member and its areas of strength in S&T

Brunei Darussalam
Biodiversity; energy; food security/ agro technology; climate change modelling; Asian studies; Islamic banking and finance.

Cambodia
Agriculture; mines and minerals; construction

Indonesia
Public health; plant sciences; environmental sciences; ecology; multidisciplinary geo-sciences; tropical medicine; microbiology; pharmacology & pharmacy infectious diseases, zoology, immunology; biology; biochemistry; molecular biology; medicinal chemistry; agronomy

Laos
Agriculture; forestry; horticulture; livestock; living aquatic; fisheries.

Myanmar
Engineering; agriculture; forestry; natural resources.

Philippines
Disaster science and management; climate change; aquaculture; biodiversity.

Thailand
Food-biotechnologies; manufacturing technologies; electronics industry; medical science.

Vietnam
Material science; biotechnology; ICT; mathematics; chemistry.

C. National Innovation Profiles

Cambodia

Issues & Challenges
Lags behind many of its regional neighbours in terms of overall development.

Innovation performance is weak. Very little expenditure on R&D, the number of researchers is low, publication levels are modest albeit growing, and patenting is extremely rare.

The relative immaturity of the country's innovation system suggests that it is too early for innovation to be at the heart of its short-term plan for development.

Continued expansion via trade and inward investment and efforts to upgrade the general business and educational environments must take priority.

Advantages
Agriculture and garment manufacturing, and employment growth has helped to reduce poverty.

General improvements to the business environment are likely to remedy framework conditions for innovation.

Indonesia

Issues & Challenges
It has not developed a technology-intensive industry structure and imports of high-technology products outweigh exports.

Significant improvements in infrastructure will be required to realise the government's growth ambitions. The ICT infrastructure, in particular, is relatively poor, in comparison to much of the regions. Other barriers include entrepreneurship and business risk which holds back rapid knowledge-based economic development.

Government policies tended to neglect the development of adequate scientific and technological base and framework conditions for innovation, but there is now a new emphasis on policies and mechanisms designed to stimulate innovation-led growth, with mechanisms freshly in place to oversee their coordination.

Advantages
The rapidly expanding higher education system is one means by high the innovation potential of Indonesia could be better harnessed.

Singapore

Issues & Challenges
Started to shift towards a more balanced approach, with increasing emphasis on developing its own R&D and innovation capability.

The emergence of a more vibrant technological entrepreneurial community is likely to be critical to Singapore's continuing transition from technology adapter to innovator.

Move nimbly and strategically to stay ahead of regional competitors in capability development in selected S&T technology clusters.

Advantages
Significant progress in developing its STI capability over the near half century since full political independence.

Its ability to attract global talent, especially innovative and entrepreneurial talent, is crucial to achieving this, even as it seeks to nurture greater entrepreneurship and innovation among its local population.

Thailand

Issues & Challenges

Tourism has been threatened by political instability.

Threatened by the more technological, learning-intensive economies of the original four Asian tigers.

Programmes to encourage R&D and technology development has had limited results.

Advantages

Services carry great potential for growth.

The government has adopted a dual track policy to enhance the capabilities of Thai firms while increasing international competitiveness by expanding foreign investment, exports and tourism.

Can boost performance in the long term by improving the skills level of the labour force, investing in ICT infrastructure, and better coordination and implementation S&T policies.

Vietnam

Issues & Challenges

Due to fewer international links, Vietnam suffered relatively less than other countries in the region from the Asian financial crisis in 1997 and the global economy crisis in 2008.

The Government dominate all aspects of S&T and research and innovation in both the public and private sectors is limited.

Continued economic growth in Vietnam and its ability to compete in global markets will depend on increasing investments in education and technology-based production.

The national innovation system needs to be strengthened in terms of public research, incentives for private R&D, and technology transfer and linkages between the public and private sectors, particularly with foreign firms.

Advantages

There is a strong case for streamlining and clarifying the role of government S&T agencies, while the country would benefit from centres of research excellence focusing on public health and environmental goods.

The expanding tourism sector and agriculture niches could also be targeted areas for research and development.

Priority sectors such as ICT continue to develop well and Vietnam is now attracting investments from multinational enterprises in IT.

D. COST COE Network

i. An Operational Model for a COST COE Network (supported by public sectors and/or private sectors, research development centres, incubators and IHLs) will establish strategic alliances with international communities in the STI space.

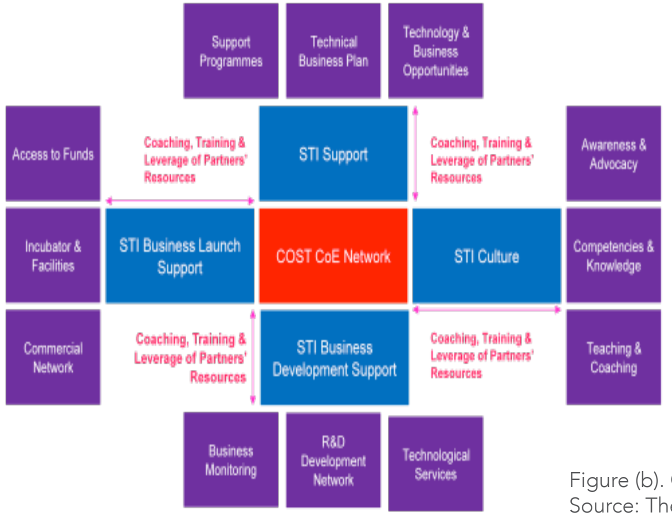


Figure (b). COSTNET Operational Model
Source: The Asean Secretariat 2015

COST COE's strategic intents and the expected impact on ASEAN-wide STI stakeholders and specifically on COST

COST Strategic Intent	COST Impact	ASEAN Wide Impact
Increased collaborative & applied research as documented	• Increase in external R&D funding, notably industry sponsored R&D projects and industry chairs. • Increase in patents filed and obtained or other manners of knowledge commercialisation and transfer.	• Open innovation mindset • Outstanding university / institutional / industrial potential • Specific mutual interest / knowledge base • Capability in technology and knowledge transfer • Entrepreneurial and creative leadership and teams • Believe in "a world without borders" and have interest and ability for cross cultural understanding and sharing • Supportive and holistic infrastructure in each location • Adequate resources, including finance • Obsession to communicate and network • Trust as a basis for success
Increased production of advanced human capital as measured by:	• Increase in enrolment of Masters and PhD students,and rise in number of PhD graduates. • Increase in placement of graduate students and research staff in short and long-term positions within collaborating firms as well as with local industry. • Updated and more relevant undergraduate and postgraduate engineering curricula.	
Developing long term R&D capability as evidenced by:	• Increase in publications of refereed journals. • Increase in joint publications of refereed journals with international authors. • Increase in joint programmes/projects/exchanges with international research organisations and institutions • External awards for research at the national and international levels. • Publications of books and technical reports.	

ii. Bridge and collaborate with STI professionals

As part of a long-term strategy, engagement with critical target groups is imperative. The following describes the strategies to bridge professionals from the academia and industry:

a. COST and ASEAN-wide interventions: Industry specialist

Talent Level	Industry Specialist	
Current Scenario	Insufficient manpower to address R&D and operational needs of member countries in critical industries.	
Ideal Scenario	Availability of personnel (both local and international) to meet R&D and needs of individual/collective needs of ASEAN countries.	
Geography	**Scenario**	**Intervention**
ASEAN Member States (AMS)	Recommendations	Increase the number of STI academics contributing to key sectors of the economy. This could be effected by mandating certain number of days of compulsory commercial work as part of their field of study. Where foreign specialists are required, locals should be integrated in the work groups to generate transfer of knowledge.
	Expected Outcomes	Maximise value extraction from human capital and access to shared resources. Increased availability of industry specialists can be highlighted by countries to attract foreign investment.
Inter-ASEAN	Recommendations	Creation of open source engagement platforms to expedite sharing of knowledge and efficiency in developing solutions for specific challenges.
	Expected Outcomes	Greater collaboration among industry specialists leading to improved mobility within ASEAN. Improved efficiency and effectiveness in addressing challenges.
Intra-ASEAN	Recommendations	Leverage on existing international relations and STI focus areas undertaken by COST to promote ASEAN as an STI opportunity for industry specialists. Work alongside Ministries of Trade to address HR requirements of foreign investors within the ASEAN region. Provide a conducive environment for talent mobility, retention and development within ASEAN.
	Expected Outcomes	Increased inflow of foreign industry specialists and corresponding transfer of knowledge to local expertise. Increased availability of human resources then acts as a catalyst to attract additional foreign investment in the region.

b. COST and ASEAN-wide interventions: Academicians

Talent Level	**Academicians**
Current Scenario	**Insufficient numbers of academicians (local and foreign) to meet teaching and research requirements**
Ideal Scenario	**Sufficient qualified academicians to address teaching needs.**

Geography	Scenario	Intervention
Country	Recommendations	Adopt peer to peer development programmes to boost the number of academicians at all levels. In the short term, develop fast-track programmes to train necessary human resources to meet immediate needs, while implementing longer term education programmes from the grassroots level. These should be mandated to contribute through teaching and research programmes.
	Expected Outcomes	Increased availability of academic strength to address human capital shortfalls across the education value chain. Increased numbers of researchers addressing local STI needs.
Regional	Recommendations	Creation of open source engagement platforms to expedite sharing of knowledge and efficiency in developing solutions for specific challenges. Development of a COST facilitated exchange programme among regional academicians.
	Expected Outcomes	Greater collaboration among industry specialists leading to improve mobility within ASEAN. Improved efficiency and effectiveness in addressing challenges.
International	Recommendations	Leverage on COST international network to promote peer to peer development programmes. Encourage human capital exchange programmes. Attract the participation of industry in the development of ASEAN's academic base.
	Expected Outcomes	Improved quality of ASEAN academicians to address research and teaching requirements. Attraction of foreign manpower to fill immediate needs in the education value chain.

Source: The Asean Secretariat 2015

Further Reading 6-7

Malaysia's focus outside of ASEAN

The Malaysian industry players are exploring opportunities to tap the potential in East Asian countries to include Korea, Japan and China for achieving new growth and a globalised approach to ultimately emerge as a developed economy by 2020. However, in line with the global economic trends, Malaysia must achieve some focus with ASEAN, alongside its expanding foot-print as well as business networks in the BRICS (Brazil, Russia, India, China, South Africa) as well as in the MIST (Mexico, Indonesia, South Korea, and Turkey).

According to Maxwell (2012), developing markets as they continue to 'emerge', have become the engines of global economic growth. To illustrate, India, China, Brazil, and many other countries are undergoing the kind of economic transformation that South Korea, Japan, and the nations of Europe experienced during the post-World War II boom. Furthermore, the economic progress in emerging markets is happening at an accelerated pace due partly to advances in technology, sound economic policymaking and reduction in poverty as a result of health, education, and other social reforms. From 1996 to 2010, emerging markets grew at more than twice the rate of developed countries — about 5% versus 2% annual GDP growth, respectively. Even more impressive is that, recently, income disparity between several certain emerging economies and developed countries are declining rapidly.

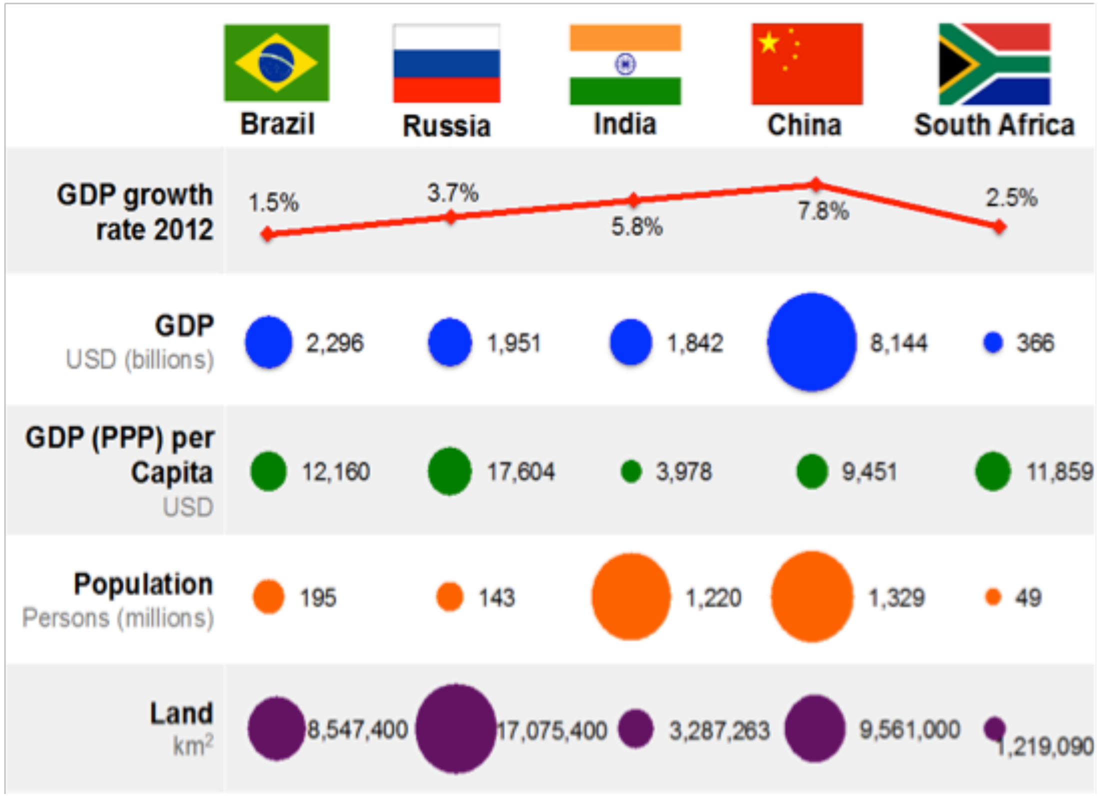


Figure (a). BRICS remain critically important markets integrated into the world economy.
*2012 figures are based on estimates
Sources: Corpart 2013; Maxwell 2012

Beyond BRICS?

BRICS' total GDP is almost four times bigger than the combined GDP of the MIST countries [Table(a)]. BRICS house more than three billion people, six times more than MIST's population. MIST economies are ranked better according to the World Bank's Ease of Doing Business Index, as well as the WEF's Enabling Trade Index. Mexico, Indonesia, South Korea, and Turkey are all ranked much higher, and are considered to be more open to business than the BRICS countries.

Over the years, Malaysia has established strong bilateral ties with countries such as Japan, Thailand, USA, China and its immediate neighbouring country Singapore for exchange of skills, knowledge, resources, and above all, business and trade.

Also, Malaysia has been actively pursuing projects in three of the BRICS economies (India, China, and South Africa) [Table (b)].

Table (a). A comparison between BRICS and MIST countries and Malaysia
*2012 GDP and GDP growth figures are based on estimates.

Indicators	BRICS	MIST	MALAYSIA
Total GDP (2012)	14.6 trillion	3.9 trillion	0.3 trillion
Average annual GDP growth (2012)	4.3%	4.1%	5.6%
Population median age (2010)	30	30	26
Ease of Doing Business (2012 average rank)	102	65	18
Enabling Trade Index (2012 average rank)	83	55	24

Source: Corpart 2013; The World Bank 2012b; World Economic Forum 2012

Table (b). Number and value of manufacturing projects approved by Malaysia Investment Development Authority (MIDA), January - May 2014 and 2013

	January - May 2014		2013	
Country	***No***	***Foreign Investment (RM)***	***No***	***Foreign Investment (RM)***
Japan	33	8,903,421,643	55	3,591,876,939
China	10	4,421,070,281	22	3,017,650,478
Germany	4	4,123,445,724	17	1,716,996,438
Singapore	52	3,237,308,489	126	4,522,314,186
South Africa	1	681,130,800	1	940,000
Taiwan	16	488,862,224	18	131,020,413
India	6	460,028,888	1	9,600,000

Source: MIDA 2014

Further Reading 6-8

Globalisation index data score

Looking at the published scores in Table (a) below, we can benchmark Malaysia's overall competitive positioning with the likes of Taiwan and South Korea and more developed nations such as Singapore and Hong Kong, with high potential opportunities for cross-border and collaborative trade, business, talent and knowledge exchanges.

a) For instance, Hong Kong's main strength lies in the exchange of technology and ideas (5.45 points higher than the global average of 3.28 of all 60 countries listed in the Globalisation Index Score).

b) Similarly, Belgium's scores on exchange of technology and ideas have also improved significantly, mainly due to a deepening broadband penetration and an increase in the number of internet subscribers.

Table (a). Globalisation index data score

Globalization Index Data Score: Ernst & Young 2014	Overall	Tech	Trade
Hong Kong	7.96	8.76	8.43
Singapore	6.34	5.76	8.67
Netherlands	5.00	4.52	6.35
Belgium	5.56	4.40	6.44
Switzerland	5.43	4.40	5.35
Hungary	4.75	4.32	6.51
Denmark	4.97	4.28	5.94
New Zealand	4.62	4.24	5.77
South Korea	4.10	4.20	5.96
Taiwan	4.60	4.19	5.90
Norway	4.39	4.19	5.36
Sweden	5.00	4.18	6.29
Malaysia	4.50	4.17	6.16

Source: Ernst & Young 2014

Further Reading 6-9

Malaysia's potential STI collaborators

Malaysia's top revealed technology advantage (RTA)	**Potential STI collaborators**	
	From top 30 most competitive countries (IMD ranking) based on ASM RTA analysis	From ASEAN countries based on COST report
Food chemistry	New Zealand	Brunei, Thailand, Indonesia, Laos, Myanmar, Philippines, Cambodia
Biotechnology	Iceland, Denmark	Indonesia, Brunei, Singapore, Vietnam, Thailand
Furniture, games	Hong Kong	Laos, Singapore, Thailand, Vietnam, Myanmar
Basic materials chemistry	Netherlands	Cambodia, Singapore, Vietnam, Indonesia
Semiconductor	Singapore, Republic of Korea	Thailand, Cambodia
Environmental	Qatar, Thailand	Philippines, Myanmar, Laos, Indonesia, Brunei
Computer technology	Israel, USA, Canada	Myanmar, Singapore, Thailand, Vietnam

Sources: IMD 2014b; OECD 2013; WIPO 2014c

Further Reading 6-10

Reasons for Malaysia to focus on multilateral collaborations compared to bilateral

The continued strength of the traditional centres of scientific excellence, such as the US, Western Europe and Japan, that invest heavily in research and receive a substantial return in terms of performance. With large numbers of research articles, the lion's share of citations on those articles and successful translation, as seen through the rates of patent registration, and the emergence of new players and leaders point towards an increasingly multipolar scientific world. This shows that the distribution of scientific activity is concentrated on a number of widely dispersed hubs.

Therefore, The Royal Society UK, in their 2011 published book, entitled "Knowledge, networks and nations: Global scientific collaboration in the 21st century", emphasised on the importance of multilateral collaborations. The reasons that they have mentioned is as below:

1. The scientific world is becoming increasingly interconnected, with international collaboration on the rise. Today, over 35% of articles published in international journals are internationally collaborative, up from 25% 15 years ago.
2. Collaboration is growing for a variety of reasons. Developments in communication technologies and cheaper travel make it easier than ever before for researchers to work together; the scale of research questions; and the equipment required demands that researchers are mobile and responsive. Collaboration enhances the quality of scientific research, improves the efficiency and effectiveness of that research, and is increasingly necessary, as the scale of both budgets and research challenges grow.
3. Collaboration brings significant benefits, both measurable (such as increased citation impact and access to new markets), and less easily quantifiable outputs, such as broadening research horizons. The facilitation of collaboration, therefore, has a positive impact not only on the science conducted, but on the broader objectives for any science system (be it enhancing domestic prosperity or addressing specific challenges).

4. The global scientific community is increasingly charged or driven by the need to find solutions to a range of issues that threaten sustainability. These "global challenges" have received much attention in recent years, and are now a key component of national and multinational science strategies and many funding mechanisms.
   (1) Global challenges are interdependent and interrelated: climate change, water, food and energy security, population change, and loss of biodiversity are all interconnected. The dynamics between these issues is complex; and yet many global assessment and research programmes are managed separately, often reflecting a lack of coordination in the policy sphere. Governments, civil society and the private sector need to take a broader perspective on global challenges in order to appreciate how they are interrelated.
   (2) Global challenges are being addressed via a number of different organisational mechanisms: through inter-governmental or international bodies, through national systems, and by private individuals and corporations. These mechanisms often deploy novel and innovative forms of partnership, some of which work well, others not so successful. Valuable lessons can be drawn from existing models in designing, participating in and benefiting from global challenge research.
   (3) Science is essential to addressing global challenges but it cannot be done in isolation: A wide range of approaches will be required, including the appropriate use of financial incentives, incorporating non-traditional forms of knowledge, and working with the social sciences and wider disciplines. Science is crucial but it is unlikely to produce all the answers by itself: the science infrastructure works best when it is supported by, and enables, other systems.

However, the primary driver of most collaborations comes from the scientists themselves. In developing their research and finding answers, scientists are seeking to work with the best people, institutions and equipment which complement their research, wherever they may be. The connections of people, through formal and informal channels, diaspora communities, virtual global networks and professional communities of shared interests are important drivers of international collaboration.

Source: The Royal Society 2011

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Ameera Hani
Dr Yunus Yasin, ASTI
Jeanette Good, The Star
Law Yao Hua, BFM
Rosmala Nasir
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AKADEMI SAINS MALAYSIA
ACADEMY OF SCIENCES MALAYSIA

20th Floor, West Wing MATRADE Tower,
Jalan Sultan Haji Ahmad Shah off Jalan Tuanku Abdul Halim
50480 Kuala Lumpur
t|+603-6203 0633 f|+603-6203 0634
w| www.akademisains.gov.my