



**Asia-Pacific  
Economic Cooperation**

**Advancing** Free Trade  
for Asia-Pacific **Prosperity**

# **Manual on Domestic Innovation Systems and Networks**

**APEC Policy Partnership on Science, Technology and Innovation**

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## ABBREVIATIONS

ABAC	APEC Business Advisory Council
BERD	Business Expenditure on Research and Development
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on Research and Development
IMF	International Monetary Fund
IPO	Initial Public Offering
MOST	Ministry of Science and Technology
MRI	Multi Research Institutions
PNGSTS	Papua New Guinea Science and Technology Secretariat
PPSTI	Policy Partnership on Science, Technology and Innovation
PRI	Public Research Institutions
R&D	Research and Development
REI	Regional Economic Integration
SME	Small Medium Enterprise
STI	Science, Technology and Innovation
WTO	World Trade Organisation

## EXECUTIVE SUMMARY

Many economies are heavily investing in building domestic innovation systems as essential policy instruments to promote economic growth. Central to this shift is the creation of knowledge platforms as the basis for technological and social change leading into the 4<sup>th</sup> industrial revolution, and investment in digital economies.

In August 2018, a PPSTI Workshop was conducted in Port Moresby, Papua New Guinea (PNG) to allow member economies to share their experiences and lessons gained from their domestic innovation systems. This APEC Manual is a synthesis of those learnings and attempts to draw key principles of innovation systems that govern the control and investment into innovation processes based on their unique comparative advantages.

Section A provides an introduction and background on what innovation is within the context of the APEC's Policy Partnership on Science, Technology, and Innovation (PPSTI) and the value of STI on APEC's Growth Strategy. It also introduces the definitions of innovation systems used by OECD, the World Bank and other policy commentators that are influential with the Asia-Pacific region. The introductory section further references a large volume of both APEC and OECD literature for additional information whilst providing some domestic context on innovation systems in some of the economies that are subjects of the manual.

Section B is on Innovation Ecosystems and Networks, and covers a broad range of issues. These include APEC perspectives on innovation systems in relation to its Growth Strategy, to support knowledge production, distribution and utilization as new forces for driving economic, income, and employment growth in the Asia Pacific region. It further identifies actors in the innovation system and the parallel interventions to address various aspects of social and economic challenges; including a wide range of policy instruments to support innovation activities. The structures of governments that enable innovation are also explored, noting that there are many different approaches to innovation systems by the member economies.

The financing of innovation is also captured because access to finance is a significant constraint for Small Medium Enterprises and innovation based Start-Up companies. In particular, the manual explores GERD as the main form of government R&D funding and also the role of fiscal policies in providing tax incentives to the industry to support R&D. Section B concludes with identifying why innovation networks are critical for innovations systems.

Finally, Section C of this manual provides policy recommendations, which were identified during the workshop. These recommendations include the following:

- Promote Regional Innovation Networks
- Establish the Ministry of Science and Technology
- Strengthen Partnerships between domestic institutions and government agencies
- PNG to focus on establishing its Agriculture Innovation System

## INTRODUCTION

This manual explores how selected APEC economies develop innovation systems to integrate government's policy on science, technology and innovation and its regulatory agencies, education and training institutions, and the industry. Development of technologically skilled human capital that meet the labor demands of the future knowledge and digital economy is also explored in the manual. This is because global competitiveness is increasing the demand for a highly knowledgeable labor force. Therefore, a coordinated whole-of-government approach is critical for establishing favorable frameworks and an environment that can propel economic growth.

In this context, R&D is discussed as the precursor to innovation and technology development. Although some innovations are developed in the absence of organised R&D programs, R&D in this context will also include innovations that are not necessarily part of the science innovation pipeline. Therefore, the definition of innovation and R&D will also include social and financial innovation. In this manual, the terms innovation and R&D will be used interchangeably.

The structures and systems that are mentioned in this manual are not best practices *per se*. The author views them as principles for discussion. The flexibility and diversity in how developed, emerging, and developing APEC economies have structured their systems and networks are considered. Therefore, what is presented here would be best viewed as general principles for the development of innovation systems and networks.

### **Background on the APEC Workshop on Domestic Innovation Systems and Networks**

In August 2017, the Papua New Guinea Science and Technology Secretariat (PNGSTS) submitted a Concept Note titled "Workshop on Domestic Innovation Systems and Networks." The motivations for this concept note arose from the persisting constraints that were limiting to the development of STI within the economy. The PNGSTS saw an opportunity for learning through an APEC workshop that could enable economies to share their experiences to inform PNG's STI policies on regional innovation policy trends.



The resulting workshop was held from the 12<sup>th</sup> to the 13<sup>th</sup> of August 2018 at the Lamana Hotel in Port Moresby, PNG. This manual is the final synthesis of the workshop presentations, desktop research and literature reviews on various innovation systems, and their role in promoting and supporting innovative growth within the Asia Pacific Region. The manual is intended for use by policy makers, researchers, NGOs, and SMEs in PNG, and other APEC member economies.

The PNGSTS had already developed several key STI policies when the Concept Note was drafted. These policies included the STI Policy, STI Plan, the National Research Agenda, and Research Guidelines for Papua New Guinea. The central theme across these policy documents is 'Knowledge and Innovation' as imperative cornerstones to achieving sustainable, equitable, and inclusive economic growth for PNG. The Secretariat also realised early in the policy development process that major policy, institutional, research, and investment gaps were contributing to low levels of STI and outputs in its economy. With such limitations, it is a challenge for PNG to effectively participate in APEC's REI process when most of the economies are focused on innovation for their economic growth. Therefore, it became apparent that broader regional conversations were needed on *innovation systems* to generate understanding about its role in economic development, productivity growth, and international trade.

The PNGSTS joined the APEC's Policy Partnership on Science, Technology and Innovation (PPSTI) fora in 2015. Subsequently, the Secretariat has actively been involved in numerous policy dialogues through the PPSTI fora and its strategic plan. Fundamentally, the PPSTI Strategic Plan 2016-2025 envisions that the APEC region will achieve innovative economic growth through PPSTI efforts by the year 2025, and to achieve the APEC leaders' initiative on

*"Towards Innovation-Driven Development"*, PPSTI aims to "strengthen the synergy of government, academia and industry, including SMEs, and engage actors involved in joint scientific research and in the technology inception, dissemination and commercialization cycle, with both its competitive commercial sectors and non-profit elements" (PPSTI 2015).

The most critical policy issues of the 21<sup>st</sup> century include the crosscutting nature and the impact of innovation on the development of new technologies, the digital economy, society, and the environment. PPSTI foresees that innovative economic growth will be achieved "through enabling eco-systems, regional cooperation, human

resource exchange, and infrastructure development” (PPSTI 2015). In essence, it is the level of integration of these actors, the enabling policy mixtures, and response to market demands that determines the form and structure of each economy’s innovation system.

## **Structure and Limitations of this Manual**

Summaries of some of the workshop presentations are provided in this manual as Case Presentations. We could not accommodate for all the workshop presentations in the manual due to space limitations. However, they will be provided in the accompanying workshop report.

There are many variations on the structure and functions of innovation systems across the APEC economies. The experiences and literature shared in this manual are not absolute and should be used as the triggers for further research into the immense body of knowledge on innovation systems.

## INNOVATION ECOSYSTEM AND NETWORKS

*Innovation* is a process of transforming ideas and knowledge into new products and services. Innovation may represent new products, new processes, new raw materials, new forms of organisation and new markets (OECD 2007). It may also include the introduction of the innovation into the market and subsequently, its diffusion and use within economies. Underpinning this process of innovation is a human need that motivates the application of science, technology and innovation to deduce solutions to meet those impending needs. Innovation has been around since the industrial revolution and is becoming a crucial factor in determining economic competitiveness and progress for many economies, including those within the APEC economic bloc (OECD 2007).

Accordingly, the APEC Growth Strategy has three objectives, which are (1) Sustainable Development, (2) Equitable Growth, and (3) Strengthening the Asia-Pacific community (APEC 2010). Under these objectives, the strategy aims to attain balanced growth, promote inclusive growth, achieve sustainable growth, enhance innovative growth, and create a secure growth within the APEC region (APEC 2010).

Many economies within the APEC region are increasingly focused on innovative growth by creating enabling environments that stimulate innovation in science and technology to drive the economy.

An analysis of APEC member economies indicates that innovative growth in some of the economies has resulted from economic policy decisions to develop innovation systems that coordinate various players and brokers into a framework. There is evidence within the APEC region and also OECD that support the role of innovation systems in promoting growth and economic development. At this juncture, it is crucial to have some definition of what an *innovation system* is.

According to the World Bank, an *innovation system* is a:

“network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance.” (World Bank 2011)

There are many other definitions available from the volumes of public policy documents that have been published. However, what appears to be fundamental to all innovation systems in theory and practice are institutional relationships and the diffusion of knowledge through these linkages, economic usages, and the institutional structures.

A system is commonly defined as a set of interrelated components working toward a common objective, which, for an innovation system, is to generate, diffuse and utilise technology (Carlsson et al., 2002).

### **APEC Perspective on Innovation Systems**

The Global Financial Crisis in 2008/2009 triggered a series of serious discussions for APEC during the recovery phase of the financial meltdown that had impacted much of the world. The perception was that the economic drivers within the region were not balanced, and some drastic measures were needed to change the economic future of the region (APEC 2010). There were other more significant concerns in addition to the financial troubles. The Asia Pacific region was becoming vulnerable to the impacts of climate change that would have serious economic consequences for the region. In addition, a lack of innovation was identified to be a potential impediment to economic growth if not addressed adequately as a critical policy measure across the region (Asia Pacific Economic Cooperation 2010, Liu 2010).

Given these concerns, the 2009 Leader's Declaration acknowledged it was essential for a new growth paradigm to be developed for the post-financial crisis period in order to develop a more balanced economic region. Hence the APEC Growth Strategy was developed to ensure balanced, inclusive, sustainable, innovative, and secure growth (Asia Pacific Economic Cooperation 2010).

It was immediately recognised that technological breakthroughs and Information and Communication Technology (ICT) play a significant role as a primary driver of **economic** growth (APEC 2010). It became evident that the future of the APEC economies depended on new products and services to promote advancement in critical areas of global importance. Innovation was needed in the areas of environment, energy, transport, agriculture, health care, logistics, emergency response, administrative services, and education. (Asia Pacific Economic Cooperation 2010)

In 2010 and following the development of the APEC Growth Strategy, the Chinese Taipei ABAC published a report titled “Advancing Innovative Growth to Strengthen the APEC Growth Strategy” to translate APEC’s position on innovative growth into business and industry acumen (Liu 2010, Asia Pacific Economic Cooperation 2010). It affirmed knowledge production, distribution, and utilisation as new forces for driving economic, income, and employment growth in the Asia Pacific region. The paper also highlighted Innovation Systems, Human Resource Development, IT Infrastructure, and Business Environment as vital aspects to foster innovative growth (Liu 2010).

There are fundamental principles that cut across all innovation systems within the APEC member economies to promote regional standards integration that encourages cross licensing of technology between the public and private sector and among firms. However, there are some variations in the structure of innovation systems from economy to economy.

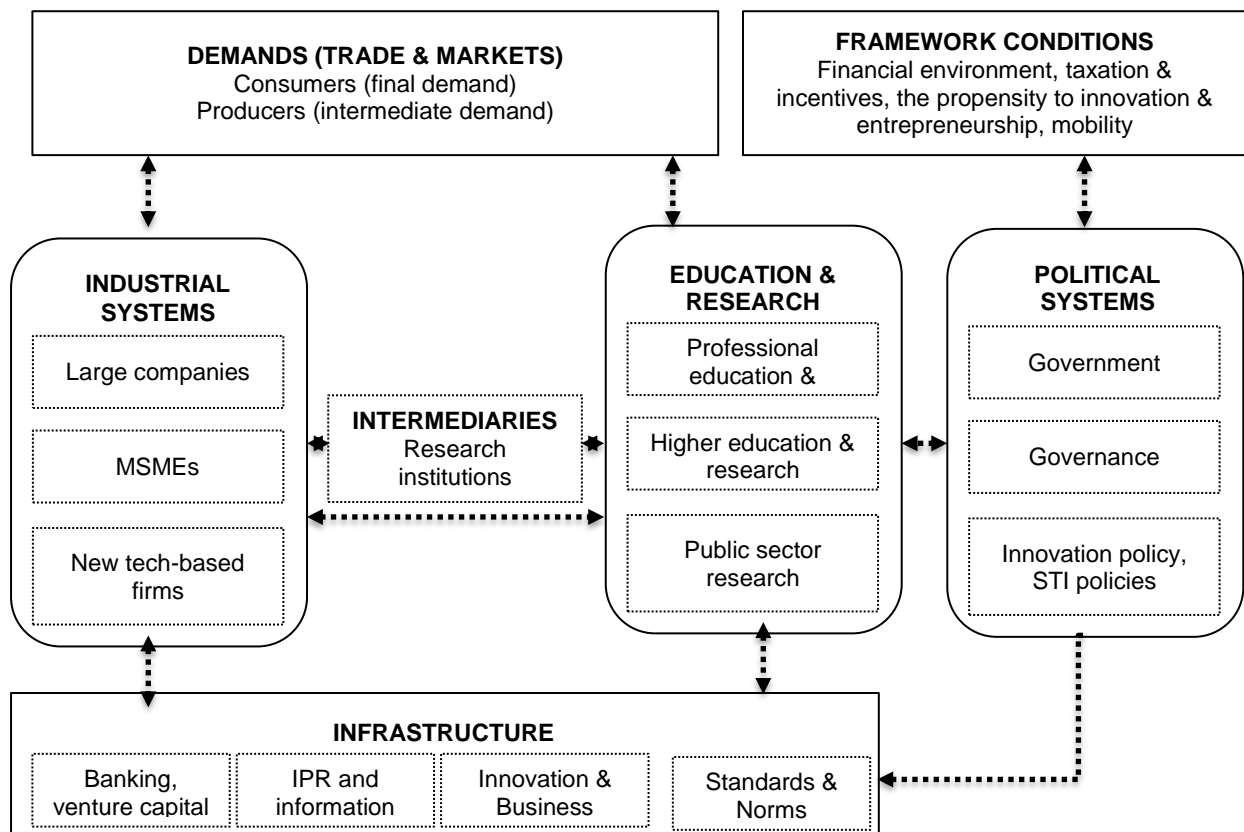
This manual draws on some examples from our APEC member economies that currently have functioning innovation systems and networks. For this manual, the author decided no individual case studies would be made because all economies have varying structures to their innovations systems. However, key principles would be extracted and elaborated upon by using examples from a few of the APEC economies. In the next two sections we explore (a) how economies have structured their government research and development structures, (b) Innovation Funding and (c) the institutional frameworks for innovation networks that integrate all actors and brokers in the innovation systems.

## **Actors in the Innovation System**

APEC economies have different systems of innovation that are at various stages of maturity. Some economies, such as the United States and China have a decentralised system of innovation while others such as Malaysia have a more centralised form of innovation system (DIS Workshop, unpublished).

It appears that larger and advanced the economies are more likely to result in decentralised innovation ecosystems. More agencies are interlinked through a plethora of policies and ensure efficient policy coordination that is functional to deliver innovation outcomes. In the United States, for instance, eleven federal agencies are involved in science and innovation (DIS Workshop, unpublished).

Despite the degree of differences in innovation systems within the APEC region, there are core features that cut across many economies. A general model of an innovation system is provided in **Figure 1** to illustrate in its simplest form the core institutions of the system and the linkages by which knowledge is diffused or shared to market value. From the figure, innovation systems may consist of four core systems beginning with a political system that should be driving the innovation policy and ensuring an enabling policy environment is established. An education and research system to build the human capital relevant for knowledge generation is the second pillar. The third core system is the industrial system, which is responsible for knowledge uptake and technology commercialization and research outcomes. For these core institutional systems to function coherently as an integrated unit, considerations must be in place to ensure that the core systems are supported by infrastructure, framework conditions, and the market demands.



**Figure 1:** Core actors of innovation ecosystems

## **Triple Helix of Innovation System**

Many commentators refer to innovation ecosystems as the “triple helix model” due to the trident composition of government (politic), education and research, and industry that form the core of the innovation ecosystem.

### **1. Political systems**

The political system is primarily the cornerstone of any innovation ecosystem. In any economy, the political system sets out the laws, policies, regulations, and enforcement to influence businesses and its citizens. Creating enabling policy environments for STI to be cultivated is strongly influenced by the political systems and its administrative powers that prioritise investment. In this manual, the political system refers to the parliament, the administrative machinery, and the policies processes that support investment in STI. This is expanded on in Section III on Government Research and Development Structures. Government policy responses in areas such as innovation funding, cross-border mobility of skilled workforce and technology transfer to stimulate economic growth, provision of tax incentives for research and innovation are some examples that are critical to innovation and growing of knowledge economies.

Some critical and enabling policies that the political system is responsible for are described in the section on Framework Conditions below.

### **2. Education and Research Systems**

Development of human capital is critical to improving and enhancing knowledge-based innovation and growth. With the changing environment in technology and industry, there is a growing shift from many institutions of primary, secondary, and tertiary education to promote innovation and entrepreneurship. There are growing global challenges in environment, society, health, education, and technology that are continually providing new opportunities for research and business. The increasingly digitised and technologically advancing global economy requires a knowledgeable and skilled labor force with entrepreneurial mindsets to solve critical societal problems.

Promoting and supporting basic research in universities underpins basic research, which in most cases does not have an immediate return on investment in monetary terms. The long-term benefits for creating and enhancing knowledge economies are immeasurable. Investment in basic research, especially in universities, is an ingredient

for knowledge creation as it provides the critical mass needed for the creation of new knowledge.

Since the 1980s, the roles for many universities within the APEC region have continued to change. From being places of learning, universities have now become centers for "discovery and inventing of the future through research, education and active efforts to move university derived ideas into industry. The latter comes with "many universities creating offices to foster the transfer of technologies developed by faculty members and students to industry. These transfers occur through technology licensing, including regional development, revenue generation, and recruiting and retaining staff" (Olson and Dahlberg n.d.).

Organisational and social innovations are also essential, and in most cases, may precede scientific and technological innovations. Therefore, other professional education and training programs in areas such as organisational management, entrepreneurship, public policy, arts, and humanities, are essential in innovation ecosystems.

### **3. Industrial Systems**

The industry is an important driver for the economy because it drives business and creates demand for research and development. The industrial systems may comprise of large multinational companies, Micro, Small and Medium Enterprises (MSMEs), and new technology start-up companies.

Large companies are instrumental in knowledge and technology transfer across borders to improve organisational and production efficiencies in host economies. They also promote labor mobility across borders, which allow the transfer of knowledge and skills, especially in highly specialised areas such as technology and innovation.

MSMEs are critical to innovation and growth as they account for over 97 percent of all business and employ over half of the workforce across the APEC economies (APEC Small Medium 2019). Within the APEC economies, MSMEs contribute toward the GDP growth from 20 percent to 50 percent, although they account for less than 35 percent of direct exports (APEC 2019).

In recognising the vital role that MSMEs play in encouraging business and growth, the Small Medium Enterprise Working Group (SMEWG) encourages the development of



SMEs to build their capacity to engage in international trade and achieve the Bogor Goals (APEC 2019). The SMEWG Strategic Plan 2017-2020 provides a road map to address the following critical issues on the growth of MSMEs in the APEC region, namely:

- Entrepreneurship, innovation and the internet and digital economy
- Financing for business expansion and capability development
- An inclusive business ecosystem that supports SME growth
- Market access for SMEs

The linear perception of innovation applies pipeline thinking, where innovation is triggered through investment in basic research, especially in universities. In ideal situations, discoveries are patented by university institutions, which enable the formation of start-up firms for product research and development. The end game is to produce a new market demand for a new product. Quite often, these R&D start-ups do not become a commercial success.

There is also an increasing departure from the rigid and vertical hierarchal systems of innovation from the industrial era. New digital spaces, motivated by technological advancements, are leading to more flexible and horizontal networks of sustainable linkages between individuals and organisations to catalyse innovation and growth (Kiriya 2012). Open innovation ecosystems are now leading to the development of new industries that are producing innovative products and services.

### **Supporting Structures for Innovation Ecosystems**

For the core actors of innovation ecosystems to function effectively as an integrated unit, there need to be supporting structures.

#### **1. Intermediaries**

Intermediary actors, particularly research institutions, are instrumental in the innovation pipeline because they serve as critical links between universities and industries. Where universities are engaged in learning and conducting basic research for new knowledge creation, they are often under-resourced to conduct applied and development research for commercialisation. In response to this, many universities within the APEC region are now creating commercialisation approaches to pursue further developments in basic research.

To address these shortfalls in the university systems, investments in public research institutes have gained popularity to address societal issues, including defense, health, education, policy, and agriculture. There is also increasing focus to invest in PRIs to assist domestic industries and upgrade SMEs to develop technologies in traditional productions of electronics, automobile, and engineering while at the same time, addressing next-generation technologies such as artificial intelligence and data sciences, biotechnology and nanotechnology. Over the last decade, relationships between PRIs and firms and non-firm actors such as universities have become more intense, open, horizontal, international, and longer-term (Intarakumnerd and Goto 2018).

There is also growing autonomy for PRIs to take the initiative in directing research in addressing and solving today's problems. It is essential to ensure that research is driven to meet existing industry and market demands. Key initiatives that allow PRIs to pursue grand research challenges and to remain relevant to the industry include, mobility of researchers that is often associated with technology transfer, competitive funds, and grants from industry and block grants from government (Intarakumnerd and Goto 2018).

Industry-funded research institutes, on the other hand, are more concentrated on the applied and development research of products and services, and commercialisation thereof. A workshop on "Researcher Mobility among APEC Economies" found that industry expenditure into research varies from more than 75 percent to less than 25 percent across APEC economies. Moreover, that three-quarters of researchers in some economies are in the business sector (Australian Department of Education and Training 2015).

## **2. Demand**

Demand stimulates the most ambitious kinds of innovation. While consumer or market demand may drive innovation, it is considered to be a weak mechanism for innovation. State-sponsored demand is critical for an innovation culture to take root and become the cornerstone of growth. Strangway observes that the "success of Silicon Valley is based on state-sponsored demand and that any economic and policy initiatives to replicate the Silicon Valley success wouldn't be successful" (Strangway 2013, Edward and Jung 2013). This is because the government mainly drove the conditions that created the demand for innovation by enabling trade and investment policies, human capital development, and access to finance and capital. Also, governments with successful innovation systems are making public procurement of

innovation a cornerstone in their innovation policies (Edler, Georghiou and Uyarra, et al. 2011). State-sponsored-demand also “focuses on creating private sector and university innovation capacity, that will build the long term knowledge economy and the consequent jobs” (Strangway 2013).

Consumer or market-driven demand, on the other hand, is important for competition to promote innovation. There are varying and unfulfilled needs of potential customers for new products, technology, and services, that drive firm or industry to innovate. Access to technology and worldwide information is changing the role and behavior of the customer and the business environment in the global marketplace (Dornberger n.d.). This is demanding a rapid uptake of technology from universities and research institutions by firms and industries for conversion to applied technology warranting that businesses must be innovative to remain competitive.

Improvement in trade facilitation and reduction on barriers to trade are further impacting on international business and innovation. The ability for many firms to operate across borders is enabling the mobility of people, including researchers and business, from one economy to another, and consequently encouraging the transfer of knowledge and technology. APEC, through its Trade Facilitation Action Plan, ensures trade opportunities are enhanced for its member economies by promoting a market-oriented framework, which is identified in the APEC Trade Facilitation Principles (APEC 2018). Furthermore, by standardising and harmonising trade regulations, APEC is supporting global value chains in the production and movement of goods and services. Again, this creates healthy competition and is critical for innovation.

### **3. Framework Conditions**

Innovation ecosystems are a complex web of relationships in any economy’s research and development systems. It provides an interlinking of government, educations and research systems, and the industry as the core actors. Governments set the economic priorities and “attempt to support the innovation process through dedicated policy instruments which set out regulations, laws and other constraints” (Remoe, Medina and Zhang 2015). As a result, innovation is increasingly becoming important for global supply and value chains, and these government policy instruments are essential in enhancing trade as the world becomes more globalised and linked to global innovation networks (Remoe, Medina and Zhang 2015).

Framework conditions are defined as:

“those economic, regulatory or other conditions that are not part of the core set of research and innovation policies; and prescribe the wider economic and institutional systems of an economy or a region that have potentially significant impacts on innovation performance. Hence innovation is not only dependent on its research and development systems but also on the wider economic and institutional environment with its interplay and interactions that enable knowledge to be transformed into commercial value in markets and hence to economic development" (Remoe, Medina and Zhang 2015).

Therefore, essential to improving innovation performance are general macro-economic indicators such as quality and standard of the education system and human resources, a propensity to innovation and entrepreneurship, infrastructure, macro-economic conditions, and incentives through the taxation system. More recently, regulations and laws allowing for the mobility of researchers across borders within the APEC region have gained increasing policy discourses (Australian Department of Education and Training 2015).

#### **4. Infrastructure**

Infrastructure is critical for innovation and support to transport new ideas and inventions from discovery to market. Physical infrastructure, such as roads and ports, energy, telecommunications, and innovative cities, are increasingly becoming necessary for innovation and to form the basis of knowledge economies. Many cities in the APEC region are now being designed and developed to encourage business and promote cultural shifts towards becoming knowledge and innovation hubs. Governments such as those in Hong Kong, China and Singapore are building enabling infrastructures in cities and growth areas to ensure that development of human talent, knowledge creation, technology, government, and global integration, are central to their innovation ecosystems.

Strategic investment in ICT infrastructure and the associated low cost of Internet access in many economies has encouraged a wave of tech-based entrepreneurs keen on solving many societal challenges. Innovative technological solutions to address issues in diverse areas such as biomedical, environment, finance, and supply and value chains are changing the global business environment. Such supply-pull for innovation generated by governments encourages private sector investment in innovation and ensures economic growth more broadly.

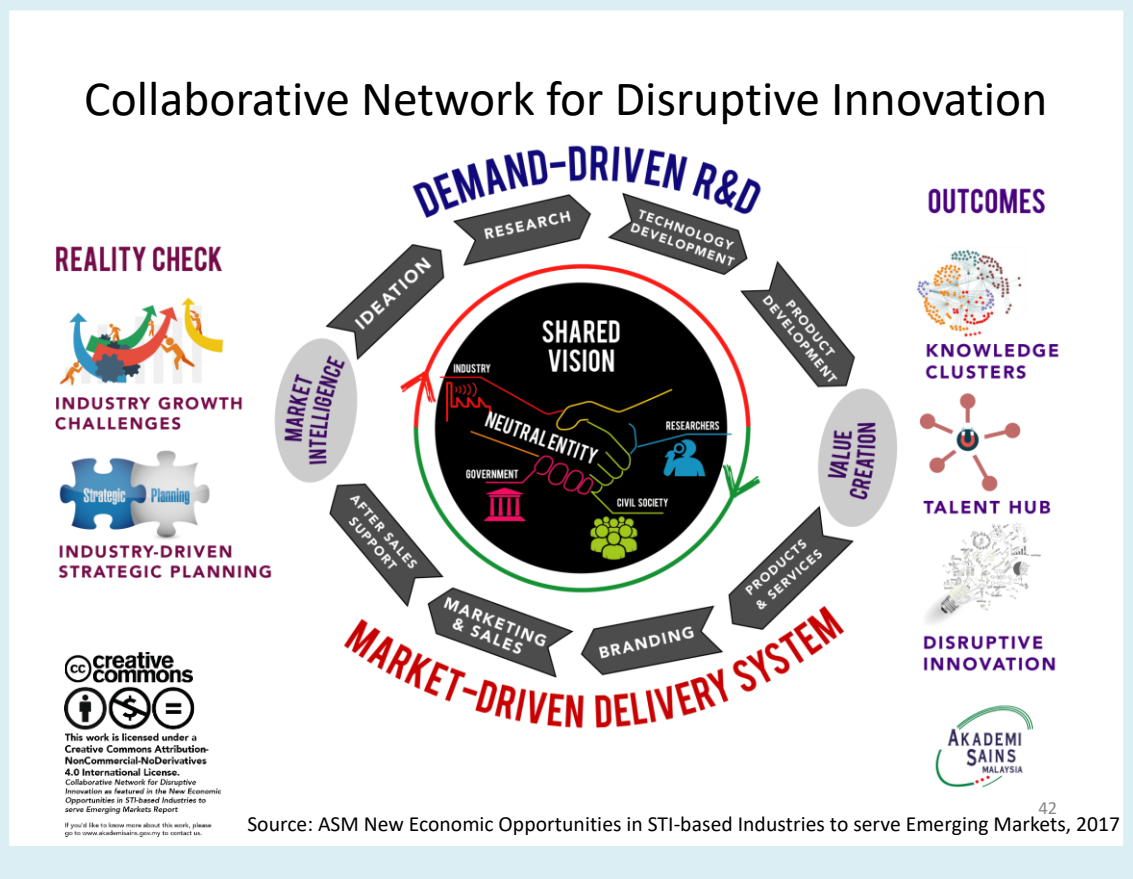
Investment in both hard infrastructures such as research and building facilities, communications, transportation, and soft infrastructure such as education and cultural amenities in *research parks* are essential for promoting university-industry relations. Research parks are where “research culture meets corporate culture” and provide a middle ground “where researchers with commercially promising ideas could work with business and financial experts to develop ideas into products” (Olson and Dahlberg n.d.). Research parks also play an essential role in turning the investment in education into good jobs and economic productivity.

Standards are another infrastructural requirement that is critical for strengthening innovation ecosystems and improving products for markets. According to the British Standards Institute, “the development of standards can help an emerging technology ecosystem rally round the issues to promote successful commercialization of new products” (BRITISH STANDARDS INSTITUTE 2019). Standards are critical to the success of innovative businesses because they set the framework and rules that establish the essential characteristics of a product or service. Standards also identify best practice within the ecosystem to enable successful outcomes. Finally, the establishment of standards also play a key role to strengthen university-industry relations, promote technology transfer, and further ensure businesses thrive in the fast-moving, highly complex 21<sup>st</sup>-century global economy (BRITISH STANDARDS INSTITUTE 2019).

## Box 1: Malaysia's quadruple approach to innovation systems

Malaysia's Innovation System has moved from a triple helix approach to a quadruple helix approach, in which civil society organisations are recognized as essential actors in the system. Quadruple helix approach is more inclusive and it helps developing economies to expedite the innovation system and increase the involvement of professionals and knowledge workers in translating science and technology into innovation.

Malaysia's approach is expected to look beyond the demand-driven R&D to the entire value chain, which includes the market-driven delivery system of value created products and services. The market intelligence will complete the positive feedback loop of this value chain. The innovation system and its network are intended to be self-sustaining through the development of organic knowledge clusters that act as a magnet for talent. The availability of talent and agile actors within the innovation system and networks can increase the disruptive innovation that will replace non-competitive industries and markets.



Source: Adopted from ASM New Economic Opportunities in STI-based industries to serve Emerging markets (ASM 2017)

## Enabling Government Structures for Innovation

### Policy and Regulatory Measures

For the 2018 APEC thematic statement to be realised, there is paramount need for governments within the APEC region to develop public policies that support innovation. Currently, there exists policy spaces for economies to develop enabling policies that can create a conducive environment for digital innovations for the future. It is imperative that functional regulatory and policy frameworks are well-designed so that there are incentives for established and emerging firms to invest in learning, knowledge, and innovation. At the same time, it is crucial to ensure that policies and regulations do not become disincentives for innovation (United Nations Conference on Trade and Development 2018).

In developing economies, where policies are often insufficiently developed and fragmented, governments have to ensure they develop STI policy frameworks that can provide a “stable and predictable environment to enable long term planning by firms, organizations that are financing technology and innovation, and other actors of innovation” (United Nations Conference on Trade and Development 2018).

Listed below are some STI related policies that are currently promoting learning, technology, and innovation for economic growth in developing and developed APEC economies. It is essential to note that there must be congruence in these policies to encourage innovation systems to support education, labor, industry, trade, foreign direct investment and competition, and long-term sustainable growth.

#### **1. Innovation Policy**

Innovation policy is public action that influences technical change and other kinds of innovations. It includes elements of research and development policy, technology policy, infrastructure policy, regional policy, and education policy. This means that the innovation policy goes beyond science and technology (S&T) policy, which mainly focuses on stimulating basic science as a public good from the supply side. Innovation policy also includes public action influencing innovations from the demand side (Edquist 2001).

While innovation can be perceived to be fundamentally the task of the private sector and entrepreneurs, it is the responsibility of government to provide the macroeconomic, business and governance conditions that create and cultivate an

innovation climate to stimulate economic and productivity growth. Innovation is an integral part of social and economic growth, and has broader societal impact that generates knowledge, talent, and entrepreneurial activities. Therefore, an innovation policy is a core function in operationalising domestic innovation systems; having a pervasive influence on education, research, trade, industry, finance, and decentralisation, among others. The combinations of these interventions are also crucial in the structure and functionality of domestic innovation systems.

## **2. Industrial Policy**

Industrialisation remains one of the cornerstones of government policy to promote economic and productivity growth. Several emerging economies within the APEC region have advanced their economies to become regionally and globally competitive through catalytic policy changes that are promoting innovation-driven industry policies.

The APEC 2018 theme was centred on “digital economy” as the future growth trajectory for the Asia-Pacific region. For this to be realised, especially for developing economies such as PNG, it is imperative for innovation-based industry policies to be developed. The future economy will be highly knowledge and information driven, which at the moment is presenting new technologies such as artificial intelligence, data science, autonomous vehicles, and the Internet of things. These new technologies will reshape regional economic development and trade relations within the entire APEC region. For emerging and developing economies, this will require changes to labour productivity, industry structures, and international trade including global value chains.

Changes to traditional labour intensive industry policy to a more innovation-driven industry policy is already growing in some APEC economies. According to a 2014 APEC report, Malaysia's "influence of recent industry policy and changes to their clinical trial regulations" have allowed its citizens to gain access to new treatments through clinical trials (APEC Policy Support Unit 2014). The new development in industry policies has seen Malaysia's pharmaceutical market increase in the order of "10-12% per annum with health care spending doubled than 10 years ago" (APEC Policy Support Unit 2014). The same report reaffirms that this rise is partly due to drug imports and tax incentives, orchestrated by the industry policy, that have encouraged companies to set up drug manufacturing facilities in Malaysia (APEC Policy Support Unit 2014).



Further to this, Malaysia’s policy is now focusing on identifying new trends in economy and ensuring that policies are becoming more agile and adaptive to latest innovations to create new industries or improve existing ones. The increasing interconnectedness and integration of the Asia-Pacific region are reducing barriers to trade and human interaction. There is more collaboration, openness and transparency as industries are transforming themselves from traditional resource intensive to more knowledge intensive producers. This is partly driven by ICT and digital innovations that are improving communication and shifting traditional economies into more knowledge generating and sharing economies as shown in **Figure 2** (ASM 2017).

## Transformation from TRADITIONAL to NEW ECONOMY

Resource focused	→	Knowledge intensive
Labour intensive	→	High-skilled talents
Requires control	→	Requires collaboration
Vertical	→	Horizontal trust orientation
Mass production	→	Mass customization
Proximity is important	→	Location less significant
Rigid	→	Flexible
Capitalist	→	Profit Sharing



**Figure 2:** Malaysia is intent on transforming itself from a traditional into the knowledge-based economy

### 3. Education Policy

Building the knowledge and technology base for APEC economies is increasingly becoming a critical response to the emerging digital economy. The principles and government policy-making process in educational spheres, as well as the laws and rules that regulate the education systems must be shaped in ways to reflect the human capital needs and strategies for developing the critical mass for the digital future. The policy must also enhance the employability and productivity of the labour force.

There is overwhelming evidence on the impact of good education policies for promoting science, technology, and innovation. Consequently, investment in education has long been associated with increased economic activity, social wellbeing, and innovation and growth (APEC 2016). The Endogenous Growth Theory supports this claim and argues that education, research and development are important factors in sustaining long term economic growth rate and innovation (Bhatiasevi 2010).

Therefore, education policies may focus on the cumulative effect of formal education and on-the-job training, as well as training of students, to create innovative ideas and designs. Such an approach is critical to building a research capital, equipped with the skills and mindset, to create new knowledge and find innovative solutions. Investment in STEM<sup>1</sup> (Science, Technology, Engineering, Mathematics) education is primarily seen as the pathway to preparing the new generation of innovators who will catalyse and spur productivity and economic growth.

In addition, education policies must place urgency and importance on Technical and Vocational Education and Training (TVET), because it will enable innovation to be adopted and translated much faster into industries. TVET also creates opportunities for broadening the economic base by ensuring industry appropriate training is provided to increase employment options for the population.

Education and training are prerequisites to ensuring an economy's propensity for innovation.

#### **4. Technology Transfer Policy**

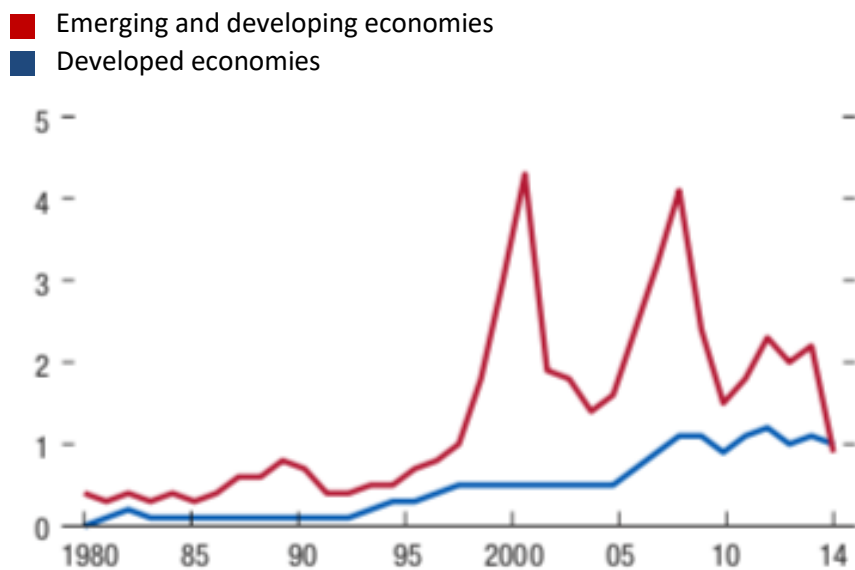
Much of the words innovations and new technology development occurs mostly within the developed economies of the Asia-Pacific region. It is reported that 60 % of global R&D occurs within the G7 economies, which include the US, Japan, and Canada, who are APEC member economies (International Monetary Fund 2016). Other developed and emerging economies within the APEC region are also increasing R&D investment to promote growth. Incidentally, many of the new technologies are disseminated throughout the world via imitation and absorption. For emerging and developing economies like PNG, transfer of technology and its inherent knowledge are critical for productivity growth.

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<sup>1</sup> In the 2018 PPSTI SOM-3 meeting, it was discussed that Art is important; hence a new STEAM (Science, Technology, Engineering, Art, Mathematics) Education approach.

There are two main channels for technology transfer that need policy interventions to support the development of a domestic innovation system:

- **International Trade:** Good policies and enabling regulations that reduce barriers to international trade are critical in ensuring domestic innovation by firms is encouraged. Domestic firms often acquire technological knowledge through the importation of “intermediate goods and capital equipment that embody foreign technology” (International Monetary Fund 2016). Some transfer of technology is also exported through interactions with foreign customers. However, this is not significant compared to the impact of imports.
- **Foreign Direct Investment:** Foreign Direct Investment (FDI) is vital for growth in emerging and developing economies. The International Monetary Fund has well-documented data suggesting that “global FDI flows have increased significantly” (International Monetary Fund 2016) since 1995. It is estimated that the “share of the world’s total FDI that flows to emerging and developing economies has grown from between 20 to 30% in the 1980s to about 50% in 2014,” as shown in the **Figure 3** next page (International Monetary Fund 2016).



**Figure 3:** Trends in Foreign Direct Investment inflows, 1980-2014. Source: Fiscal policies for innovation and growth, IMF, 2016.

It is essential that emerging and developing economies within the Asia-Pacific region develop *Trade and Investment* policies consistent with APEC Committee on Trade and Investment to, promote trade and investment liberation and facilitation as the cornerstones of APEC’s mission and activities (APEC 2019). APEC commitments on trade and investment will provide positive productivity gains for emerging and developing economies, which can benefit from the inflow of FDIs.

The economic and innovation returns from Thailand’s investment in the automobile industry provide a glimpse of the benefits of FDI. Most of the world's vehicles and auto part brands including Toyota and Hyundai have transferred their technology to their affiliate companies in Thailand, and have generated positive productivity spillovers, created new employment opportunities, and improved organisational and management practices. Thailand's automobile industry has also created other spin-off industries and SMEs that are now part of the entire value chain.

It must be recognised, however, that technology diffusion through trade and investment is not immediate. For Thailand to grow the economy by advancing in the automobile industry, there had to be an investment in human capital to enable productivity spillovers from FDI into the economy. Investing in “adequate levels of infrastructure, such as well developed ground transportation and shipping ports; and

creating pools of well-trained scientists and engineers are all critical to facilitating technology adaptation and innovation” (International Monetary Fund 2016).

### **5. Competition Policy**

Competition Policy is aimed at ensuring that competition is not restricted or undermined in ways that are detrimental to the economy and society. It is crucial for APEC economies to ensure that appropriate policies are assigned that encourage competitive markets, which are central to investment, efficiency, innovation, and broad economic growth. Traditionally, competition policies have been developed to target three anti-competition practices. Firstly, it is to minimise restrictive practices, such as collusion by competing firms to fix prices and engage in other market-sharing arrangements. Secondly, it is to regulate and ensure that some restrictions are provided for monopolies from abusing their position. Lastly, it is to ensure that mergers do not result in damaging reductions in competition that far outweigh any potential benefits.

Therefore, almost all of the APEC economies rely on competition law and policy to promote long "term growth, innovation, and productivity in their economies" (CleanGovBiz 2012). It is imperative that competition is encouraged within domestic innovation systems is encouraged so SME's can thrive on being innovative in the market place and at the same time managing inefficiencies and favouritism (CleanGovBiz 2012). The OECD continues by stating that:

“By preventing the unhealthy concentration of economic market power throughout the economy, competition law and policy contributes to a democratic system. This is best achieved by independent competition authorities with the necessary powers to enforce competition rules and to advocate sound competition policy throughout the government.” (CleanGovBiz 2012)

### **6. Information and Communications Technology Policy**

Development and implementation of innovation-friendly ICT policies are essential for the successful formation of functioning and efficient domestic innovation systems and networks. In general, domestic ICT policies would typically cover telecommunications (telephone and mobile communications), broadcasting (TV and radio) and the Internet to share information and data across domestic, regional, and international boundaries.

Within the context of developing efficient and effective innovation systems, there is urgency in integrating domestic ICT policies with other established policy and regulatory frameworks. An integrated policy approach covering technology, industry, telecommunications, and media, with those of sectoral policies such as education, employment, health, and welfare is critical. It will ensure appropriate support is provided not only to the government to assemble domestic innovation systems, but to those in the industry or private sector who are the beneficiaries.

In the emerging digital economy, linkages and networks between innovation and technology actors will become increasingly dependant on ICT for coordination and effective management of innovation systems. Hence, there are strong demands requiring governments to develop feasible ICT policies to support innovation and economic growth.

### **7. Intellectual Property Policy**

Intellectual Property protection is one way to promote innovation, vitally with IP arrangements such as patents, copyrights, and trademarks. Intellectual property is an intangible form of property since it embodies ideas and knowledge created by people, and may entail high fixed costs.

The IMF asserts that:

“The protection of IP takes different forms. Copyrights are developed to protect original expressions of art and industrial form, while trademarks protect distinguishing phrases, logos, and pictures. Patents on the other hand provide creators of an innovative product, process, formula, or technique a monopoly on its exploitation for a limited period of usually 20 years” (International Monetary Fund 2016).

Therefore, IP protection crucially plays an essential role in reducing the risk for creators of new knowledge and inventions by ensuring these actors reap acceptable returns for their investments in IP generation. It also ensures there is competitiveness between firms that are commercialising their products and services, and therefore, encourages innovation.

In respect to the APEC regional context, IP protection (especially patents) are crucial in the negotiations of bilateral and multilateral agreements. This is in part due to the

cross-border implications, especially where technology is transferred from the economy to another. Standards for patent designing and enforcement are also under the auspices of the World Trade Organisation, which has allowed for increased inflows of FDIs between economies.

## **8. Procurement Policy for R&D**

Public procurement significantly contributes to the successful implementation of innovation policies and therefore, can be considered an important instrument for domestic innovation systems. There is renewed interest in public procurement from a "demand perspective" to drive innovation in goods and services while at the same time improving government's service delivery (The World Bank 2010). Public procurement of innovation-related activities triggers growth in the development of new products in areas such as e-health, pharmaceuticals, energy, environment, transportation and logistics, security, and digital content (Edler and Georghiou 2007).

The increasing role of public procurement in motivating innovation is well documented. For example, a 2007 report by Edler and Georghiou demonstrated that "48 percent of projects that lead to successful innovation was triggered by public procurement or regulation" (Edler and Georghiou 2007). The US public sector alone spends US\$ 50 billion per year on R&D procurement and therefore drives innovation (Edquist 2001). There are other examples of economies that have benefited from developing public procurement policies for R&D, and subsequently, increased innovation.

More generally, public procurement of innovation is essential for creating the market potential for innovative products and services for several reasons.

- Government purchases may target innovative or alternative solutions to meet needs and enhance public service delivery;
- To encourage *pre-commercial procurements* or technology procurement of goods and services that are not yet in the market in order to reduce market risks;
- Promote *catalytic procurement*, whereby the government acts as the launch customer so that goods and services can quickly diffuse more widely and reach a critical mass.

There are, however, issues relating to developing public procurement policies that can work. It requires governments to build capacity because purchases of innovation can be complex and therefore, can be seen as a critical barrier. Further to that, lack of experience in particular procurement for innovation can result in a higher cost to the buyers of innovation and can be considered as a high-risk business. This is where governments might feel the need to subsidise innovation procurement, which ultimately be seen to be promoting preferential treatment according to WTO rules (Edler, Uyarra and Yeow 2014).

### **9. Fiscal Policies**

The role and impact of innovation systems in economic and productivity growth can be fully realised when supported by good domestic fiscal policies. Many innovation systems especially those in developing economies are fragmented due to lack of government financial and investment support. Therefore, governments have an important role in ensuring that revenue and expenditures positively influence the level of innovation within the economy.

There is strong evidence showing that investment in R&D lifts GDP in the long term. In particular, R&D expenditures are widely seen as essential drivers for Total Factor Productivity and GDP growth, especially from new technology development and innovation. As such, advanced economies benefit from “well designed policies that include fiscal R&D incentives and complementary public investments in basic research... and to increase their cost effectiveness” (International Monetary Fund 2016). Emerging and developing economies, on the other hand, need to develop fiscal policies that support investment in education and infrastructure to strengthen their capacity to absorb technologies from abroad. It is vital for governments to find an appropriate policy mix that balances various government objectives, including budget and income distribution.

Fiscal incentives such as *research subsidies* and *R&D tax incentives* are other fiscal policy options that can lower the private cost of R&D so that firms are inclined to invest more. IMF suggests that "Subsidies are especially useful for supporting the research component of R&D at the early phase of the innovation process in which knowledge spillovers tend to be larger. Tax incentives can complement these subsidies by providing across-the-board incentives to all firms investing in R&D." (International Monetary Fund 2016) In average advanced economies, an increase of 10% in private R&D would boost the level of GDP by 1.3% in the long term. Therefore 40% of the investment made into R&D can raise GDP by approximately 5%.



On the outset, micro-economic and macro-economic fiscal policies are critical for the other innovation-enabling policies to work.

An ecosystem approach to the implementation of these policies through a coordination framework such as innovation ecosystems and networks elicit several essential policy changes within the economy. Some economies have carefully instituted these to impact innovative growth by creating market research and innovation with a focus on the following.

- Researcher and academic mobility
- Investment in Research Infrastructure
- Cross border cooperation of research funding agencies
- Creating links with high growth and advanced economies
- Deregulation and reduction of trade barriers

### **Institutional Setting and Governance**

Coordination of all key government departments is essential for growth based on research and innovation to occur. Many governments within the APEC region have focused on STI as a pillar for economic growth and are managing this through their domestic innovation systems and networks. This is supported by examples of new projects and research outcomes presented through the APEC Policy Partnership in Science, Technology and Innovation meetings.

An element underpinning the success of many APEC economies in increasing innovation and digital based growth is their government's institutional structures. The success of many APEC economies depends on the way the government manages its human resource development, government's regulatory departments, science and technology policy, industry and R&D funding, and international cooperation as its institutional driver for innovative growth. These governments are also progressive in creating new institutional structures and repurposing old ones with changing context and emerging challenges (Husain 2015).

In order to support the hypothesis that government's institutional structures play a pivotal role in determining the direction of research and innovation, a review was conducted in Canada, Korea, Singapore, and Chinese Taipei. This review was principally to understand how these economies have positioned science, technology and innovation as important growth promoters.

From the analysis of these APEC economies' government structures, it became clear that it is critical to have a Science and Technology Council as the primary government entity with the responsibility of driving research and innovation. In Korea and Chinese Taipei, the Chairmanship of the Science and Technology Council rests with the President or Prime Minister of the economy to give STI merit and prominence in driving economic growth (Kotilainen 2005). While the structure provided in **Figure 4** is from an assessment of four APEC economies, the other economies have somewhat similar structures. However, one common trend runs across all economies, and that is, the Science and Technology bodies all report to the cabinet.

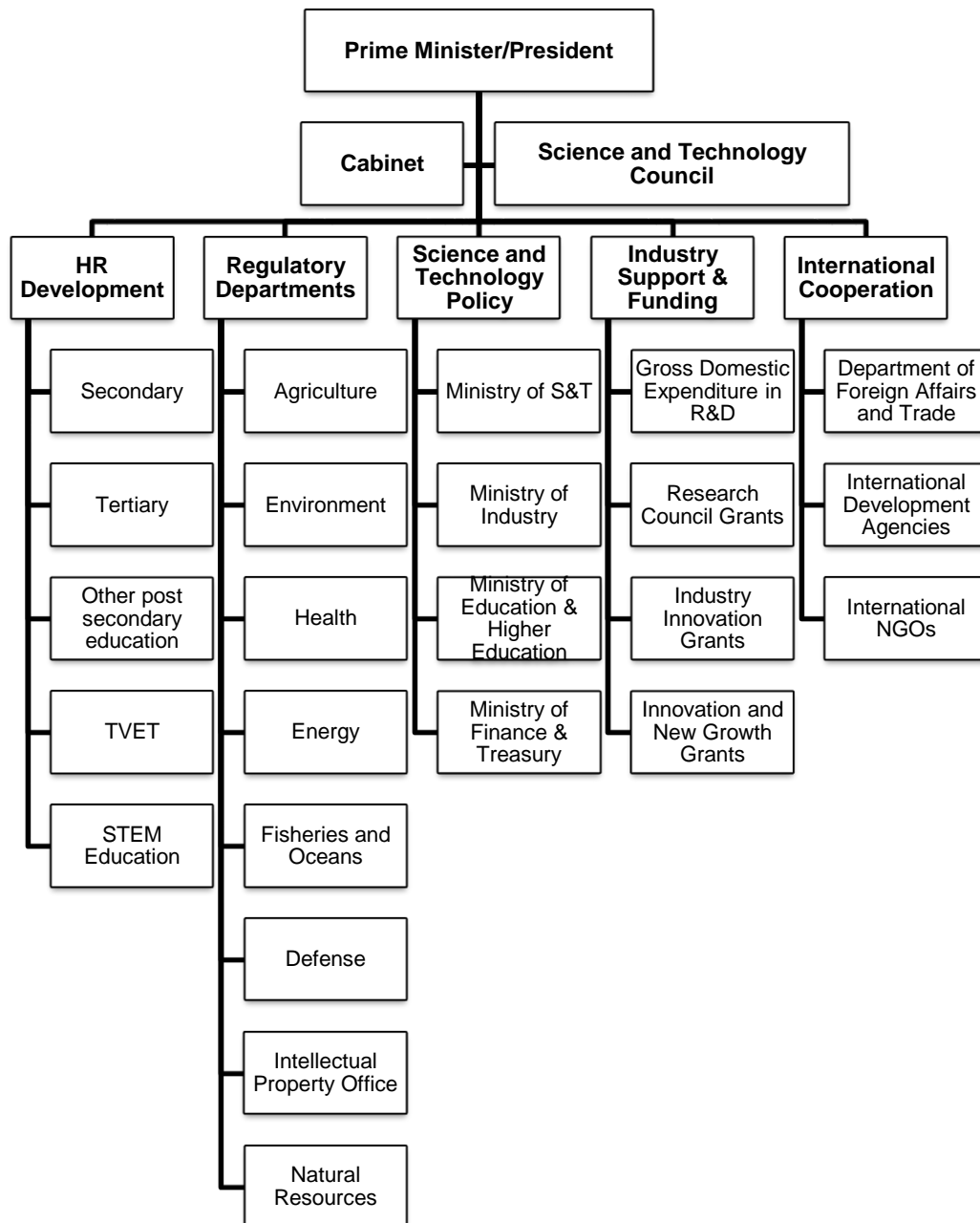
Essentially the economy's Science and Technology Policy becomes the main policy driver that enables innovation<sup>2</sup>. The policy outlines the foundational aspirations for knowledge-based economic growth driven by innovation and its impact on the industry, markets, and social change. Ideally, it is recommended that this policy must be managed by a separate Ministry of Science and Technology<sup>3</sup>. Line departments that support the S&T Policy may include the Ministry of Industry, Ministries of Education and Higher Education, and the Ministries of Finance and Treasury. The mentioned line ministries are essential because they oversee critical actors in STI, including education and training, industry development, and provision of funding to implement the policy.

Examples of APEC economies that have a Ministry of Science and Technology to develop and implement their government's science and technology policies are Chile, Malaysia and Thailand. For the case of Malaysia, the Ministry and the Department concentrate on applied funding and developmental research with strong industry and market focus. The Malaysian government leaves the basic research to the Ministry of Higher Education, universities, and some research institutions.

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<sup>2</sup> Not all innovations are products of science and technological research.

<sup>3</sup> During the PPSTI Workshop, Chile stated the imperativeness of having Ministry of Science and Technology to implement its S&T policy.



**Figure 4:** A generic structure of government that enables innovation

Government departments and agencies that have regulatory functions to affect direct or indirect impact on STI are essential components of the government's institutional structure. These agencies may include departments that are overseeing agriculture, environment, energy, fisheries and oceans, health, defense, intellectual property rights, and natural resources including minerals, oil, and gas. These agencies, albeit governed by different Acts of Parliament, have mandatory responsibilities that include the application of science and technology or regulations that impact on the

implementation of STI policies. Therefore, it is crucial to take a whole-of-government approach for promoting inter-agency collaborations to ensure that the government and its administration are adequately structured to coordinate and nurture these relationships through policy and legislation. The crosscutting impact of science and technology on the economy has caused many economies within APEC to elevate their science and technology policies as critical pillars in economic planning (Kotilainen 2005).

The criticality of innovation (as an outcome of R&D) to economic growth impacts profoundly on a government's investment to research and development. A government's investment is measured as the economy's Gross Domestic Expenditure on Research and Development (GERD). Many developed economies within the Organization of Economic Cooperation and Development (OECD) and APEC strategically invest a percentage of their GDP into R&D to improve the production of innovative goods and services, and to foster economic growth. More discussions on GERD will be elaborated upon in the next section. Such government investments allow the culture of research and innovation to take root in the economy and create conducive policy and business environments for industry growth. As industries grow and advance in technology and products, they also create industry-funded research and development, targeting a specific market and product needs. Some economies such as Korea and Singapore have developed specific innovation funds that look at the funding of new technologies such as artificial intelligence, data sciences, the Internet of things, and new molecular tools as new drivers of growth (Korea Electronics Technology Institute 2016).

The development of knowledgeable and technologically skilled human capacity is critical for a government's innovation structure to work. Many economies are now changing the approach for human development because the future of the global economy depends on people who can generate and apply knowledge and ideas in the workplace and society at large (Schaaper 2014). While general education is needed for developing basic literacy and numeracy skills, consideration of the labor market and industry demands are becoming necessary for growth and growth projections. Some governments are developing human development programs to create a labor market to meet the demands of the evolving global economy that is perpetuated by the new digital and technological evolution. Human development planning for the future covers policies and legislation to advance training at all levels of education, from elementary school up to tertiary education and also other post-secondary skills training. There is also some policy emphasis on STEM education to ensure students

develop critical and analytical thinking from an early age. Therefore, favorable education and human development policies are an integral, if not one of the most critical components of a government's R&D structure. The lack of skilled personnel is a key barrier to innovation that must be addressed (OECD 2000).

International trade and investment policies are essential in ensuring that the domestic economy is competitive, lawful, and compliant to international laws. Good domestic policies on trade and investment affect innovation, especially technology diffusion through imports, foreign direct investment (FDI), and trade in technology. It impacts on the economy's ability to be domestically and internationally competitive, and to be able to export value-added goods and services (Kiryama 2012). The APEC organisation's vision to promote free and open trade generates multiple opportunities for trade in innovation and technology. The prospects for cross border trade and investment in innovation and technology are led, in many instances, by the departments of foreign affairs and trade within the APEC economies through bilateral and multilateral agreements. These high-level agreements among the economies provide the platforms for FDI, labor mobility and skills and technical training that allow for technology and knowledge transfer between economies. FDIs, especially from big firms, transfer technology flows as capital, skills, and information into developing economies and thereby improving the receiving economies global competitiveness (UNCTAD 2003).

## Box 2: The US Innovation Ecosystem

The USA is widely acknowledged as the most innovative nation in the world. The size of US markets provides an advantage to the US innovation system. It allows US innovative businesses to grow large, delivering high returns from successful marketing or technological innovation. However, the US Government plays a significant role, perhaps greater than recognised, in shaping innovation.

The Cold War years saw significant investment by the Federal Government in supporting Research & Development activities in industries and universities, especially in defence-related technologies, life sciences, and energy. It provided a powerful impetus to the development and commercialisation of new civilian technologies in commercial aerospace, semiconductors, computers, and computer software. These then attracted increased private investment into the development of civil technologies with wide commercial applications.

The Defence Advanced Research Projects Agency (DARPA), created in 1958, remains instrumental in fostering these spillovers by developing technological initiatives, providing funding but also skills and management support to businesses, and providing a brokering function between university research, businesses, and the public sector. The budget of this Agency is about \$3 billion per year and funds exclusively challenge-led schemes in high-risk high-reward areas of life sciences, physical sciences and engineering.

US federal research funding for academic and business institutions is distributed by governmental departments and agencies, including the Department of Defence (DoD) the Department of Energy (DoE), the National Science Foundation and the National Institutes of Health (NIH). The NIH has an annual budget of \$32 billion and is the largest civil agency.

Over the last couple of decades, faced with more intense foreign competition, more limited financial resources, and the growth of regional US clusters, federal policymakers launched more decentralised programs spread across several agencies. These programs seek to strengthen civilian technological capabilities by subsidising and promoting joint research, encouraging collaboration between US universities and industry in technology development, and supporting collaboration between US industry and the federal laboratories. In the late 1980s programmes such as the National Center for Manufacturing Sciences (NCMS), the semiconductor research consortium SEMATECH, the Advanced Technology Program (ATP) of the Department of Commerce, and the National Science Foundation's Engineering Research Centers all represented a new technology policy and relied on expanded funding from the private sector.

Public procurement is also a lever effectively used by the US Government. The Small Business Innovation Research Programme (SBIR) require Government Departments and agencies with large budgets to use 2.5% of their research procurement to support small business initiatives. SBIR funding is about \$2 billion annually with additional contributions at local levels. For instance, North Carolina matches all federal SBIR funds dollar for dollar.

Other US initiatives in technology policy were to reduce antitrust restrictions on collaboration in research and improved intellectual property protection. Today's US Innovation System has some definite characteristics. Integrated innovation systems within US Government Departments (e.g., DoE, DoD and NIH) include support for research and proof of concept work, as well as support for product development and public sector organisations acting as a lead customer for innovative products and services through programs such as the SBIR.

Public funding to undertake long-term, challenge-led research and R&D activities with universities and businesses. These programmes have played a significant role in the development and commercialisation of major innovations, e.g. telecoms and the internet. Increasingly the funding of these programmes is linked to international collaborations.

An exceptionally strong public and university research base, supported through federal agencies like the National Science Foundation and National Institute of Health, provides a bridge to commercialisation and help to de-risk private investment, funding activities at a later stage of the innovation cycle than UK Research Councils. The US also provides significant incentives for universities and business to commercialise innovations, through offering ownership of all IP arising from federally-funded research, which has encouraged US institutions to invest in their technology transfer and exploitation capability.

The existence of diverse and large companies that are investors in R&D and also in wider forms of innovation, ranging from ICT companies such as IBM, Microsoft or Cisco, to aerospace and defence companies such as Boeing, and Life Science companies such as Pfizer, Amgen, and Johnson & Johnson. Large companies in non technology-based sectors are also important customers for innovative products, notably Amazon and Wal-Mart, whose investment in logistics and supply chain management technologies in the 1990s had a significant impact on US retail productivity growth.

A dynamic entrepreneurial culture, which tolerates failure, linked to strong clusters e.g. Silicon Valley, Boston, Austin and North Carolina helps to drive innovation. The combination of the availability of venture capital, business angels, and other forms of public and private investment alongside strong mentoring programmes, facilitate business start-up and rapid growth to large scale in high-technology sectors. The important role of new small businesses in commercialising technological advances appears to be unique amongst major economies.

A successful government sponsored funding programme for small businesses (SBIC). For every \$1 an SBIC raises from a private investor, the Government provides \$2 of debt capital, subject to a cap of \$150 million. This attracted \$840 million of private capital in 2010-11. Since its inception, the SBIC program has helped finance thousands of small businesses, which have grown to a significant scale, including Costco, Amgen, Staples, Apple, AOL, FedEx, Intel etc.

In 2009 the President announced a Strategy for American Innovation, a broad-based economic development strategy that channelled stimulus funding.

Source: Adopted from Innovation and Research Strategy for Growth (BIS 2011)

## Innovation Funding

Funding for research and development of innovation activities are a critical component of domestic innovation ecosystems and networks. In this section, we explore the various innovations funding available in some economies, to promote innovation and economic growth.

### Government-funded investment

#### Gross Domestic Expenditure on Research and Development

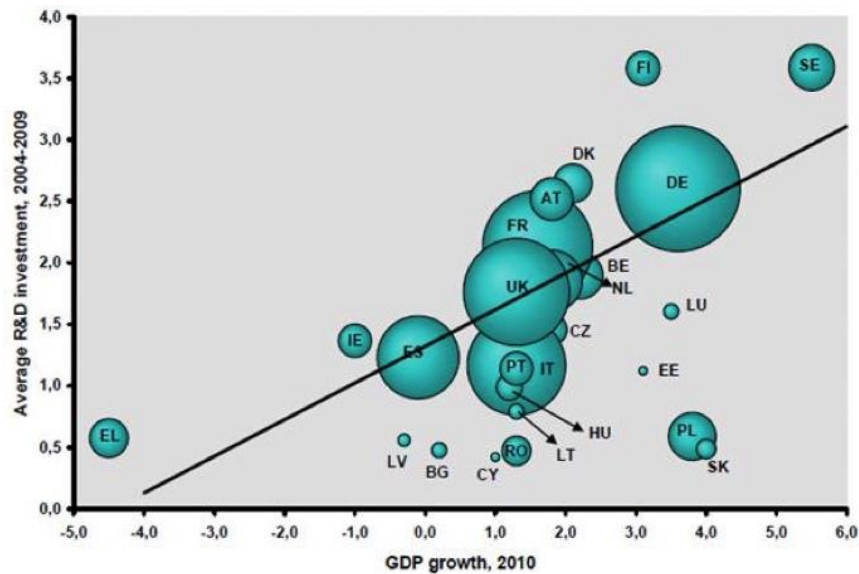
Many governments in developed economies invest a percentage of their GDP as GERD, which is now a globally recognised measurement system for STI performance. The level of investment varies across economies, depending on the size of the economy and individual development and growth priorities. Generally, there is evidence showing a proportional relationship between R&D investment and GDP growth.

In many cases, systemic investment into R&D has led to many innovations, although some innovations do occur by trial and error (Kiriya 2012). Many economies are supporting R&D by integrating it into their long-term economic framework to reduce uncertainty and encourage business investment in R&D, which is often targeted especially when addressing market demands. For an integrated system for R&D that involves both public and private investment, policy instruments have to be consistent, implying that key government agencies, universities and research institutions, and industry players need to coordinate (Hämäläinen and Schienstock 2000, METCALFE 1995, UNCTAD 2003).

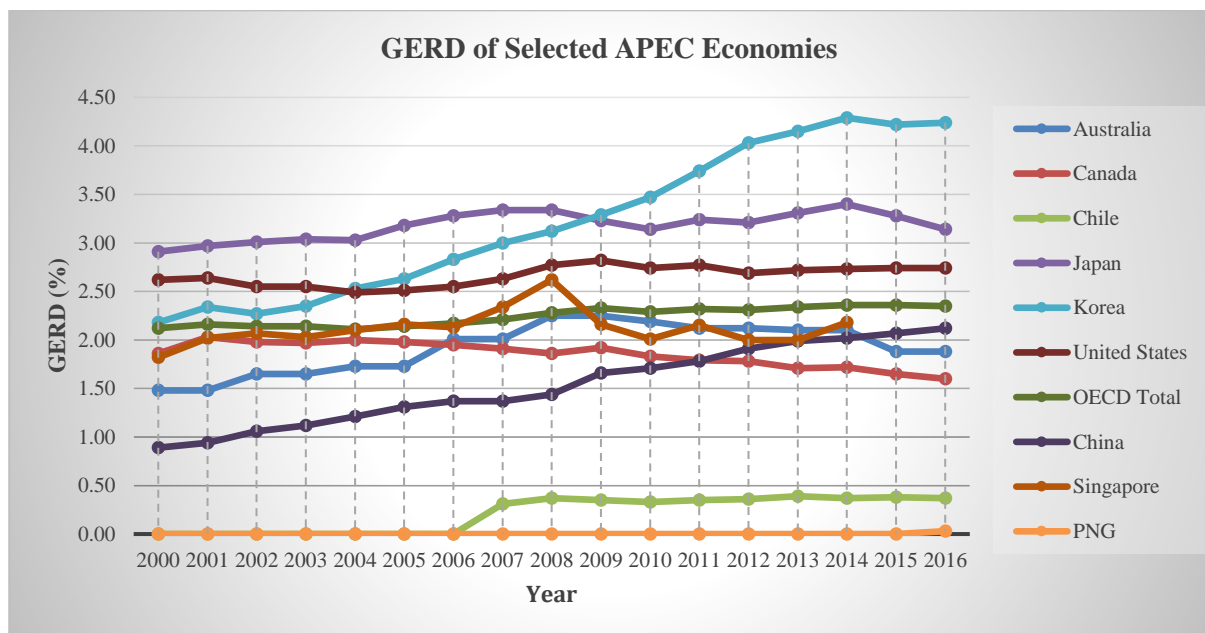
The graph in **Figure 5** shows average R&D investment between 2004-2009 and GDP growth in 2010 in the European Union (Marini 2012 ). What emerges is that high investment in R&D contributes immensely to an increase in GDP growth. In the example provided, Sweden invested 3.6% of GDP from 2004-2009 and experienced over 5% GDP growth. Estonia, on the other hand, invested 0.5% in the same period and experienced negative growth. The evidence strongly supports the argument that for any economy to be competitive globally, it is imperative for investment into creating a knowledgeable and technologically skilled labor force to meet labor market demands for the emerging digital economy. The new workforce must be able to generate new knowledge and/or have the capacity to use advanced technology to



promote innovation and growth. Economies that have made investments in R&D to encourage innovation are now becoming global economic leaders (Marini 2012 ).



**Figure 5:** Relationship between R&D investment and GDP growth in the EU (Marini 2012 )



**Figure 6:** Gross Domestic Expenditure of selected APEC economies. Raw data was sourced from the OECD database, 2018.

It is important at this juncture to investigate the level of R&D investment by APEC economies. For this manual, only an overview of GERD will be provided as an in-depth analysis of the types of R&D investment would be beyond the current scope. **Figure 6** demonstrates the GERD as a percentage of GDP investment by some APEC economies between 2000 and 2017.

The graph reveals the Republic of Korea (ROK) has consistently increased investment in R&D from 2.2% in 2000 up to 4.24% investment in 2016. ROK's surge in growth triggered the government's decision for digital transformation. ROK began with the establishment of publicly funded research institutions for R&D in electronics, and IT spaces to complement its strong manufacturing sector based on the steel industry (OECD 2015). The ROK government is maintaining a strong commitment to R&D with projected investment regimes to support new growth engines, including the Internet of Things, Autonomous Driving, Energy IT, Robot-AI, and Human Care, to name a few (Korea Electronics Technology Institute 2016). ROK has made significant progress in investing in public funding to build its human capital and grow its technology capacity. Through continued investment in science and technology, ROK has sustained economic growth over the past few decades and is now part of the OECD (OECD 2015).

Similarly, the graph reveals China's increased investment in R&D from 0.8% in 2000 to 2.2% investment in 2016. While a number of policy priorities have spurred China's growth, it is crucial to understand the drivers of their economy. One of the key determinants of the current economic growth is continuous improvements and reforms in the economic structures (Yang 2012). These reforms have shifted China's economy from an agricultural to an industrial focus, which is supported by robust urbanisation policies. The changes to China's industrial and spatial structures were intended to improve the allocation efficiency of production factors and improve growth. With these reforms, China has increased the GDP contribution of industrial value-added goods from 35% in the 1960s to 45% in the 1970s. This figure remains stable to date (Yang 2012). It is noted that the shift in China's industrialisation has been supported by a focused investment into R&D to help its industrial base.

For PNG, the scenario is quite different. There has been no information on the level of R&D investment since 2000. In 2016, the PNG Science and Technology Secretariat conducted a survey and discovered that in 2016, the government's investment was a mere 0.03% as shown in the graph on **Figure 6** (unpublished data). Unfortunately, this investment is not used to fund research and development, instead it is used for administrative costs to run research institutions and universities. In essence, PNG is not doing well compared to the other APEC economies and seems to be more focused on the export of non-value added commodities and is highly dependent on imported technologies. This poses a grave concern for PNG given the regional appetite for R&D investment, knowledge generation, and creation of innovation-driven industries.

There are also counter-arguments that GERD does not impact on the growth of the economy. It is argued that innovation is an intrinsically uncertain economic activity to

which outcomes or returns of investment cannot be predicted (Paolo and Giordaniz n.d.). These arguments are valid to a certain extent; if one takes it literally that R&D investment is the only indicator. The argument presented in this paper is that R&D investment is just one imperative to having a solid basis for nurturing STI culture to promote growth. As discussed in the previous section, an overarching government R&D structure is required to provide the right policy environment. It will help set the economic direction and prioritise policy action so that there is a favorable return of investment (Yang 2012).

### **Government R&D Grants**

Government's investment in the form of GERD promotes innovation and economic growth and is best realised when governed through targeted granting mechanisms. These grants generally support the research activity pipeline from basic research through to applied and development research.

Qualifying R&D activities can be defined as the systematic, investigative, or experimental activities in a field of science or technology. Activities include:

- *Basic research*, namely experimental or theoretical work undertaken primarily to acquire new scientific or technical knowledge without a specific application in view
- *Applied research*, namely work conducted to gain scientific or technical knowledge and directed towards a specific practical application
- *Experimental development*, namely work undertaken which draws on scientific or technical knowledge or practical experience to achieve technological advancement and which is directed at producing new or improving existing, materials, and products. Devices, processes, systems, or services, including incremental improvements.

To fund R&D research activities and efficacy, government grants to support R&D are critical. How these grants are prioritised for investment depends on each individual economy and their state of the economy and STI policies. However, there is a general trend on the expenditure or investment of these grants for capital investments, research and development, training and employment, sustainability, and international cooperation.

As such, government grants are:

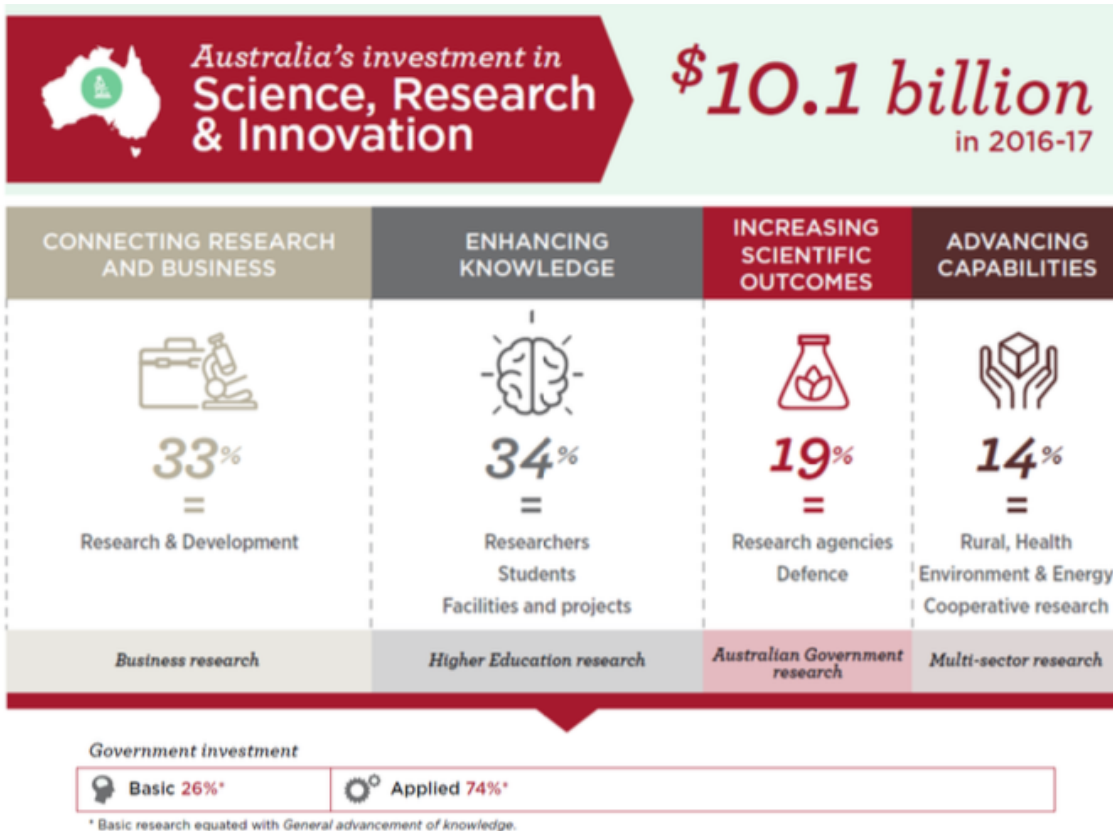
“Supporting research universities which are increasingly becoming hotbeds for innovation. There is a strong relationship between the strength of an economy’s higher education system and its ability to innovate. Thus, fiscal investment by the government must include indirect investment to educate and train scientists and researchers, build world-class institutions and facilities, facilitate interactions with global communities to generate fresh ideas and new perspectives, and build structures to commercialize innovation” (PricewaterhouseCoppers 2010).

Grants for capital investment through R&D infrastructure has an immediate impact and can take physical forms such as universities, buildings, laboratories, logistics, and transportation, or in an intangible form such as graduates.

While basic research has long term focus and aims to serve the public interest, government funding must be theme-based and technology-driven. For example, governments or funding agencies must select specific projects that expect significant spillover effects on business and economy growth. (Workshop presentation by Dr. Ma Leju).

To encourage collaboration and foster win-win cooperation, governments also subsidise R&D investment in industry to drive innovation. The ongoing global financial crisis that started in 2009 has impacted many economies access to finance and subsequently, industry R&D expenditure. Therefore, government grants to stimulate innovation in areas such as clean energy technologies and health may compensate for falling industry investment into R&D (PricewaterhouseCoppers 2010).

As a case in point, the Australia government's investment in science, research, and innovation in 2016-2017 was \$10.1 billion. The investment targeted business research, higher education research, Australian government research, and multi-sector research. Of these, 26% of the investment was in basic research, and the other 74% targeted applied research.

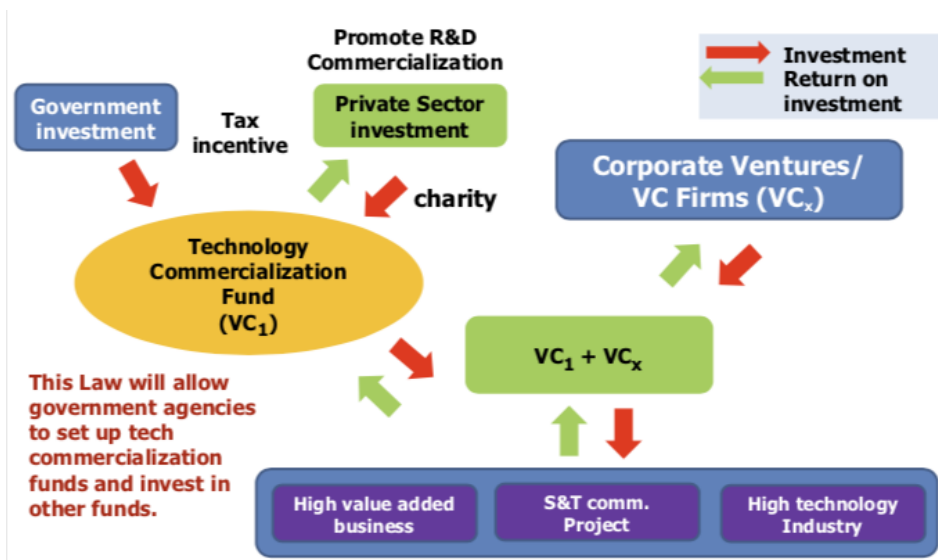


**Figure 7:** Australian innovation funding schedule. Source: Innovation Australia

In their efforts to promote innovation and create new businesses, the Thailand government has made some key legislative changes to ensure laws and appropriate legal frameworks support government R&D funding. The Thailand National Science, Technology and Innovation Office created two laws that support R&D investment (Durongkaverroj 2015).

The first law was an Intellectual Property Commercialization Law. This law allows for the transfer of IP ownership from the government's funding agency to the grantee. This is to provide financial support for SME's R&D, streamline IP process, build the capacity of technology transfer offices, and also to initiate a Translational Research Fund (Durongkaverroj 2015).

The second law passed by the government allows for government agencies to contribute funding to a Technology Commercialization Fund (TCF). In a public-private partnership arrangement, companies also put funding into the TCF as a tax incentive exercise. TCF is then accessed by high value added businesses, science, and technology competition projects, and high technology industries. Corporate ventures and Venture capital firms also invest in this fund for a return on investment (Durongkaverroj 2015).



**Figure 8:** Thailand's venture capital model (Durongkaveroj 2015)

The United State has an excellent example of how government grants for R&D in small businesses, and SMEs is critical for innovation and economic growth. The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs were initiated at the National Science Foundation and signed as a Federal-wide program in 1982 by President Ronald Reagan (Small Business Innovation Research n.d.).

SBIR-STTR's mission is to support scientific excellence and technological innovation through the investment of Federal research funds in critical American priorities to build a robust domestic economy (Small Business Innovation Research n.d.). Since its inception, SBIR-STTR has awarded over \$43 billion to research-intensive American small businesses and has involved over 450,000 engineers and scientists, making it one of the largest STEM talent concentrations in the world (Small Business Innovation Research n.d.).

### Box 3: Information on United States SBIR and STTR Programs

#### **The SBIR Program**

The Small Business Innovation Research (SBIR) program is a highly competitive program that encourages domestic small businesses to engage in Federal Research/Research and Development (R/R&D) that has the potential for commercialization. Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated, and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

#### **The STTR Program**

The Small Business Technology Transfer (STTR) is another program that expands funding opportunities in the federal innovation research and development (R&D) arena. Central to the program is the expansion of the public/private sector partnership to include the joint venture opportunities for small businesses and nonprofit research institutions. The unique feature of the STTR program is the requirement for the small business to formally collaborate with a research institution in Phase 1 and II. STTR's most important role is to bridge the gap between the performance of basic science and commercialization of resulting innovations.

More information can be found on their website: <https://www.sbir.gov/about>

### **Research and Development Tax Incentives**

APEC economies have developed key mechanisms to promote the industry's investment in R&D by providing R&D tax incentives. However, it still is common for many companies not to invest in R&D for a diverse number of reasons, including uncertainties around the success of R&D projects and spillover of new knowledge to competitors and the rest of the economy. This leads to losses and poor returns on investment for those companies that do invest in R&D. The broader impact of the lack of R&D investment on innovation and economic growth can be considered adverse. Therefore, by providing R&D tax incentives, governments encourage more companies to stimulate investment in R&D, while alleviating initial reasons for not investing (Australian Government 2018).

In Thailand, the government is playing a key role in creating legislations that promote tax reductions for institutions and companies that are investing in research and development. The Thailand government enhanced tax deductions for research, development and innovation expenditures from 200 percent to 300 percent (Durongkaverroj 2015). It further expanded the scope of expenditure to cover innovation in automation (of equipment), training, R&D, IP and technology acquisition, IP registration, and design. Thailand is also providing tax exemption for

Private Equity Fund and Crowdfunding to encourage angel investors and venture capital investment (Durongkaveroj 2015).

Finally, in Malaysia the "pharmaceutical market has been growing rapid in the order of 10% - 12% p.a and spending on healthcare has doubled. This is partly due to a rise in drug imports, as well as tax incentives that encourage companies to establish manufacturing facilities in the economy" (APEC Policy Support Unit 2014).

#### **Box 4: Research and development tax incentive for Australia**

The tax incentive reduces company R&D costs by offering tax offsets for eligible R&D expenditure.

Eligible companies with a turnover of less than \$20 million receive a refundable tax offset, allowing the benefit to be paid as a cash refund if they are in a tax loss position. All other eligible companies receive a non-refundable tax offset to help reduce the tax they pay. The program is available to companies who are:

- incorporated under Australian law
- incorporated under foreign law but an Australian resident for income purposes
- incorporated under foreign law and a resident of an economy with which Australia has a double tax agreement

Innovation and Science Australia (ISA) and the Australian Taxation Office (ATO) are jointly responsible for administering the tax incentive. The Department of Industry, Innovation and Science assists ISA to register R&D activities, while the ATO manages the rules for eligible entities and costs.

Each year ISA reports on the tax incentive in their annual report.

More information can be found on

<https://www.industry.gov.au/funding-and-incentives/business-and-startups/research-and-development-tax-incentive>

#### **Industry Funded R&D**

Many companies are now developing innovation platforms to access knowledge and acquire innovations necessary to better serve customers (Zahra and Nambisan 2011). Historically, large companies R&D investments remained in the automobile, food, and manufacturing sectors. About a decade ago, a large investment was noted in the pharmaceutical industries. While these older or mature companies have always maintained some level of R&D investment as integral to their business and growth,



new companies are now at the forefront of introducing new ideas, business practices, and technologies into the mainstream.

Recent data show that there is a growing shift in industry R&D investment, towards new technology development that is spurred by the latest digital and information revolution. The ICT sector and companies such as Apple have established platforms to develop innovative applications to enhance their global reach and functionality of their new products. These new and emerging companies are taking advantage of the knowledge that is available within innovation ecosystems to develop new products and services (PricewaterhouseCoppers 2010).

Accordingly, in 2017, the top five R&D spenders were mostly technology companies. Amazon was leading with \$17.4 billion, followed by automobile company Volkswagen that was spending \$15.1 billion (Visual Capitalist 2019). There is consistent and increasing investment in R&D for new technology products such as artificial

Rank	Company	R&D Spending
1	Amazon	\$17.4 billion
2	Volkswagen	\$15.1 billion
3	Alphabet	\$14.5 billion
4	Intel	\$12.8 billion
5	Samsung	\$12.8 billion

intelligence, data sciences, the Internet of things, autonomous vehicles, machine learning, and robotics etc. A 2016 report by TechNavio reported that R&D investment in robotics would increase by 17% between 2016 and 2020 (TechNavio 2019).

**Figure 9:** R&D expenditure

Generally, there has been increasing investment by business into R&D in the last ten to fifteen years. While reductions in business investment in R&D were observed in 2009 due to the financial crisis that affected the global economy, there has been notable increase in investment thereafter. Data obtained from [OECD Stats](#) shows a gradual and consistent increase in R&D investment since 2009, as shown on the table of Business Expenditure on R&D (BERD)<sup>4</sup> in selected APEC economies between 2008 and 2015.

<sup>4</sup> BERD represents the component of GERD incurred by belonging to the Business enterprise sector. It is the measure of intramural R&D expenditures within the Business enterprise sector during a specific reference period

Business Expenditure on R&D for selected APEC economies									
Economy	Currency (millions)	2008	2009	2010	2011	2012	2013	2014	2015
Australia	Australian Dollars	17,291.20	16,759.60	18,006.90	18,321.30		18,849.40		
Chile	Chilean Pesos	142,246.93	99,801.69	108,821.46	145,976.20	162,045.78			
Korea	Won	26,000,068.84	28,165,859.14	32,803,239.56	38,183,291.34	43,222,925.54	46,559,916.25		
Japan	Yen	13,634,478.00	11,983,844.00	12,010,033.00	12,271,778.00	12,170,475.00	12,691,955.00	13,586,360.00	13,685,745.00
New Zealand	New Zealand Dollar		1016.00		1193.00		1246.00		

Figure 10: BERD in selected APEC economies. Data was obtained from OECD Statistics ([https://stats.oecd.org/Index.aspx?DataSetCode=BERD\\_COST](https://stats.oecd.org/Index.aspx?DataSetCode=BERD_COST))

### Venture Capital

Although there are many factors that determine the level of entrepreneurship, it is the availability of capital that is critical for the survival of these new companies. Venture capital is an important source of financing where risk is too high for banks and other secured lending, and capital markets are inaccessible. In 2014, Asia-focused venture capital fundraising peaked at \$14.1 billion from over 300 funds that were cumulatively raised (Egidio, et al. 2017).

A recent report by global audit and consultancy firm KPMG states “China’s venture capital investment reached a record high in 2018 as a string of big deals led by tech giants drove up the market volume. It is reported that VC investment totaled \$70.5 billion in 2018, a surging 52.9 percent year-on-year” (China Daily 2019). KPMG further reported that:

"In China, corporate VC is growing rapidly, and more companies have VC arms, and they are actively looking for disruptive technologies that can enhance their core business. Industries such as healthcare, life sciences and education, as well as AI and other highly innovative technologies with broad applicability, will continue to attract significant funding in Asia in 2019” (China Daily 2019).

Some economies are responding by offering incentives directly to venture capital firms. In China, for example, venture capitalists investing in high-tech companies may offset 70% of their investment against future income (PricewaterhouseCoppers 2010).

In Malaysia, start up or speed capital investors receive deductions equivalent to the value of investment (alternatively, a ten-year exemption of certain income). In Singapore, realised investment losses on the qualifying company may be offset against other taxable income (PricewaterhouseCoppers 2010).

### **Case Presentation 1: Venture Capital in Hong Kong, China by Mr Nicholas Brooks**

The future of Hong Kong, China is going to be based on Innovation, Technology, and Entrepreneurship, according to Mr Nicholas Brooks in his presentation at the workshop.

The Hong Kong, China Science and Technology Parks Corporation was established in 2002 to support the development of innovation industries. The organisation targets R&D of Technology Applications (Science Park), Brand Design and Marketing (Innocentre) and Skill-intensive advanced manufacturing (Industrial Estates). To date, HKSTP supports over 330,000 m<sup>2</sup> of R&D Office spaces, and more 680 Tech Enterprises employing over 13,000 working population. They represent 22 nationalities of Park Companies making Hong Kong, China a major technology incubator with over 260 start-ups in programs.

To reach such success, HKSTP has created a network of investors who, through several investment programs, expand the investor network to stimulate Innovation and Technology related activities. HKSTP has effectively developed an incubation support strategy that provides for the TechnoPrenuer Partnerships (for six universities and 17 co-working spaces), Incubation Programs, Angel Investment, Venture Capital Partnerships, and Leading Enterprises Acceleration Program.

Through these efforts, HKSTP has achieved some critical milestones in the past 16 years, leading up to 2017. They have successfully built partnerships with fifty corporations, which have expanded into China, the APEC region, and the globe. Hong Kong, China's Incubation program has three core investment priorities namely Incu-App, Incu-Tech, and Incu-Bio. The program has graduated 542 companies, of which 409 are still in business with 4 having completed IPOs and listing in Hong Kong, China.

A total of \$1.2 billion was raised in the 2017 -2018 financial year to direct engagement for all park companies. There has also been a 6-fold increase in the funds raised for

incubates and graduates in the 2017 -2018 financial year compared to the 2016 -2017 financial year (unpublished, workshop presentation).

This case study illustrates the impact of venture capital and targeted incubation programs to develop and advance innovation and technology companies.

#### **Box 5: Venture capital incentives**

Tax incentives to encourage venture capital (VC) investments are offered by many economies to accelerate investment in technology and other priority sectors. China, Malaysia, and Singapore provide direct incentives to VC firms. In China, VCs investing in new high-tech business may offset 70% of their investment against future VC income. In Malaysia, start-up or seed capital investors receive deductions equivalent to the value of their investment (alternatively a 10-year exemption of certain income) and in Singapore, realized investment losses on the qualifying company may be offset against other taxable income.

Investors themselves, including VC firms, consider the capital gains tax and the tax treatment of dividends to be very important factors in creating an advantageous investment environment. (PricewaterhouseCoppers 2010)

#### **Other financial mechanisms**

A key deterrent for investment is the high risk associated with R&D and commercialisation. From the private sector perspective, funding of innovation often comes down to risks versus rewards. Therefore, the best approach is to encourage companies to fund innovation financing models that increase the reward from innovation while reducing risks to returns on investment (Ryan MacFarlane, unpublished).

While innovation produces intangible assets, the returns on investment into innovation are highly uncertain. These risks may include operational risks, demand risk, financial risk, and political risks. To address these risks, researchers and innovators must understand the different available financing variations.

The *first category* involves financing institutions that are after social value and are only interested in the impact on the community. These include Not-for-Profit Charities that may consist of grants and PRI/MRI Investments. These funds are usually those that are provided through venture philanthropy.

The *second category* of financiers is driven by For-Profit-Companies for the creation of financial value. These funders are driven by the need for impact and financial investment. Profit-with-purpose companies, companies with Corporate Social Responsibilities or corporate philanthropist, and market companies may provide funds for this category.

The *third category* of funders is those interested in “blended” social and financial value and believe in impact first and finance second. This is the social enterprising category and can be funded through trading revenue and by companies who wish to reinvest profitable surpluses into innovations that impact the communities, whilst at the same time earning financial returns. Blended financing is the “use of development finance and philanthropic funds to mobilize private capital flows to emerging and frontier markets” (OECD 2015) that result in mutual benefits to both investors and communities. This kind of financing is suited to developing economies to scale up commercial financing and channel towards investments that have development impacts. This may include financing that supports an economy’s progress towards achieving the UN Sustainable Development Goals.

Not surprisingly, there were APEC resolutions made in 2018 in relation to blended finance for sustainable development. References can be found in the following links:

[http://mddb.apec.org/Documents/2018/MM/AMM/18\\_amm\\_008.pdf](http://mddb.apec.org/Documents/2018/MM/AMM/18_amm_008.pdf)

[http://mddb.apec.org/Documents/2018/MM/FMM/18\\_fmm\\_009.pdf](http://mddb.apec.org/Documents/2018/MM/FMM/18_fmm_009.pdf)

### **Case Presentation 2: Blended Financing for Waste Management by Dr. Ryan MacFarlane**

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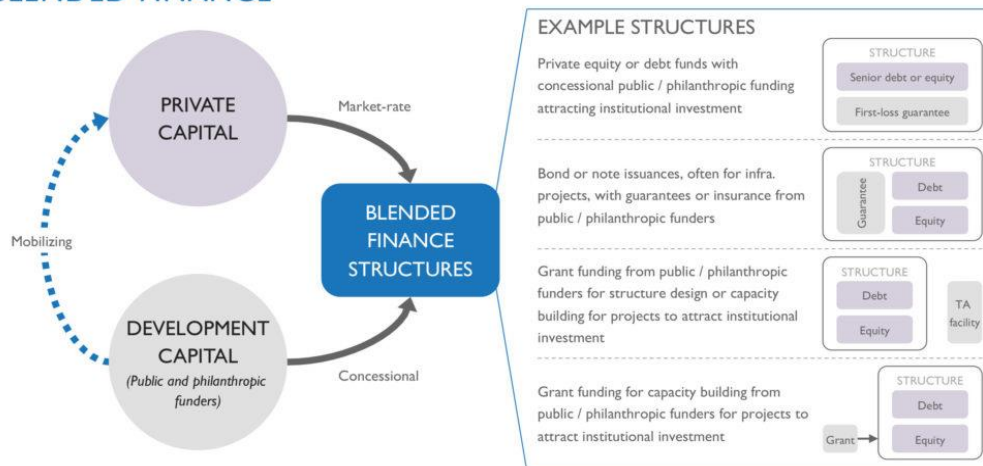
The utilisation of blended financing to invest in waste management systems was presented during the PPSTI Workshop on Domestic Innovation Systems and Networks. With the Asia-Pacific region forecasting the generation of 1.4 billion metric tons/year of municipal solid waste by 2030, the APEC Virtual Working Group on Marine Debris recommended the need for innovative funding mechanisms to develop innovative solutions that address environmental problems associated with marine litter (2015/SOM3/CD/019). The volume of global waste is growing exponentially and poses high environmental and socio-economic costs to the Asia-Pacific region. To mitigate these negative impacts, solid waste management systems that will “increase economic growth, generate jobs, reinvigorate tourism, and reduce emissions of toxins and greenhouse gases” need to be developed through blended financing models (APEC 2016).

Incidentally, there is a global revenue gap of \$40 billion that is projected to finance the solid municipal waste sector. This is a significant financial undertaking that requires a whole of government approach to create the “political, economic, and legal/regulatory conditions to incentivize investment in waste management in APEC economies by private investors, multilateral development banks, and other sources of capital” (APEC 2016). A stacked or blended investment by various financial sources can be significant and would mitigate the human health, ecological, and economic costs that is associated with poor waste management infrastructure (APEC 2016). **Figure 11** next page provides some examples on blended finance structures.

In the concluding Senior Official Meeting in Peru in 2018, some policy and practice recommendations were made on how to overcome barriers to financing waste management systems and reducing marine litter. Nine policy and practice recommendations were endorsed by the Oceans and Fisheries Working Group, the Chemical Dialogue, and the Committee on Trade and Investment (APEC 2016). For instance, recommendation number 6 is to enable innovative, transparent funding approaches that include independent blended pooled funding entities from governments, private sector, donors, and DFIs. Such pooled financial resources allow for a “manageable investment with no undue burden on any one party” (APEC 2016).

In conclusion, Blended or Stacked financing is an innovative funding mechanism that developing APEC economies such PNG can apply to attract investments and finance innovations that promote the UN Sustainable Goals.

## BLENDED FINANCE



**Figure 11:** Examples of Blended or Stacked Financing Model (Source: MacFarlane)

More details of the APEC Policy and Practice recommendations on Overcoming Barriers to Financing Waste Management Systems and Reducing Marine Litter can be accessed at the following link:

[http://mddb.apec.org/Documents/2016/SOM/CSOM/16\\_csom\\_010.pdf](http://mddb.apec.org/Documents/2016/SOM/CSOM/16_csom_010.pdf)

## Institutional Frameworks for Innovation Networks

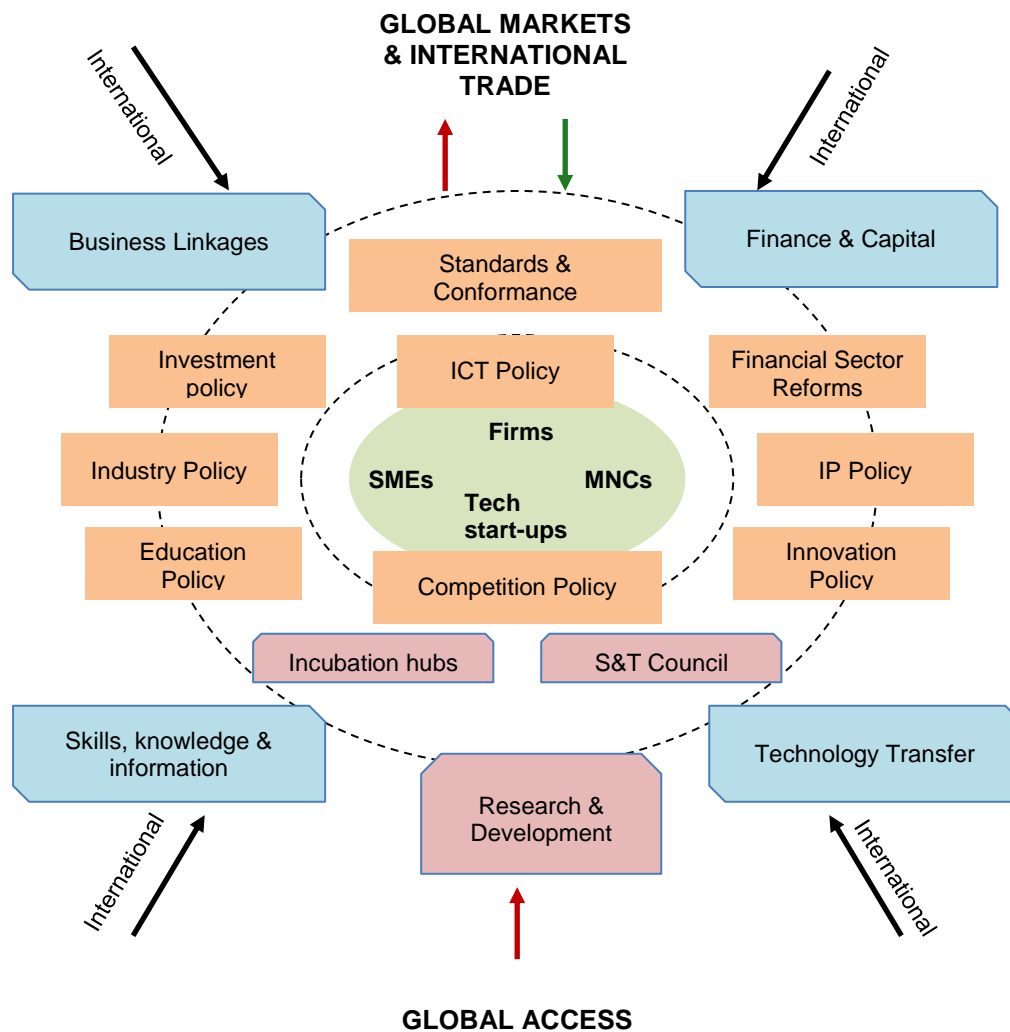
Technological and scientific progress propels economic growth and long-term wellbeing. There is evidence that prescribes stable *innovation networks* as conduits for the cumulative process of technological and scientific progress (Acemoglu, Akcigit and Kerr 2016). The use of innovation networks is now widely considered as a key determinant in increasing innovation-driven growth. However there is no consensus about the appropriate definition of networks and the context at which they function (Hämäläinen and Schienstock 2000). The key characters of innovation networks are mutual interdependence, intensive communication, reciprocity, and high levels of trust (Hämäläinen and Schienstock 2000). The relationships in these networks may be vertical or horizontal depending on the value-chain channels within the economy. Vertical and horizontal networks can be described as “vertical networks are those that connect firms or production activities along a particular value-chain or production process; and horizontal networks connect individuals and organizations in particular functional areas such as research, production, logistics and marketing etc.” (Hämäläinen and Schienstock 2000)

With the above definition, innovation networks within APEC economies were analyzed and a framework was proposed that encompasses both vertical and horizontal relationships. The innovation networks framework proposed and shown in **Figure 12** next page, has a global and regional APEC context with a focus on international technology diffusion and also human capital formation in domestic economies. As shown in the figure:

“It is critical that a network of institutions, ideas, policies, strategies, agents and incentives are organized and are coherent in order for DIS to function effectively. At the heart of the innovation network, is the effective interfacing of socio-economic, productive and knowledge, intersectoralising of sectors, and forging of interdependency between agents and structures of DIS.” (Baskaran and Muchie 2008)

In the following sections, four imperatives that make innovation networks functional and the framework conditions that govern the networks are explored. The functional imperatives to be discussed below are potential entry points for APEC economies to develop regional partnerships, in line with the PPSTI Strategic Plan and other cross-fora partnerships. It is important that adequate policy conditions are generated to strengthen domestic innovation networks and further ensure that cross-border science and technology partnerships are enhanced. Therefore, having robust innovation networks both domestically and within the APEC region, is critical for domestic innovation systems.





**Figure 12:** Web of networks that promote innovation and growth

### Functional Imperatives for Networks

The following imperatives are critical in setting strategic directions for the innovation network:

- (i) Skills, Knowledge and Information
- (ii) Technology Transfer
- (iii) Business Linkages
- (iv) Finance and Capital (Kotilainen 2005)

While they guide the general direction for the content and context of the network, they are also critical determinants in many bilateral or multilateral agreements. Many economies give attention to STI issues at the highest level of government through the

establishment of high-level ministerial councils to ensure greater coordination in undertaking these functions (AKCIGIT 2016). International Technology Transfer is particularly vital for developing economies, such as PNG, that are in the process of catching up through imitation and technology acquisition rather than independent research and experimental development (R&D) and innovation.

### **Skills, knowledge and Information**

Universities and other higher education institutes are critical to the science and innovation systems as they perform research and train researchers and other skilled personnel (Ebersberger 2005). Within the APEC region, the role of the universities, particularly in creating innovative solutions within the framework of domestic innovation systems, has broadened. The growing demand for economic relevance in research and innovation is now driving universities and research institutions to adjust to the pressures of innovation systems in their economies. This is particularly true when investment in education and research allows economies to “develop and adopt innovative technologies to accelerate employment growth and moving the economy towards more complex and value generating industries” (APEC 2016). At the same time, "universities are establishing closer links with business through cooperative research, networks, and exchange of information" (Ebersberger 2005). The Association of Pacific Rim Universities (APRU) is an example of this shift within the APEC region.

To support this increasing demand for innovation and economy, the APEC Education Strategy 2016-2030 provides a blue print for promoting competencies in innovation employability. The APEC Education Strategy 2016-2030 " reflects not only the importance given to education and development cooperation by APEC member economies but also the increasingly important role of education in economic growth and integration in the APEC region" (APEC 2016).

### **Case Presentation 3: Association of Pacific Rim Universities by Christina Schönleber**

APRU brings together thought leaders, researchers, and policy makers to exchange ideas and collaborate on effective solutions to the challenges of the 21<sup>st</sup> century. With a membership of a 50-member university, APRU recognises the importance of university networks in creating solutions to development challenges. Since domestic innovation systems are ecstatic and continually evolving, APRU has developed an adaptable network of universities since its inception in 1997.

APRU's strategic priority is to support productive innovation networks through a reliable platform for sharing of common goals, conducting focused research, securing adequate funding, and its ability to build strong partnerships. This is achieved through the creation of knowledge platforms that identify societal challenges, and investments are targeted to find appropriate solutions from an APEC perspective. By embedding networks under thematic areas, APRU takes an interdisciplinary approach that incorporates sciences, social sciences, and humanities.

These networks include both internal networks and external networks. The former is considered to be priority and targets higher education and research programs, Asia-Pacific and Global Leaders, and partnering on solutions to Asia-Pacific challenges. APRU's internal innovation networks offer Pacific Rim Challenges on a number of focus areas including Global Health, Multi Hazards, Population Aging, Gender Equity (Asia-Pacific Women in Leadership), Digital Economy and Artificial Intelligence, Pacific Ocean, and Sustainable Cities and Landscapes. Through collaborative research within the 50 members, APRU's internal innovation networks are generating impact and contributing to regional solutions.

The internal innovation networks impact APRU's external innovation networks, which are essential for global policy impact. The external networks promote advocacy across Asia-Pacific and support engagement with policymakers, businesses, and community. Strong partnerships underpin APRU's external innovation networks.

### **Technology Transfer**

Another essential element of successful innovation networks is technology transfer, which can occur across international borders or domestic firms and institutions. Technology transfer is the movement of scientific methods of production or distribution from one enterprise, institution or economy to another, usually through foreign investment, international trade, licensing of patents rights, technical assistance or training. The process to commercially exploit research varies widely. It can involve licensing agreements or setting up joint ventures and partnerships to share both the risks and rewards of bringing new technologies to market. Other corporate vehicles, e.g., spin-outs, are used where the host organisation does not have the necessary resources or skills to develop new technology. In international markets, it is usually transmitted through International Technology Transfer Agreements.

It is essential that technology transfer activities be guided by enabling policies that may cover the following categories: 1) absorptive capacity policies; 2) measures related to intellectual property rights (IPR); 3) FDI promotion measures; 4) FDI restriction and FDI screening; 5) performance requirements; and 6) investment incentives. (Kowalski, Rabaioli and Vallejo 2017)

#### **Case Presentation 4: International Technology Transfer Network by Mr John Zhang**

Networks are critical to the efficient and effective functioning of any innovation system. In presenting on the principles for establishing and maintaining innovation systems, Dr. John Zhang shared experiences with the International Technology Transfer Network (ITTN) organisation. The ITTN organisation was established in China in 2011, and it carries out work in association with well-known technology transfer and innovation service organisations both domestically and internationally. ITTN has since fostered long-term partnerships with more than 200 international Technology Transfer organisations in 15 economies.

ITTN's overall goal is to foster international technology transfer and promote APEC STI APEC cooperation and connectivity. The ITTN aims to

“achieve this by building a platform for science and research organisations, enterprises and government departments; offering and promoting two-way international technology transfer and international Innovation Cooperation of technology introduction and technology output; promote quick implementation of innovation cooperation programs; and realizing the conversion of commercial value and creating win-win solutions through cooperation.” (ITTN 2014)

According to Dr. John Zhang's presentation, ITTN now has an international committee that is present in more than 40 economies (including APEC economies), over 22 official work mechanisms, and over 400 Technology Transfer Organisations. The ITTN Global Think Tank group is divided into three Sub-committees based on various elements of technology transfer including; Professional Service Committee, Technical Cooperation Committee, and the National Cooperation Committee (John Zhang, unpublished). Therefore, ITTN is an excellent example of an innovation network that has an international focus science and technology cooperation focus within the APEC region, and also contributes to new technology development and productivity growth.

Presently, ITTN is focused on a number of innovation and technology frontiers. This includes ICT, bio-medical and healthcare, rail transit technologies, engineering of new materials, energy and environmental protection, high-end gear, modern agriculture, modern science and technology services, other cutting edge technology fields, and other emerging industries. These initiatives to develop advance technologies can be enabled through technical cooperation, which requires an open innovation approach to allow the movement of professionals and experts across APEC economies. The flow of knowledge and technology, particularly from developed to emerging and developing economies, can be viewed as a critical enabler in advancing APEC's Regional Economic Integration (Committee on Trade and Investment 2018). It is vital that developing economies are supported so that they can develop their comparative advantages and further improve their research capacities. Therefore, there is increasing urgency to develop a regional strategy to support and promote technology transfer across APEC economies.

In 2017, ITTN and MaTRineX Academy of International Innovation and Strategy jointly filed an application for APEC funding for a project titled "Foster International Technology Transfer Professionals for the APEC STI Cooperation and Connectivity". The project aimed to propose relevant policy recommendation through research on industry standards and knowledge systems of international technology transfer. This is to progress regional cooperation in scientific and technological innovation for transformation to promote economic growth within the APEC region. The project execution team is now completing the Manual of APEC Cross Border Technology Transfer.

### **Business Linkages through innovation networks**

Business linkages are crucial for innovation networks to flourish and support the development of a functioning domestic innovation system. Businesses within the Asia-Pacific region can benefit from open-innovation platforms, which promote cross-border and domestic networks, and support sharing of knowledge and technology to improve products and services. An excellent case of such a network is the APEC Accelerator Network that supports start-ups and young entrepreneurs. While new knowledge generation and innovation are critical to growth of the region, APEC realises the economic and productivity gains that structured business networks among businesses can generate in the region.

There is evidence that the uptake of external information and knowledge by SMEs is becoming increasingly critical. Particularly, when SME's have limited technical or business expertise (tacit knowledge) and need to acquire such information and/or skills from third parties. By creating business networks of trainers and/or consultants with technical knowledge, staff in SMEs and start-ups can be trained or retrained with new skills and diffusion of technology. Such an approach may allow the expansion of the SME sector, especially where early adopters of new technologies or business approaches can gain competitive advantage and access to new markets ahead of their 'laggard' competitors.

The sharing of knowledge, skills, and innovation available through domestic innovation networks is, therefore, critical to expanding the SME base in the economy. International transfer of knowledge and experiences by SMEs could be obtained by linking with international or multinational companies for international technology transfer described above in. Many more economies within the APEC region are focusing on collaboration and knowledge diffusion, due to the notable improvements being made in productivity within economies that have imported knowledge from technology leaders (through technology transfer). Focusing on collaboration and knowledge diffusion through these innovation networks, in particular, improves business performance.

For more information, refer to: <https://www.apec.org/Publications/2015/01/APEC-Accelerator-Network>

#### **Box 6: APEC Accelerator Network**

Given the significance of start-ups and young entrepreneurs to economic growth in the Asia- Pacific region, in 2012, APEC Leaders supported the implementation of the Young Entrepreneurs Network and APEC Start-ups Accelerator Initiative. Leaders also encouraged the mutually beneficial collaboration among firms, big or small, to foster their intellectual capital, optimize their core competencies, and minimize potential disputes that would discourage MSME development.

Since then, APEC acknowledged the importance of an enabling environment to accelerate start-ups and boost the development of SMEs through addressing trade, investment, and regulatory barriers for SMEs and offering improved and efficient services to them. APEC is also committed to further advance SME cooperation for innovative growth through promoting start-ups. The development of start-ups in the APEC region facilitates job creation and has the potential to increase international trade that benefits APEC member economies.

## Finance and Capital

There has been a good coverage on innovation funding in Part V of this manual. Therefore, in this section, a case study on Thailand's innovation grants will be considered to provide an insight into how financing networks targeting innovation centered SMEs can promote economic growth.

### Case Presentation 5: Thailand's financing and entrepreneurship model by Dr. Charles Tuchinda

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Thailand's National Science and Technology Development Agency's (NSTDA) experience was shared during the workshop. In January 2016, NSTDA established the National Startups Committee (NSC) to ease funding access for startups and to drive collaboration across agencies and organisations to support startups. The NSC committee initially developed a 6-month program for trial and evaluation to assess its impact on the growth and success of new start-ups. The outcomes of the program were provided to the Thailand government as policy recommendations.

Thailand's funding and entrepreneurship comprised of the following 5 modules:

**Module 1:** *Entrepreneurial Education* – innovation awareness and training in 30 universities and TVET colleges for approximately 30,000 students.

**Module 2:** *Startup District* – 17 Startup districts identified and developed.

**Module 3:** *Idea to Startup* – at least 550 business models and prototypes developed in 30 universities.

**Module 4:** *Research Commercialization* – at least 100 research projects encouraged for commercialisation in government universities and research organisations.

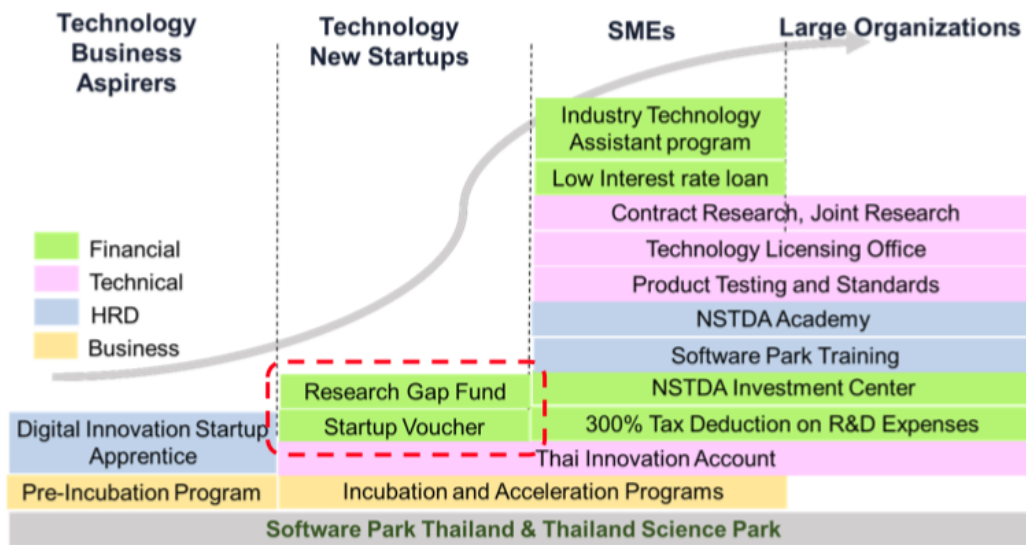
**Module 5:** *Business Brotherhood* – collaboration between large corporations and universities established in 5 universities.

The success of this exercise has been remarkable. Out of the 150 funded projects, at least 50 had been successful. Monetary wise, NSTDA, and NSC invested US\$ 7 million, and after six months (2017) the return on investment from these startup ventures was US\$ 4 million. The expected return on investment in 2018 was around US\$ 18 million. Intellectual property and rights created from this investment accounted for 9 Patents, 10 Petty Patents, 3 Copyrights, 1 Trademark, and 1 Trade Secret.

Thailand's financing and entrepreneurship model (shown in **Figure 13** next page) has a broad coverage in their innovation ecosystem, which covers financial, technical, human resource development, and businesses as prerequisites to their innovation network. Their networks include Technology Business Aspirers who are beneficiaries of pre-incubation programs, New Startups who are supported through research gap grants and Startup Vouchers, SMEs who are funded through Industry Technology Assistant Programs and low interest rate loans, and Large organisations who are financed through NSTDA Investment Center and are also incentivised by 300% Tax reduction on R&D expenses. Thailand has demonstrated that creating a platform for innovative funding mechanisms can support entrepreneurial activities and provide solutions to their development needs. These platforms can maximise knowledge and technology outputs.

Thailand's Software Park and Science Park are NSTDA's research and development institutions that are driving the economy's entrepreneurial financing program to reach their current level of innovation success. As state institutions, they were established to strengthen Thailand's capabilities in research and innovation under their specific research priorities. The entrepreneurship program is an initiative to popularise and diffuse research outcomes and to translate knowledge into products for commercialisation and consumption within the economy or abroad. This is a good example of the impact of government decisions and clear policy intent to financially support startups. From the experiences that were shared, NSTDA's approach ensures there is adequate financial sustainability as start-ups progress into becoming SMEs.





**Figure 13:** Innovation funding for Thailand entrepreneurial program (Durongkaverroj 2015)

## Frameworks for Innovation Networks and Linkages

Developing networks among STI actors (**Figure 12**) is critical to developing well-functioning domestic innovation systems (United Nations Conference on Trade and Development 2018). It implies that robust and evolving linkages enable organisations to translate new knowledge into innovations, enhance productive capacity and meet societal challenges. Essentially, the capability of innovation systems to stimulate the flow of knowledge, technology and learning across all STI actors depends on the dynamics of the network of actors. Many economies that have built successful networks and linkages have been versatile in responding to the changing global and domestic demands for skills, learning capabilities of firms and their absorptive capacities. These economies also provide the policy basis for the effective flow of key resources, including finance and human capital (United Nations Conference on Trade and Development 2018).

Framework conditions provide the basis for the development of new policies or for the realignment of existing policies so that the economy offers a favorable policy environment to promote innovation and growth. It ensures policies are adjusted to the growing importance of science, technology, and innovation for economic growth. Numerous policies and regulations can be created depending on the development trajectory of the individual economy.

An active list of enabling policies to improve science, technology, and innovation are provided and briefly described under *Policy and Regulatory Measures* on page 22. It is critical that while these innovation-friendly policies are in place, there has to be domestic and:

“international collaboration across economic sectors, technology sectors, technology areas, and scientific disciplines. The coherence of these policies and regulations, and the collaboration of the STI actors along supply and value chains, financiers of innovation, and the final users of new technologies ensure that innovation responds to demand, is socially accepted and has a better chance of succeeding in the market.” (United Nations Conference on Trade and Development 2018)

### **Government’s responsibility in fostering networks**

The ability of STI actors to collaborate and network does not happen at random, especially in innovation systems that are developing. Many innovation systems especially in the developing APEC economies are fragmented and inhibited by various system failures. Active and coordinated action is required by governments to develop innovation systems that responsively address economic, social and environmental challenges through a collaboration of STI actors.

Furthermore, there has to be “policy and regulatory linkages from government, education and training institutions and the industry” (Hämäläinen and Schienstock 2000). Where there is no clarity of relationships, reforms are needed to define the rules that govern science-industry relationships based on market principles. It is vital that incentive structures are developed for researchers and policies to increase the mobility of personnel within the science systems and between the science system and industry. By doing so, benchmark links are developed between science and industry to increase firm competitiveness and growth. Central is the role that STI policies perform in the uptake of new knowledge and technologies developed in universities, research institutions, or private R&D into the industry or market place. Collaboration in research groups and science-industry interactions are becoming key policy focus areas with the formation of clusters to develop or adapt technologies. Many universities are now developing innovation hubs or centers of excellence as they gain more autonomy so they can become competitive and high performing with the ability to commercialise research outcomes (Schaaper 2014).

## APPLICATIONS AND POLICY RECOMMENDATIONS

The two-day workshop on Domestic Innovation Systems and Networks led to a number of recommendations for policy initiatives and applications within APEC PPTI. These recommendations were developed through the delivery of presentations and the Question and Answer sessions for each thematic session. The list of recommendations summarised in this manual are provided in order of regional focus and PPSTI, government ministry for science and technology, inter-department partnerships for STI, and finally focuses on PNG's domestic need for agricultural development as the inspiration for the development of its domestic innovation system.

### Strengthen Regional Innovation Networks

It was recommended more regional innovation networks be developed within the APEC economies to encourage an open science and technology cooperation for member economies. With PPSTI fora taking the lead in constructing new innovation networks, it is critical to start implementing the PPSTI Strategic Plan (2016-2025), beyond policy discourse to innovation action. PPSTI recognises that innovation can “improve the quality of growth, promote economic and social development, and address common challenges and achieve prosperity of the Asia-Pacific and beyond” (PPSTI 2015). However, innovation must be “open and socially embedded in which new scientific options, accumulated production knowledge and market demands interact with each other” (Hamalainen and Schienstock 2000) and bound to be transferable cross the APEC economies, with guidance from the PPSTI Strategic Plan.

As stated, the PPSTI Strategic Plan must inform and provide the policy direction on the design and development of innovation networks. Hence, the content and inspiration of the PPSTI is to promote “Innovation-Driven Development” through intensified cooperation among the relevant stakeholders. It further states:

“...declaration of innovative growth through enabling eco-system, regional cooperation, human resource exchange, and infrastructure development, PPSTI is to strengthen the synergy of government, academia and industry, including SMEs, and engage actors involved in joint scientific research and in the technology inception, dissemination and commercialization cycle, with both its competitive commercial sectors and non-profit elements” (PPSTI 2015).

In line with this declaration, important collaborations and networks have been developed between APEC economies and also cross-fora. The Association of Pacific Rim Universities is good evidence of the network of research institutions collaborating to create solutions to development challenges in the Asia-Pacific region. APRU's current research priorities include hazards and natural disaster risk reduction, women in leadership, population aging, sustainable cities, artificial intelligence, the Pacific Ocean, and labor mobility. It becomes a great model of the collective education and research capabilities of APEC member economies in regional cooperation to deliver policy solutions that together can be strengthened.

Key policy areas to pursue by PPSTI and other fora include:

- Enhance cross border researcher mobility
- Improve regulatory measures for trade and investment in science and technology goods and services
- Improve cross-border innovation procurement within Asia-Pacific
- Encourage more scientific and technological cooperation across borders

The PPSTI Strategic Plan 2016-2025 can be accessed through this link:

[http://mddb.apec.org/Documents/2015/PPSTI/PPSTI2/15\\_ppsti2\\_004.pdf](http://mddb.apec.org/Documents/2015/PPSTI/PPSTI2/15_ppsti2_004.pdf)

## **Establish a Ministry of Science and Technology**

In the age of knowledge-based economies, STI has become a key driver of development and growth. However, in developing economies, investment and policy support for STI is limited. In PNG's case, data collected in 2016 shows that GERD was 0.03% of GDP, which is very low compared to APEC's average of approximately 2% GERD. The low level of GERD investment significantly affects the production of new knowledge and lowers the absorption capacity of the economy to absorb new technology. One of the reasons for the low GERD in PNG is the high economic dependence on the extractive industries, including mining, oil and gas, logging, and commercial agriculture. The overall economic productivity is quite low across several developing economies that have a heavy reliance on natural resource extraction.

There is now strong evidence that creating a Ministry of Science and Technology (MOST) in government has improved knowledge and technology production in many emerging and developing economies. Chile's representative at the workshop stated that "it is imperative to create MOST for governments to be given prominence to STI

in development plans and to ensure priority is given to investment in knowledge-based economy" (Chile, unpublished). The Chilean economy has experienced success in economic growth since creating its Ministry of Science and Technology (Chile Today 2018). Chinese Taipei's Ministry of Science and Technology was initially established as the National Science Council in 1959 and was later reorganised to be a ministry in 2014. Chinese Taipei's MOST aims to integrate academic research with industrial development (Ministry of Science and Technology 2019). It intends to drive forward scientific and technological innovation and is a significant pillar of the economy's plans for growth and progress. Malaysia has also taken a similar approach by creating its MOST to focus on market oriented research and development. Although the economy and its STI capabilities were severely affected by the financial crisis in 1997 and 2009, Malaysia's MOST is strengthening its STI capabilities and its innovation system in its quest to become an innovation driven economy (Thiruchelvam 2017). From these experiences, it is evident that creating of MOST should be prioritised for developing economies to build science and innovation capabilities for the future knowledge and digital economy.

A key policy recommendation from the workshop is the establishment of a Ministry of Science and Technology, particularly in developing economies to ensure that STI investment is prioritised amidst many competing development interests.

### **Strengthen domestic partnerships across government agencies**

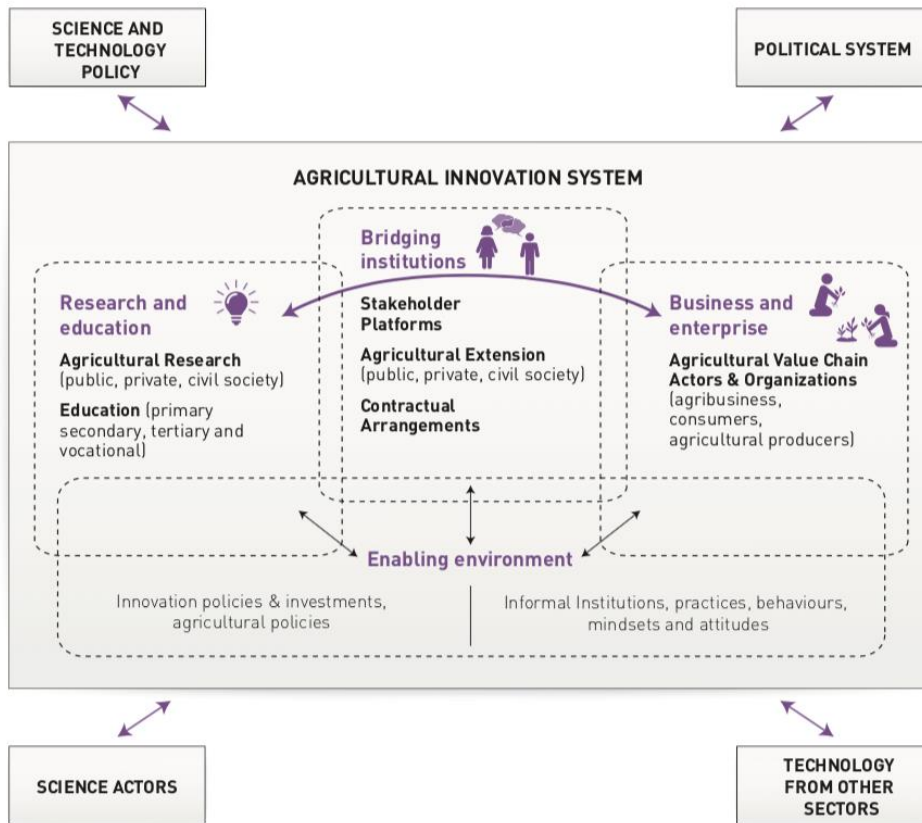
A significant shift in encouraging and strengthening partnerships and linkages within the public sector is imperative to having a functioning DIS. This is to alleviate any existing institutional constraints amongst policymakers and to ensure that policy and regulatory measures are synchronised and linked to the economy's development goals. Key government departments and line agencies need to build dynamic relations so that domestic policies on access to knowledge and technology, and policies on trade, technology transfer, intellectual property rights, and STI partnerships are effective and favorable to research and learning institutions, and the private sector. It is important to have a cohesive public policy environment for the economy to benefit from innovative growth, and to enjoy equitable and inclusive economic prosperity.

## Develop an Agriculture Innovation System for Papua New Guinea

The workshop participants supported PNG's ambition to develop its domestic innovation system and further identified agriculture as the focus for innovation and growth. This is consistent with the PNG government's policy to focus on agriculture as the main economic and productivity driver, as prescribed in its Alotau Accord 2 (Government of Papua New Guinea 2018). The direction taken by the government is critical to PNG's growth because more than 80% of the population currently work in subsistence agriculture or in the informal sector. This policy change can potentially raise the productivity of smallholder farmers and informal enterprises, and improve people's quality of life. The key challenge going forward is creating new opportunities for agricultural development by developing the mechanisms to translate such a policy into action.

The workshop recommended that establishing an Agricultural Innovation System is the key to advancing PNG's innovation policy in agriculture. Small-holder agriculture, which is presently supporting the bulk of PNG's population, currently suffers from a number of constraints including access to finance, infrastructure, lack of market access, limited information and technical assistance, low skill levels, limited supply networks and lack of access to global-value-chains. The plethora of challenges consequently impact on the overall performance of the economy.

In response, new efforts for the involvement and collaboration of different actors such as farmers, research bodies, educational institutions, banks, NGOs, SMEs and large corporations, along with a strong government coordinating and supporting role, are required. The systemic and systematic coordination of actions by these actors must have a strong PNG's social and cultural context to adequately address the constraints faced by farmers. Required are good policies, sustained investments, business and enterprise environment, training and upskilling, research and education, and the flow of knowledge and technology to farmers and stakeholders through extension programs. This should form the heart of PNG's Agriculture Innovation System (See **Figure 14**). To conclude, the Global Innovation Index for 2017 focuses on agriculture with the theme 'Innovation Feeding the World.' One of the recommendations from the GII 2017 asserts, "more innovation convergence is needed globally, with developing economies perfecting their innovation systems." (Cornell University; INSEAD; WIPO 2017) This recommendation provides a direction for PNG's participation in the future digital and knowledge economy.



**Figure 14:** An Agricultural Innovation System that may be suitable for PNG. Source: FAO (Aerni, et al. 2015)

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