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Compendium of Smart Manufacturing Policy and Regulatory Approaches in APEC

APEC Market Access Group

April 2019

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Produced by
Monash University of Malaysia on behalf of
Ministry of International Trade and Industry
Level 10, MITI Tower, Jalan Sultan Haji Ahmad Shah, 50480 Kuala Lumpur
Tel: +603 62000575/ +603 62000595
E-mail: alia@miti.gov.my/aedreena@miti.gov.my

For
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: (65) 68919 600
Fax: (65) 68919 690
Email: info@apec.org
Website: www.apec.org

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1. Introduction

Over the last decade, policy-makers across the globe have started to strongly advocate the use of Smart Manufacturing technologies to enhance the reach and richness of products and services. Advanced new technologies enable firms to vertically and horizontally integrate supply chains and production systems, enabling quick adaptation to changing market conditions and resist shocks to the economic systems. Economies and firms that have successfully adopted these emerging technologies have managed to improve productivity and mitigate risks associated with market uncertainties.

The adoption of emerging advanced technologies has led to what is commonly called the fourth industrial revolution. This fourth industrial leap is interchangeably called Smart Manufacturing or Industry 4.0. In its essence, the fourth industrial revolution is characterised by a Smart Manufacturing ecosystem in which cyber-physical systems are coupled to create transformative jumps in efficiency and productivity.

A study by PWC of 2000 firms from 26 economies in 2016 shows that firms are expected to spend US$907 billion in state-of-the-art smart manufacturing technology; obtain a return of investment in revenue of US$493 billion; and cost & efficiency gain of US$ 421 billion "(PWC, 2016). Given the significant level of gain there is an increasing recognition by governments that Smart Manufacturing has the potential to not only improve the competitiveness of firms but also increase the economic wealth of economies adopting smart manufacturing technology. While some APEC economies have been proactive in enhancing the development of the Smart Manufacturing ecosystem, the preparedness of other economies in the adoption of Smart Manufacturing technology remains at an early stage. This divide in Smart Manufacturing ecosystem readiness has the potential of increasing the wealth gap among member APEC economies.

Based on publicly available sources, the following Compendium of APEC Practices on Smart Manufacturing was undertaken by Monash University of Malaysia, and the recommendations, ways forward and analysis included in this paper are the views of the authors only. The objective of this report is to:

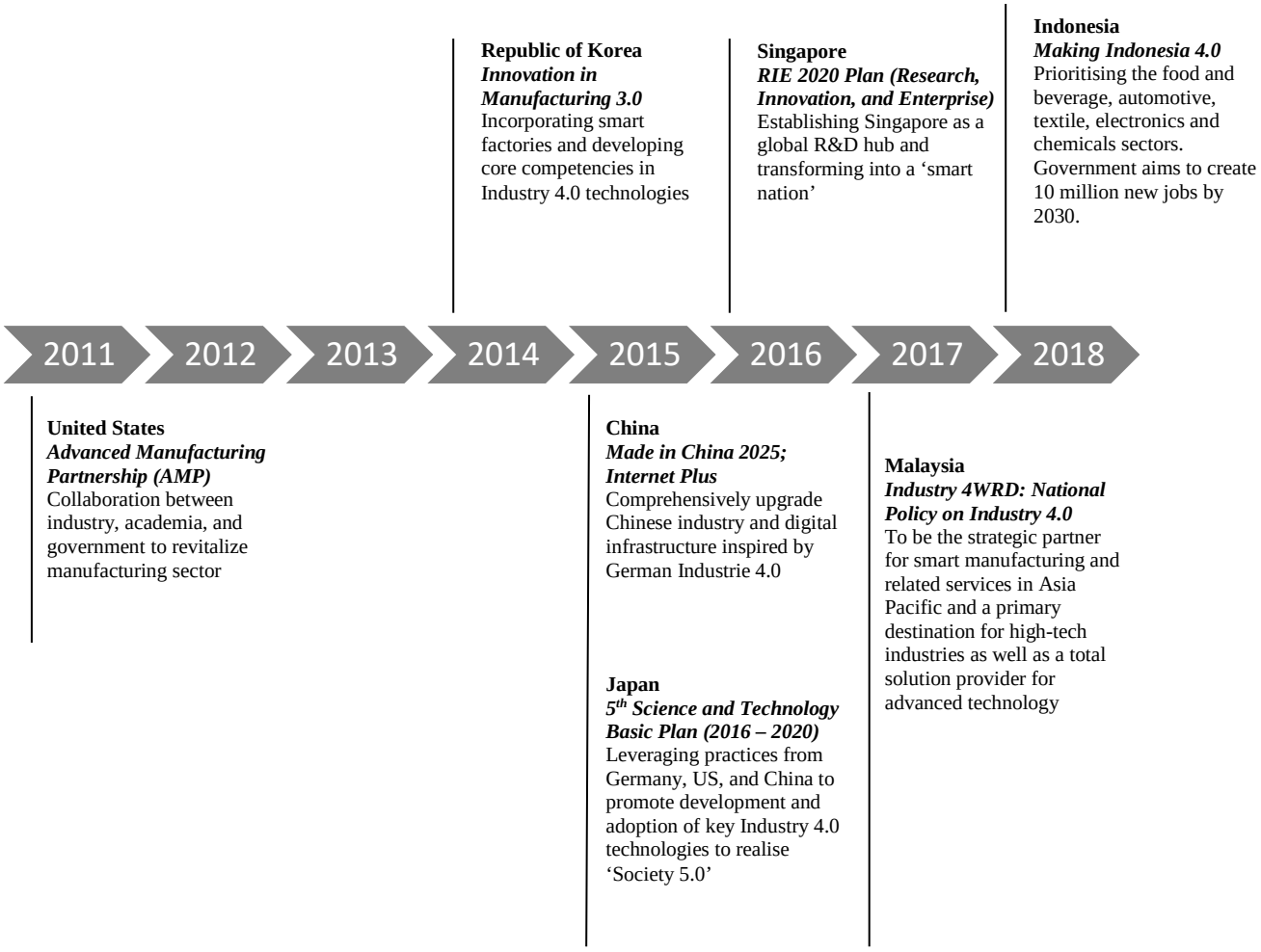
(i) establish a compilation of Smart Manufacturing policy and regulatory approaches among APEC member economies;
(ii) highlight existing practices in selected pace-setter APEC economies that have led to the adoption of Smart Manufacturing technology among firms and other economic agents following the APEC Seminar held in Penang; and
(iii) recommend areas for further collaboration among APEC economies following this initiative.

2. APEC Baseline Study on Smart Manufacturing

Overview of Smart Manufacturing among APEC economies

The benefit of Smart Manufacturing in raising the competitiveness of firms and economic development of APEC economies has led to a flurry of policy development among member economies. A number of APEC economies have initiated various programs and plans to intensify the diffusion of Smart Manufacturing technology. This includes the development of various institutional reforms and policy initiatives that are dove-tailed with sound fiscal and non-fiscal incentives schemes for the various economic agents to adopt Smart Manufacturing technology. The earliest implementation of Smart Manufacturing commenced in the USA in 2011, followed by the introduction of Industrie-4.0 by Germany in 2012. The chronological roll-out of smart manufacturing initiatives among selected member economies is shown in Figure 1**.**

Figure 1: Initial roll-out of Smart Manufacturing and Industry 4.0 Initiatives



Source: Appendix 2; compiled by Monash University Malaysia

The economies that started the journey of Smart Manufacturing early have been able to make significant headway in leveraging these technologies for wealth creation though the nurturance of strong supportive ecosystems. Economies that are in early stages of the journey are still in the process of understanding the concepts and applications to see how Smart Manufacturing fit with their specific contexts.

The United States is one of the most advanced in the development of a sophisticated and carefully dove-tailed Smart Manufacturing ecosystem. Its *Advanced Manufacturing Partnership* (AMP*) 2.0* is a multi-stakeholder collaborative initiative founded on a coherent innovation policy to accelerate development and integration of emerging technologies to revitalize US's leadership in advanced manufacturing. It is based on three main pillars, emphasizing advanced manufacturing and leading innovation; securing the talent pipeline capable of spearheading advanced manufacturing industry; and strengthening the business climate to facilitate knowledge sharing and transfer between large companies and SMEs. The initiative provides investment into shared R&D infrastructure and rapid prototyping facilities to reduce technological barriers in research and product development, especially for SMEs; greater university-industry collaborations and multi-university collaborative framework to leverage cluster development into building technology roadmaps and priorities.

Other leading economies, such as Singapore and Japan similarly have Smart Manufacturing initiatives that are backed by well-rehearsed and well-aligned policies. For instance, Singapore's *Research Innovation and Enterprise* (RIE) plan is driven through four strategic thrusts. The focus of the four thrusts underpins a variety of programs and specific activities to ground and strengthen an enabling digital infrastructure, incentivize technology adoption and ensure a good supply of manpower with the requisite skills for advanced manufacturing as well as provide access to research agencies and institutions for innovation and transformation of specified industry sectors.

Other economies, such as Australia and Canada have made good progress but are still in the process of putting in place various parts of the Smart Manufacturing jigsaw. For instance, in Australia's *Industry 4.0 Advanced Manufacturing Forum* (AMF) the key component of the initiative is the *Testlabs* program. *Testlabs i*s a $5 million Industry 4.0 pilot program with the aim of preparing businesses to transition to smart factories of the future[1]. *Industry 4.0 Testlabs* are to be established at five Australian universities and will provide a physical space for businesses and researchers to trial, explore and showcase Industry 4.0 technologies and processes; enable educational institutions and industry, particularly small and medium enterprises, to collaborate; and develop skills needed to take advantage of opportunities presented by Industry 4.0. Complementing *Testlabs* is the *Higher Apprenticeship Program* in which technicians are trained to a higher skill level to meet future needs of the economy (in areas such as advanced manufacturing processes, automation and robotics, IoT, cloud computing, advanced algorithms, smart sensors).

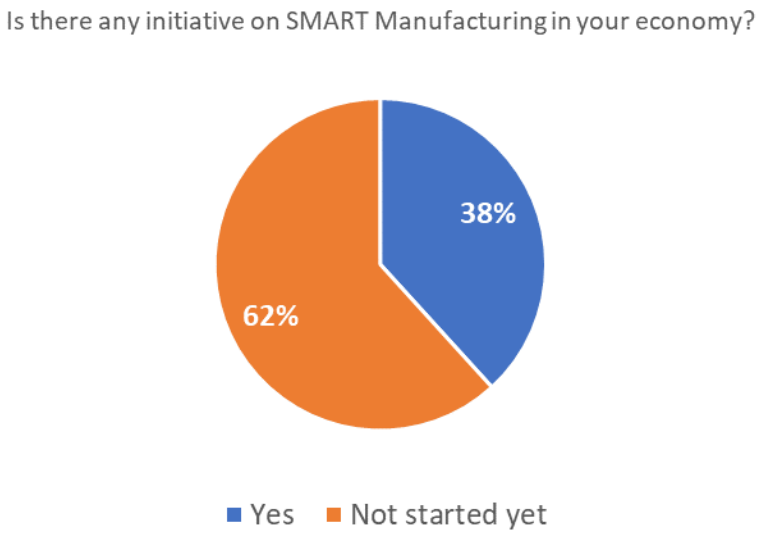
A number of other economies, such as China, Korea have made strong progress in establishing a strong foundation for leveraging Smart Manufacturing technologies to transform their industries and wealth creating capacity. Other economies are in the early stages of Smart Manufacturing ecosystem development. Economies, such as Malaysia, are aggressively promoting their manufacturing sector to upgrade their capabilities in line with the current megatrend by launching a comprehensive program also known as the National Policy on Industry 4.0: Industry 4*WRD*. However, it remains a nascent discussion in APEC particularly when some economies are unsure of how to or cautious in taking that first step towards a Smart Manufacturing journey.

[1] Industry 4.0 Testlabs in Australia (Department of Industry, Innovation and Science, 2017). https://www.industry.gov.au/data-and-publications/industry-40-testlabs-in-australia

3. APEC Survey Results and Analysis

To establish understanding of the state of play of Smart Manufacturing ecosystems in APEC economies a survey was administered among member economies. Sixty-eight individuals from various APEC economies participated. However, due to the low number of participants for the survey, the overall findings of this baseline study are only indicative and non-exhaustive. Despite the low number, responses provide formative insights on the subject matter. Survey of APEC economies indicates 38% are aware and engaged in some level of Smart Manufacturing activity. Significantly, a large proportion (62%) of respondents indicated they have yet to embark on Smart Manufacturing initiatives even though there is awareness of the need to build Smart Manufacturing ecosystem.

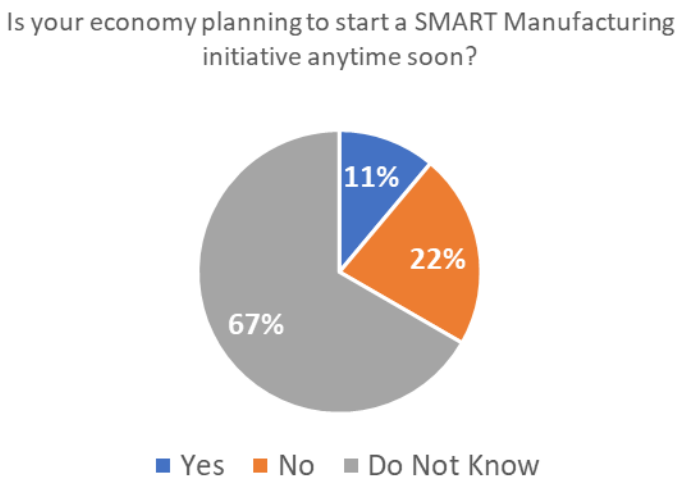
Figure 2. Presence of Smart Manufacturing in the Economies



Source: Monash University Malaysia Analysis, n = 68

Of those economies that have not started yet towards any Smart Manufacturing, a large number (67%) remain unsure about embarking on such a journey. Only 11% stated that they would be launching a Smart Manufacturing initiative in the near foreseeable future.

Figure 3. Plans to adopt Smart Manufacturing

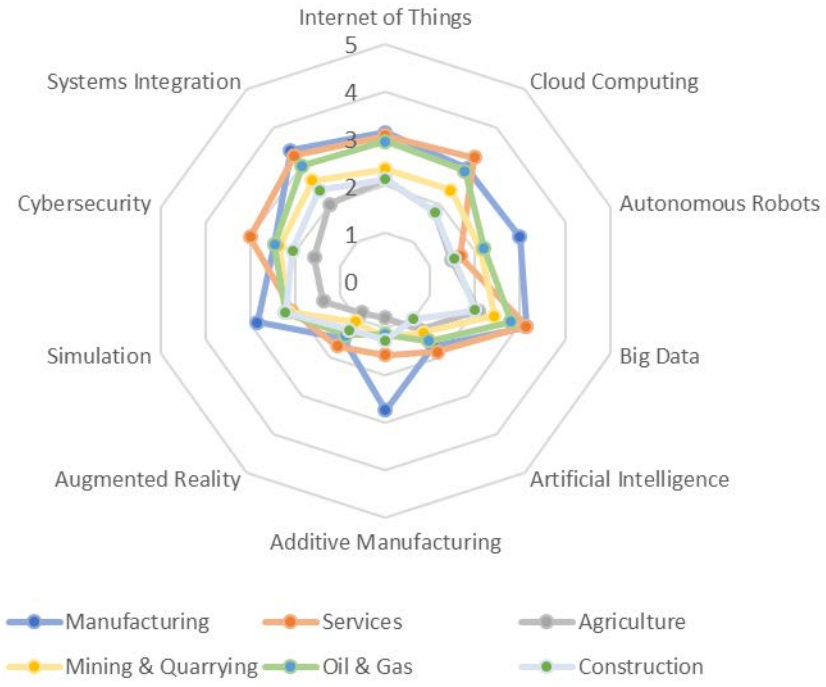


Source: Monash University Malaysia Analysis, n = 36

For those APEC economies that have already started to use the confluence of advanced technologies that constitute Smart Manufacturing, there is some variation in the uptake of the various Smart Manufacturing technologies. This is especially observable across different industry sectors.

At a generic cross-industry level, Cloud computing, Data Analytics, Robotics, and Additive Manufacturing are the key areas of uptake. The highest level of uptake is within the Manufacturing, Services and Oil & Gas sectors. Within the manufacturing sectors, we observe Robotics, Additive Manufacturing, Data Analytics and Simulation as key areas of focus. Services sector, such as that typified by banking and finance, on the other hand have started to place higher importance on cyber security and big data. Currently, the level of uptake of artificial intelligence and augmented reality remains relatively low. These technologies, as they mature, are likely to find their way into business operations. Agriculture, Construction, and Mining & Quarrying are industries with the least penetration of advanced technologies to-date. However, each of these sectors is awakening to the potential of advanced technologies to deliver enhanced profits through higher levels of product and service quality.

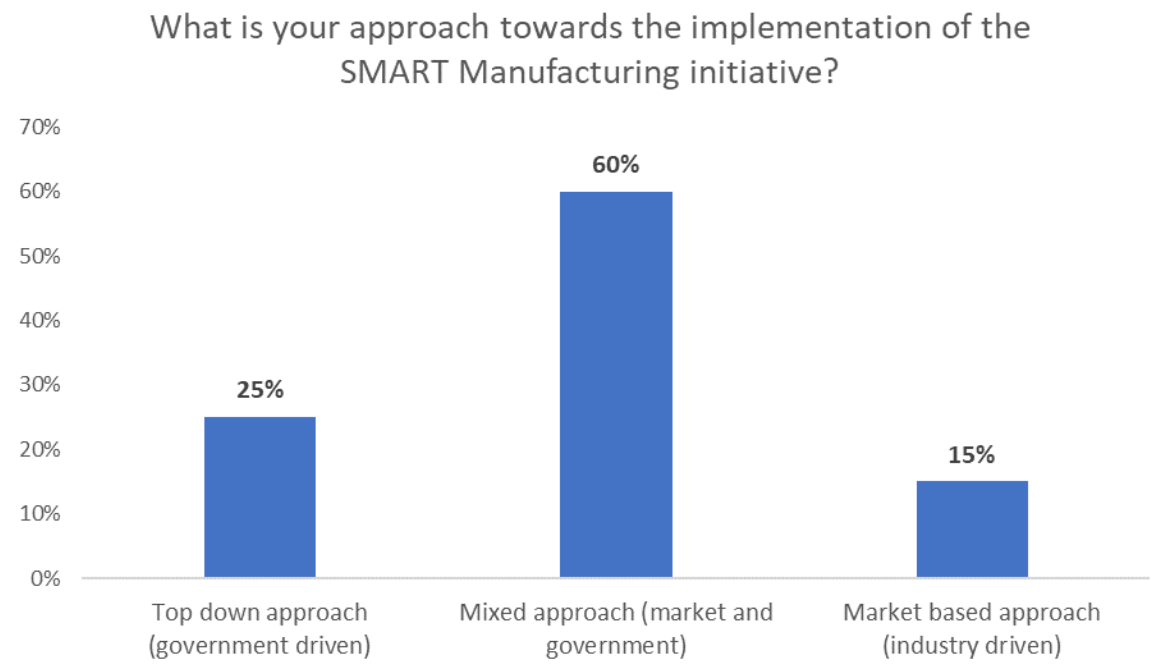
Figure 4. Adoption of Advanced Technologies by Industry Sectors



Source: Monash University Malaysia Analysis

APEC economies take contrasting approaches to the implementation of the Smart Manufacturing programmes. In Figure 5, a majority of the APEC economies are inclined to a mixed approach in which both the private sector and the government play in a role in Smart Manufacturing implementation. Nonetheless, a significant number (25%) of the APEC economies rely purely on top-down programmes, whilst a smaller number (15%) rely solely on private industry-led initiatives.

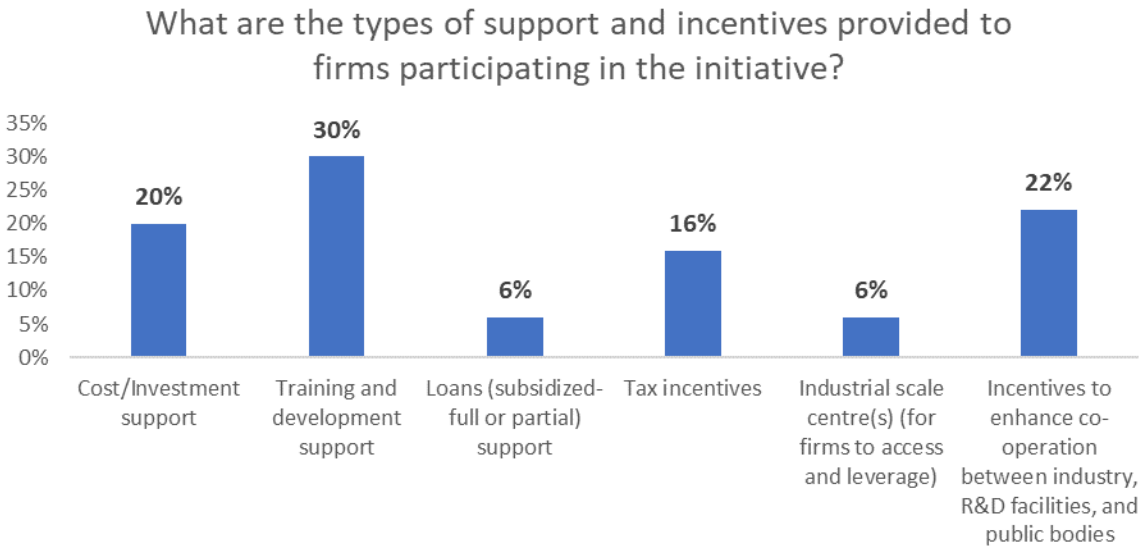
Figure 5. Smart manufacturing initiative approaches



Source: Monash University Malaysia Analysis

Delving further into how implementation initiatives are introduced, we observe that APEC economies rely on a range of supports to drive the Smart Manufacturing implementation initiatives. The top mechanism in APEC economies is the provision of training and development support for adopting firms. There is also strong focus on incentivizing cross institutional cooperation and providing industry access to advanced facilities in universities and labs, as well as reducing the cost of adopting new technologies through investment support. Fiscal incentives are also used to drive Smart Manufacturing technology adoption.

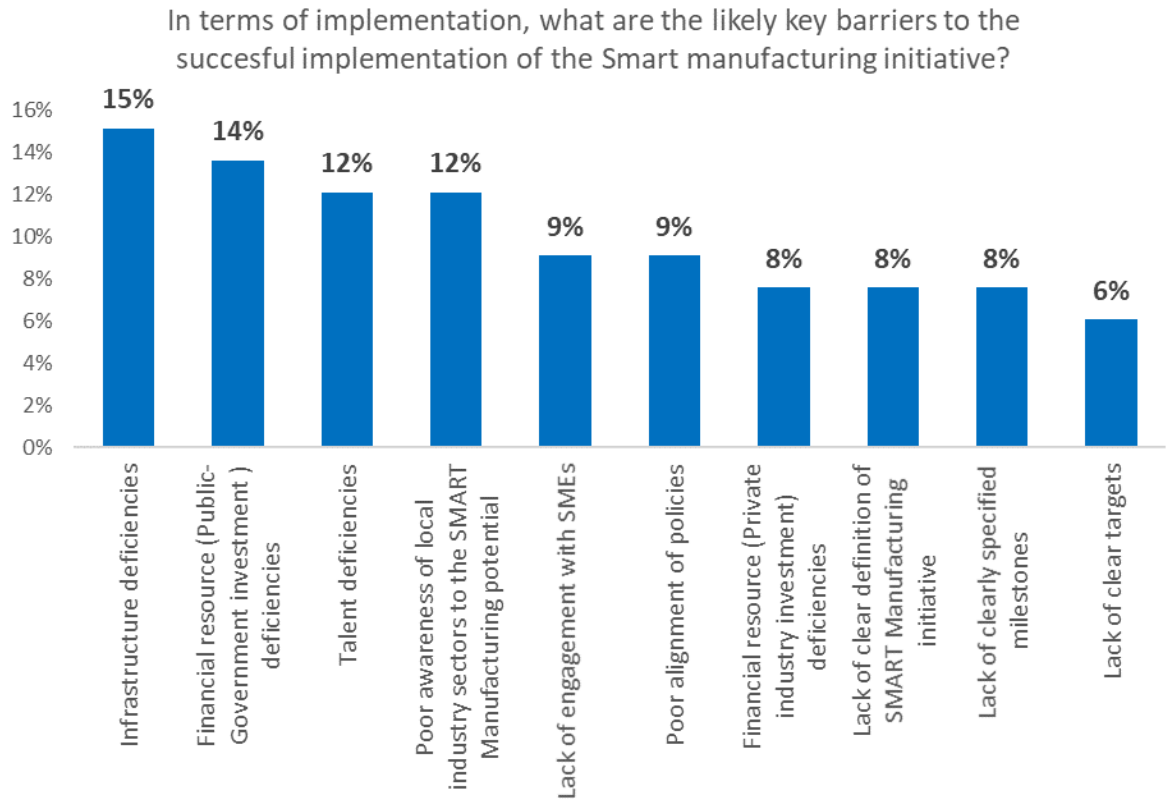
Figure 6. Types of support and incentives available for firms



Source: Monash University Malaysia Analysis

Considering the reasons as to why implementation of Smart Manufacturing initiatives is proceeding at a slow pace, a number of obstacles have been identified. The top four perceived barriers from the survey are infrastructure deficiencies; inadequate financial support (from the government); talent deficiency; and industry players' lack of awareness of the potential of newer technologies to advance their business profits and competitive advantage.

Figure 7. Key barriers to successful implementation of Smart manufacturing

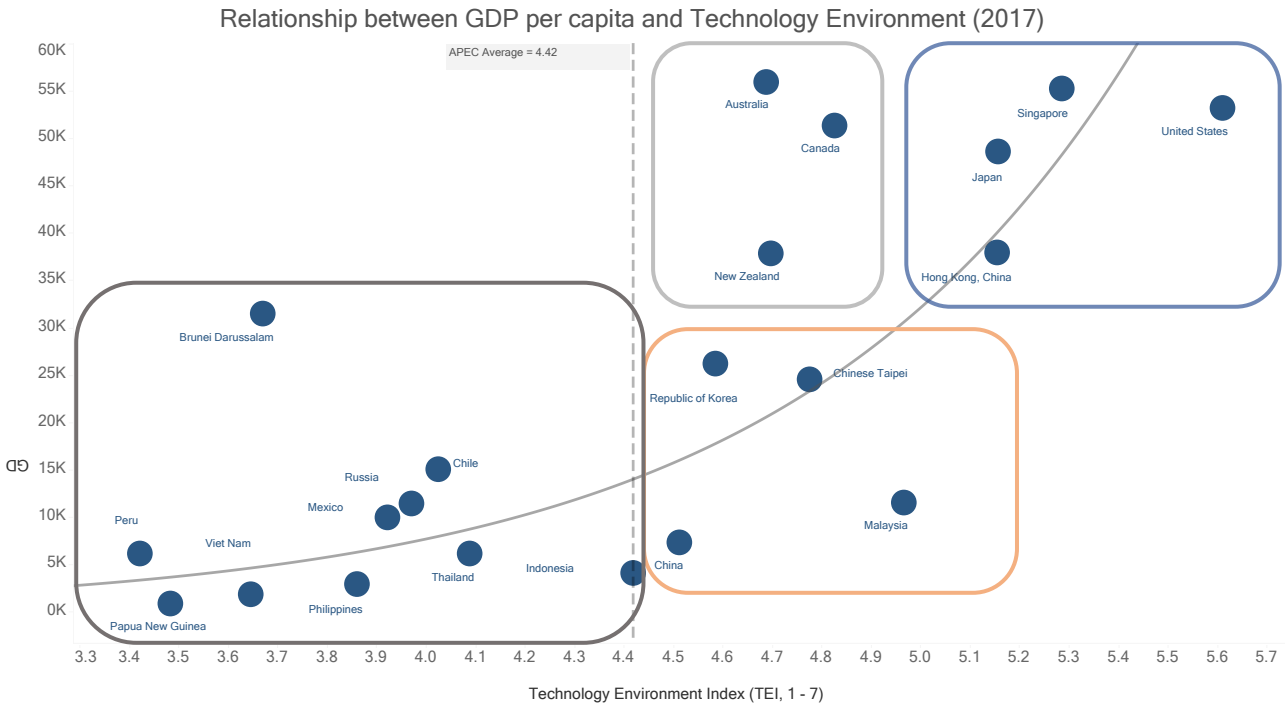


Source: Monash University Malaysia Analysis

In order to construct a holistic picture of the Smart Manufacturing ecosystem, both the enabling environment and firm level outlook of each economy was scrutinized using a mix of primary and secondary data. The enabling conditions portray the sufficiency in the existence and sophistication of a digital infrastructure, the availability of the necessary quantum and quality of talent and research prowess, as well as the industry's supply chain and market capabilities to harness Smart Manufacturing technologies. Firm level conditions are indicative of the willingness and capacity of the firms within the economy to take the risks in adopting new technologies for competitive advantage. Taken together these conditions comprise a Technology Environment Index (see Appendix 1 for detailed dimensions) that reflects the level to which a specific economy's environment is facilitative or restrictive to the development of a Smart Manufacturing ecosystem.

Detailed examination of the mapping of GDP per capita to the Technology Environment Index surfaces four distinct groups of economies in terms of Smart Manufacturing ecosystem development sophistication (see Figure 8).

Figure 8. Relationship between GDP per capita and Technology Environment in APEC Economies (2017)
Data Sources: World Economic Forum: The Global Competitiveness Report, World Bank
Analysis: Monash University Malaysia



Pace-setter Economies. These are pioneering economies who have already built a strong facilitative environment. These economies possess high level of Smart Manufacturing technical know-how, an institutional environment that encourages entrepreneurial behaviour of firms to experiment and spear-head adoption of Smart Manufacturing technologies, a sophisticated workforce as well as R&D capabilities to adopt and leverage gains in competitiveness. (HKC; Japan; Singapore; and the US).

Early Follower Economies. These economies have in place the technological environment that is conducive to the development of Smart Manufacturing ecosystem. However, in order to fully capitalize on the benefits, they require further investment and planning. These economies are well placed to raise their Smart Manufacturing capabilities and competitiveness across the global supply chains in which their industries operate. The pace of catch-up depends on the level of investment and appropriate strategies. (Australia; Canada; and NZ).

Follower Economies. Follower economies have already started the process of putting together a Smart Manufacturing ecosystem. However, they remain at an early stage of the journey; and even though significant progress has been made in the development of the Smart Manufacturing ecosystem platform, there remain considerable areas that need to be strengthened. Most of the economies in this quadrant are still at the early stage of building experience in the adoption and use of Smart Manufacturing technologies and face a unique variety of institutional and firm level challenges in scaling-up Smart Manufacturing adoption. There is much work that remains to be done, especially in terms of building cases for adoption through the establishment of proof-of-concept testing and use-cases to encourage Smart Manufacturing uptake and adoption. (China; Republic of Korea; Malaysia; and Chinese Taipei).

Nascent/Emergent Economies. This group of economies remain in the early stage of awareness of the importance and benefits of Smart Manufacturing ecosystems. Economies are just taking their first steps in policy formulation and institutional support for Smart Manufacturing implementation.

(Brunei Darussalam; Indonesia; Mexico; Papua New Guinea; Peru; Philippines; Russia; Thailand; and Viet Nam).

Table 2 charts the key strategies and polices that have been employed to-date by the four groups of economies and how these have shaped their current level of progress in the development of a Smart Manufacturing ecosystem.

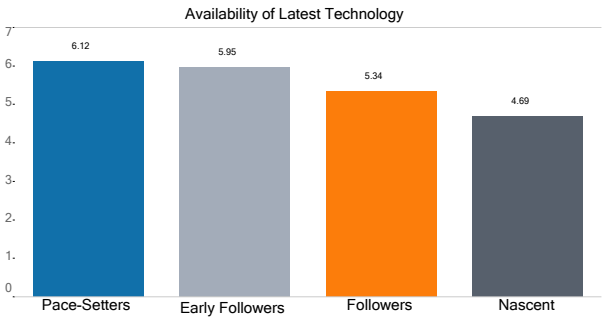
Table 2. Comparison of key strategies and policies across the four groups of economies

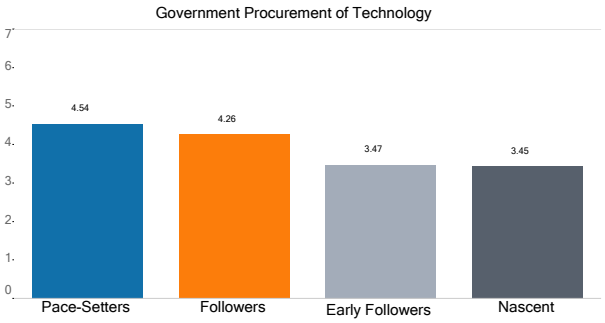
Pace-setters	Early-followers	Followers	Nascent
1. Clear policies, strategies and plans (Fore-sighting and readiness for action).	1. Clear policies, strategies and plans (Fore-sighting and preparedness for action).	1. Clear policies, strategies and plans (strengthening existing technological base; incremental fore-sighting).	1. Reflecting on policies, strategies and plans to implement.
2. Strong resources investment in new and existing technology, future talent nurturance, infrastructure, institutional development.	2. Strong resources investment in new and existing technology, future talent nurturance, infrastructure, institutional development.	2. Resource investment in existing technology, talent, infrastructure, institutional development (in existing legacy systems and technologies).	2. Inadequate resource investment in advanced technology, talent, infrastructure, institutional development (focus on legacy systems) – High risk of disruption.
3. Innovative development of frontier smart technologies and applications.	3. Innovative but cautious approach to frontier smart technologies and applications.	3. Incremental and cautious approach to frontier smart technologies and applications (slow movers).	3. Imitators, locked in to foreign technology, labor intensive and over reliance on old paradigm of competition.
4. Partnership approach to the development of smart industry ecosystem.	4. Strengthening of partnerships and ecosystem	4. Emerging partnership and ecosystem	4. One-sided, uncoordinated and patchy partnerships.
5. Maturity in use of advanced technology and knowledge transfer.	5. Mid-stage technology development and knowledge transfer.	5. Early stage technology development and knowledge transfer.	5. Weak technology development and knowledge transfer.
6. Development of appropriate regulatory architecture for the digital economy.	6. Grappling with the development of appropriate regulatory architecture for the digital economy.	6. Grappling with the development of appropriate regulatory architecture for the digital economy.	6. Inappropriate regulatory architecture for the digital economy.

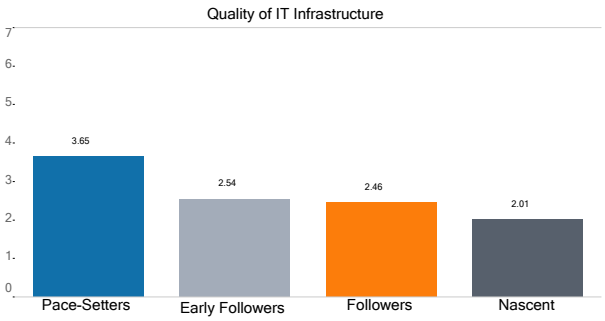
How well each of the four groups fare in terms of disaggregates components of the Smart Manufacturing ecosystem is shown in Figure 9. It can be observed that Pace-setter economies exhibit higher level of strength across all pillars that comprise to make up the Smart Manufacturing ecosystem. In terms of advancement in the development and readiness to take advantage of the Smart Manufacturing ecosystem Pace-setters lead, followed by Early Follower, Follower and Nascent economies.

Figure 9. Comparison between Technology Environment Index Groups

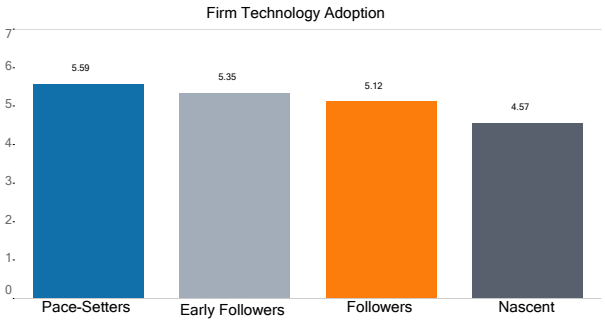
Digital Infrastructure

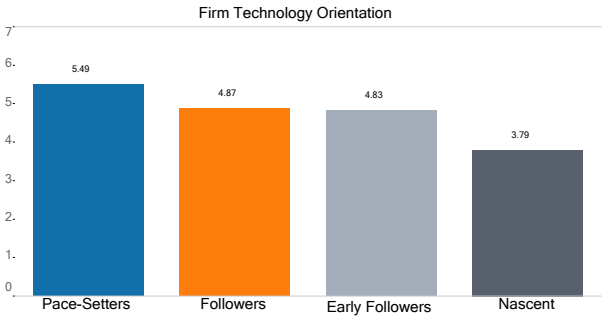




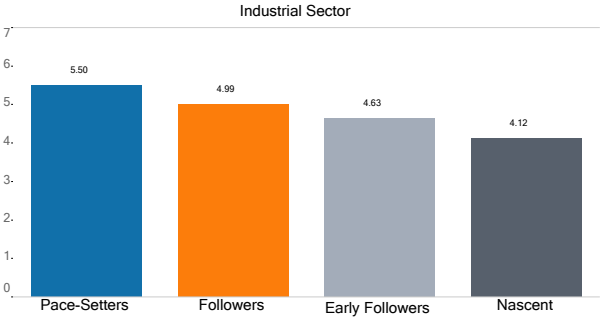


Firm Technology Environment

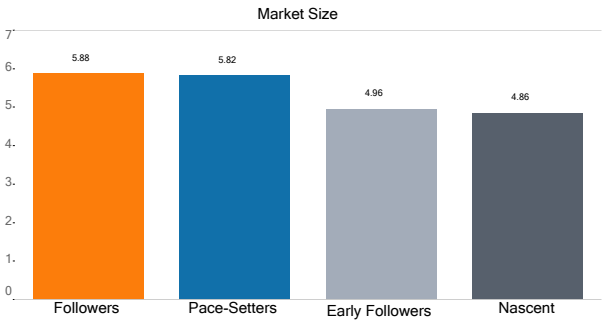




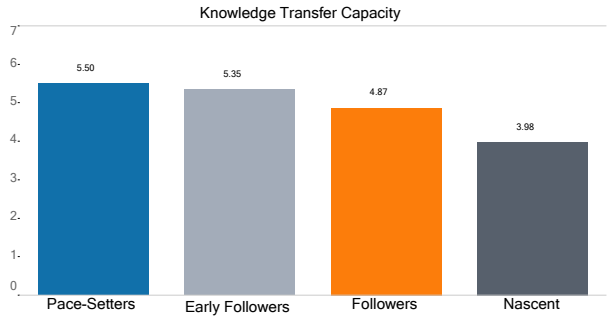
Supply Chain Maturity

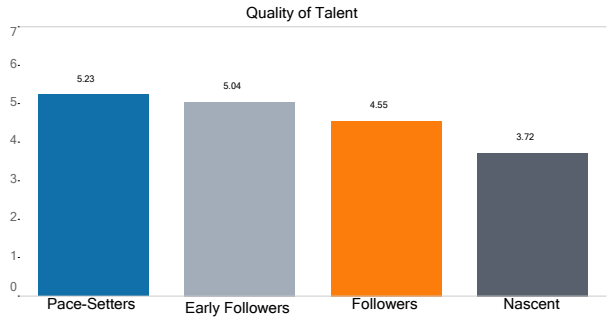


Market Size



Talent & Research





Data Sources: World Economic Forum: The Global Competitiveness Report, World Bank
Analysis: Monash University Malaysia

Economy Groupings: Pace-Setters – Hong Kong, China; Japan; Singapore; United States
Early Followers – Australia; Canada; New Zealand
Followers – China; Chinese Taipei; Malaysia; Republic of Korea
Nascent – Brunei Darussalam; Chile; Indonesia; Mexico; Papua New Guinea; Peru; Philippines; Russia; Thailand; Viet Nam

Each group of economies is faced with pressing challenges if they are to build competitiveness and prosper in an increasing hyper-converged global economy. The risk of creative destruction is everywhere, and all economies must respond in accordance to their unique contextual circumstances.

- Pace-setter economies must work out how or what they must do to remain ahead. These include ensuring they are at the fore-front of developing new innovations and applications in the smart manufacturing; and integrating these new innovations in all sectors of the economy.
- Early Followers must work out ways to tweak their current capabilities to catch-up with the pace-setter APEC economies in the implementation of smart manufacturing technologies within all sectors of the economy. The economies should strengthen their technological capability by investing in technology infrastructure, research & development, creative talent and new governance architecture that will spur new innovations in smart manufacturing that are strategic to the development of key sectors of the economies
- Followers need to reflect on the possibilities and routes of leap-frogging leading economies from their current position of development. These include identifying key smart manufacturing technologies and key strategies pertaining to talent, governance and incentives for firms and consumers to adopt new technology to enhance their reach for resources, information and markets in an inter-networked global economy.
- Lastly Nascent economies whose approach has largely focused on traditional business models utilising low cost based labour advantage need to ascertain whether they can continue in the face of new modes of production that will erode their cost-based advantages. To enhance their global competitiveness, these economies need to put in place radical strategies to upgrade their technological infrastructure; increase the diffusion new technology among firms and consumers; increase the supply of creative talent; improve the fiscal incentives for firms to adopt new technology and undertake adaptive innovations that meet the needs of the various stakeholders in the economy; and improve the governance and regulatory ecosystems to meet the needs of digitally connected economy.

Without significant response by the Follower and Nascent economies, the state of development of smart manufacturing and economic competitiveness between these economies and Pace-Setter and Early Follower economies is likely to widen in the coming years. Pace-setter and Early

Follower economies are likely to come out as the clear winners in a new world that challenges old world axioms of competitive advantage.

Smart Manufacturing Practices Cases following APEC Seminar held on 25&26 September 2018, Penang

The initial APEC Baseline Study was undertaken prior to the APEC Seminar on Smart Manufacturing was held, was to ensure that a more holistic discussion takes place in APEC forum. Although, APEC has been an advocate of GVC development and cooperation as well as facilitating Digital and Internet economy, there is no dedicated initiative or project on Smart Manufacturing. Due to the extensive transformation and disruptive nature that these technological changes bring, the current Government policy, framework and regulation would not be adequate to address issues faced through digitalisation. As such, this project seeks to address the gaps existing in this space for APEC to contribute towards challenges and opportunities incumbent with Smart Manufacturing.

Supplementing the conclusion of the APEC Baseline Study on Smart Manufacturing, the APEC Seminar provided a macro overview of the Asian Development Bank's (ADB's) white paper for the World Economic Forum (WEF) on how the Fourth Industrial Revolution could propel regional economic integration further for ASEAN. Other practices among APEC economies from the pace-setter and follower grouping economies provided examples for the participants namely A*Star of Singapore, Japan, People's Republic of China and Chinese Taipei. To also differentiate between the views of the private sector either through APEC Business Advisory Council (ABAC), Multinational Corporations (MNCs) and Small and Medium Enterprises (SMEs), various speakers provided their view point on how APEC economies can learn from each other's experience and collaborate going forward.

Case Study: A-STAR powering Singapore's Smart Manufacturing Initiative

The A-STAR in Singapore is an important driver for the economy's smart manufacturing plan through a collaborative multi-stakeholder ecosystem. It has established strong research entities in the biomedical and engineering areas with a strong focus on commercialisation of research and capability development via a successful graduate academy that trains the next generation of researchers.

A-STAR has played a key role in the establishments of the following state of the art-facilities for industry to enhance their technical and innovative capabilities:

- *Tech Labs* – enable firms, especially SMEs to test new technologies without adversely impacting their current operations and work closely with other stakeholders to develop new innovative solutions to improve their operations and quality of products.
- *Tech Access* – provide firms access to advanced tools and technology for prototyping, testing and other capability development programs that will enhance the competence in adopting advanced smart manufacturing technology.
- *Tech Depot* – provide firms access to technology and digital solutions that will improve firms' efficiency and productivity.

In essence, A-STAR has created a dynamic and vibrant smart manufacturing ecosystem that fosters experiential learning, continuous improvement of production processes and co-innovation platform. To date, the Institute has spent close to $340 million on industrial R&D, worked on more than 2,100

strategic projects, seconded over 60 research scientist and engineers to close to 56 local industries and more than 75% of the licenses are with the local industry.

Reference:

Tong, L.K. (2018), A*STAR's Future of Manufacturing Initiative, 28 September 2018.

Case Study: Japan's Connected Industries leading a new vision for the future

Japan's Connected Industries envision a new society that is both human centric and solution oriented which is built upon the three pillars of multilevel cooperation, human resource development, and a new digital society. Its development blueprint includes a multi-pronged approach ranging from regulatory reforms to talent development.

One of the key applications is by the Tokyo Electric Power Company Holdings. They have developed a system for automatically inspecting power facilities using drones. Together with advanced sensors monitoring partial discharges, they have achieved continuous monitoring of power transmission cables and able to do predictive maintenance to minimise downtime of the power grid.

Reference:

Ministry of Economy, Trade and Industry (METI, 2018) – Connected Industries: Achievements, Challenges and Next Steps in Japan's Smart Manufacturing, 25 September 2018

Case Study: China's plan to encourage industry uptake of ICT tech and Promoting Smart Manufacturing

China's Smart Manufacturing Experiment and Illustration Program launched in 2015 contributed to the promotion of Smart Manufacturing. China encourages the industry to keep up with industry trends via guidance and illustrative examples. The availability of a common platform and ability to engage multi-stakeholder partnerships has also been crucial to their success. The program selects firms that have a demonstrable significance in advanced smart manufacturing status annually to use them as a replicable experience for the rest of the industry.

One such example is KuteSmart from the Redcollar group. By offering increased customization within the clothing industry, KuteSmart has leveraged integrated production systems as their competitive advantage and lead with 20% profits while the industry average is only 5%. Subsequently, Redcollar group has expanded their portfolio as a manufacturer into a service and solution provider where they consult for other firms in the industry to transform their management and production systems.

Reference:

Xu, C. (2018) – Chinese Government's Approach to Smart Manufacturing, 25 September 2018

Case Study: Chinese Taipei's Smart Machinery

Chinese Taipei's Smart Manufacturing ecosystem centers around its established machinery industry. By building upon and transforming their existing industrial networks and supply chains, Chinese Taipei aims to be a leading player, especially in the field of semiconductors, electronics, and automotive parts.

One such exhibit is their Bicycle Intelligent Production Demonstration Line. The facility integrates across the pillars of Smart Manufacturing, leveraging the advantages of advanced robotics, big data

and cloud computing, real-time monitoring and reporting to showcase the production line of the future.

Reference:

Department of Investment Services, Ministry of Economic Affairs (2017) - https://www.roc-taiwan.org/uploads/sites/30/2018/03/Smart-Machinery.pdf
Smart Machinery (2017) - http://www.smartmachinery.tw/page/about/index.aspx?kind=57

Case Study: ISIS (Institute of Strategic & International Studies) calls for a paradigm shift for national attitudes towards Industry 4.0

ISIS has commented that the transition of Malaysian industries towards Industry 4.0 has been slow despite several initiatives such as Automation Capital Allowance and Technology Transfer schemes that involve partnership with international players.

Looking at other leading economies, ISIS has identified common themes such a public-private cooperation and a strong focus on technology adoption and upskilling of the workforce. On the other hand, they have also noted differences in approaches between the 'East' and 'West' where the government plays a more enabling role with limited active interventions in the 'Western' approach while the government has a more active role with direct interventions in the 'East Asia' approach.

Reference:

Tan Sri Rastam Mohd Isa, Dr. Yatid, M., Cheng, C. (2018) – Smart Manufacturing via Smart Policies, 25 September 2018

Case Study: Siemens' drive for a digital enterprise for discrete industries

Siemens leverages their Digital Twin model to enable a holistic end-to-end framework across the entire value chain from initial product design to post-production services. This integrated production has delivered impressive results:

- *Maserati* – 30% shorter development time; 3 times more production capacity; custom combinations of up to 70,000.
- *Bausch and Ströbel* – 30% shorter engineering time; increased flexibility; consistent end-to-end digitalization

Siemens anticipates an increasing digitization of the discrete and process industries as both technical and business drivers become more readily accepted and available. Technical drivers include sensors, connectivity, computing power, data capturing, storage, and analytics, cloud integration with physical systems. Business drivers include new business models, paradigm shifts from product-focused to user-centric.

Specifically, Siemens Digitalization Hub in Singapore aims to address the issues of transitioning industries onto a digital platform. The Hub employs talents across multiple disciplines, including data scientists, solution architects, software engineers, domain specialists. It also integrated with Singapore's digital ecosystem to co-develop digital solutions along their four pillars of focus: Urban Infrastructure; Oil and Gas; Industry 4.0; Healthineers. These are constantly working in conjunction with local university-industry collaborations for major research and development projects

Reference:

Lahiri, I. (2018), Driving the Digital Enterprise for discrete industries, 25 September 2018

Case Study: ViTrox as an enabler in the adoption of Industry 4.0 tools towards Smart Manufacturing

ViTrox is a world leading automated machine vision inspection solution provider in Asia Pacific, Europe and America focus primarily on innovation. As an SME that previously supplies to large OEMs, Vitrox provided the view point of how the business grew from being a contract manufacturer to an innovative solutions provider against the Smart Manufacturing background.

ViTrox's latest product is the highly customizable software platform, V-ONE which integrates the sensor systems with real-time processes and data analytics. It is designed to optimize manufacturing performance through remote, visualize, monitor and control in real-time, and implement condition-based alerts to reduce downtime and increase throughput. Data collected from fully automated machines are used by V-ONE for prediction modelling which will be used to predict downtimes and offer timely solutions.

It is also a Centre of Excellence (COE) for Machine Vision which fosters machine vision technology among companies by providing training, R&D work and incubation services. Vitrox's COE was developed predominantly to assist SMEs to make the leap into digital transformation to be more competitive in the long run.

Reference:

Leong, G. (2018) – Smart Manufacturing and its adoption: MNCs and SMEs, 25 September 2018

Case Study: Rolls Royce Innovation and Smart Manufacturing

Rolls Royce believes that the key trends that will define the future economic landscape are electrification, digitalisation and sustainable energy across their key industries of civil aerospace, defence and power systems.

In 2017 RR, A*STAR and SAESL collaborated to form a S$60million joint facility aimed at developing new technologies intended for aerospace through the employment of advanced processes, automation and digital technologies.

So far, RR has invested more than £ 1.3 billion in research and development, and places importance in skilling future workforce through the establishment of 31 university technology centres and 7 advanced manufacturing centres.

Reference:

Scheffer, L.C. (2018) - Smart Manufacturing, 25 September 2018
https://www.rolls-royce.com/country-sites/sea/discover/2018/how-to-harness-collaboration-for-smart-manufacturing.aspx

Case Study: Injection Moulding 4.0 (iPlast)

iPlast 4.0 Platform focuses on bringing Injection Moulding 4.0 to the plastics moulding value chain by automating and digitising manufacturing.

It has helped customers implement Innovation Centres and Model Factory Cells (MFC) through Injection Moulding 4.0 Readiness check (IM40RC) and Digital Transformation Roadmap (DTR) in the fields of Scientific Moulding, Smart Maintenance, Smart Automation, Smart Manufacturing.

Reference:

Tan, A. (2018) – First Step: Injection Moulding 4.0, 25 September 2018
http://www.injectionmouldingasia.com/oct2017/malaysian-plastics-firms-to-embrace-industry-4-0.html

Case Study: PSDC's push for public-private collaboration for Smart Manufacturing

PSDC highlighted the tripartite model of Government, Industry, and Talent Institutions where each module of the model is necessary for facilitating transformations, embracing transformations, and to enable transformations to take place respectively.

From the talent module, economies require a transformational workforce built upon hybrid and holistic programs in order to enable the industry to migrate to the next rung of the technological value ladder.

Industries also need to focus on cultural changes to have digital transformations and data-driven decision making embedded into their corporate DNA.

The government then acts as the facilitator and mediator between industry and institutions where their effectiveness is crucial to minimising the skills gap in their economies. To achieve this, governments need to signal industry trends and allocate resources appropriately to drive institutional and industry changes hand-in-hand.

Reference:

Muhamed Ali Hajah Mydin (2018), Understanding the Impact of Smart Manufacturing: Public-Private Collaboration, Smart Manufacturing, 25 September 2018

4. Recommendation and Way forward: Continued discussion on Smart Manufacturing in APEC sub foras

Analysis of evidence gathered from the primary survey, focus group discussion, secondary sources, and practices provides lessons and insights on the way forward. Whilst considering these, it is important to keep uppermost in mind that APEC economies are highly diverse with localized characteristics ranging from highly sophisticated economies with high production costs to low cost, low productivity economies.

Disruption of industries brought about by the rise of Smart Manufacturing has moved beyond hype to reality, one in which a wide variety of industries are being transformed. APEC economies are not immune to the pressures of change, or the potential opportunities that it provides for competitiveness and economic development. The biggest challenge for economies is not simply one of technology adoption but one of nurturing a vibrant Smart Manufacturing ecosystem appropriate for the needs of the different industry sectors that operate in the economies.

Significant number of APEC economies' governments is proactively involved in helping support the development of a Smart Manufacturing ecosystem. For instance, "Made in China 2025" is an initiative that sets out to comprehensively upgrade Chinese industry through the adoption of Industry 4.0. The primary focus is to invest in R&D that enables development of frontier technologies, products and processes. Supporting this, China proactively supports setting of technical standards that undergird data and knowledge exchange for advanced innovation.

While the current leaders of a strong Smart Manufacturing ecosystems come from developed economies of the West, such as the US, there is considerable scope and potential for emerging economies to catch-up and even possibly surpass the Pace-setter economies through the adoption of appropriate leap-frog strategies. Leap frog possibilities present themselves in part because in many emerging economies the manufacturing industry is relatively young. They do not have to deal with deeply entrenched legacy systems. As such, it is potentially easier for firms in these economies to overhaul and alter their operations. This is particularly true if firms in the economies take steps that go beyond piece-meal adoption of advanced technologies and implement end-to-end integration of the global value chain.

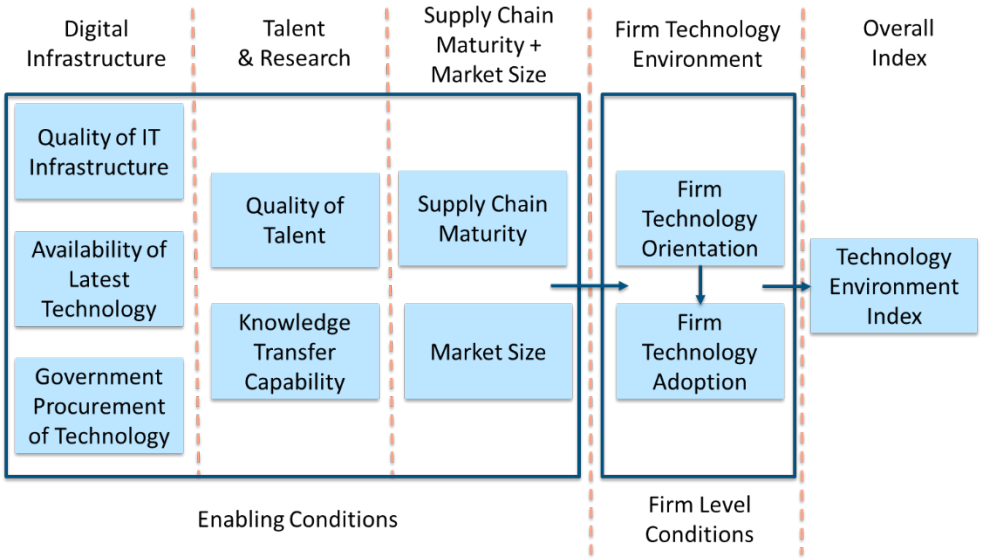
It is important to note that even for Pace-setter economies, such as the US and Singapore, the building of a vibrant and full Smart Manufacturing ecosystem remains at an early stage of development. It is a vision that will be realized over the next 20 years or so. As such, the key challenge for the moment is to prepare for the future and develop roadmaps that allow the economies to fully capitalize on the possibilities that present themselves by creatively overcoming obstacles and challenges each APEC economies face.

To ensure a more inclusive effort among APEC economies, continued discussions of possible areas for collaboration following this project's initiative is crucial for APEC to be among the pioneer in this area. The following capacity building proposal though non-exhaustive, should be considered to be championed by respective forums:

(i) MAG-GOS APEC Seminar on Understanding Policy and Regulatory Approaches focused on digital services in the services sector; and
(ii) Smart Manufacturing related standards under SCSC.

6. Appendices

Appendix 1: Dimensions of Technology Environment Index



Appendix 2: Policy Sources (Retrieved 9 January 2019):

1. United States of America: President's Council of Advisors on Science and Technology (PCAST) https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/0905%20AMP2%200%20slides_v2.pdf
2. Singapore: National Research Foundation (NRF), Prime Minister's Office https://www.nrf.gov.sg/docs/default-source/default-document-library/rie2020-publication-(final-web).pdf
3. Japan: Ministry of Economy, Trade and Industry (METI) http://www.meti.go.jp/english/press/2017/pdf/1002_004b.pdf
4. Australia: Australian Advanced Manufacturing Council (AAMC) https://www.industry.gov.au/funding-and-incentives/manufacturing/industry-40
5. Testlabs, Department of Industry, Innovation and Science https://www.industry.gov.au/sites/g/files/net3906/f/July%202018/document/pdf/industry-4.0-testlabs-report.pdf
6. Canada: Canadian Manufacturers & Exporters (CME) | Ministry of Industry, Science and Economic Development http://www.industrie2030.ca/download.php?id=77
7. South Korea: Ministry of Science and ICT (MSIT) http://www.msip.go.kr/dynamic/file/afieldfile/msse56/1352869/2017/07/20/Master%20Plan%20for%20the%20intelligent%20information%20society.pdf
8. Malaysia: Ministry of International Trade and Industry (MITI) http://www.miti.gov.my/miti/resources/National%20Policy%20on%20Industry%204.0/Industry4WRD_Final.pdf
9. China: State Council https://www.uschamber.com/sites/default/files/final_made_in_china_2025_report_full.pdf (translation) http://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm (original)
10. Indonesia: Ministry of Industry http://www.kemenperin.go.id/download/18384
11. Thailand: Ministry of Commerce https://thaiembdc.org/thailand-4-0-2/ (translation) http://www.libarts.up.ac.th/v2/img/Thailand-4.0.pdf (original)
12. Philippines: Department of Trade & Industry (DTI)http://industry.gov.ph/wp-content/uploads/2017/11/DTI-Policy-Brief-2017-05-Philippine-Inclusive-Innovation-Industrial-Strategy.pdf