

# Assessment of Smart Manufacturing in APO Member Countries



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# **ASSESSMENT OF SMART MANUFACTURING IN APO MEMBER COUNTRIES**

Assessment of Smart Manufacturing in APO Member Countries

Prof. Chen-Fu Chien served as the volume editor.

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# FOREWORD

**T**he manufacturing industry around the world needs to be prepared for the future. Artificial intelligence has been emerging, and automation in different forms has been common for decades. Whether advanced or emerging, it is only a matter of time before economies everywhere must embrace data-driven smart manufacturing. The future may be uncertain, and developments may be slow, but the transformation to smart manufacturing is inevitable. The question is how to be adequately prepared for it.

APO member economies have different industrial structures and not all are ready to migrate to the advanced cyberphysical systems required for Industry 4.0. As an alternative, Industry 3.5 was proposed in the Republic of China as a hybrid strategy between existing manufacturing known as Industry 3.0, which is the current mainstay in APO member countries, and the desired goal of Industry 4.0.

The APO conducted research to examine the current status of smart manufacturing in six of its member countries. The aim was to identify optimal strategies and policies to enable the adoption of smart production technologies and practices in their manufacturing sectors. This publication presents the results of the research and is expected to contribute to discussions on promoting smart manufacturing ecosystems in all APO members, creating greater productivity and efficiency in industry, and ultimately improving the quality of life for citizens.

Dr. AKP Mochtan  
Secretary-General



# INTRODUCTION

Leading industrialized countries with advanced economies have emphasized the importance of smart manufacturing via their respective national competitive strategies. Examples from the western world include Industry 4.0 (Germany) and Advanced Manufacturing Partnership (USA).

In Asia, the Republic of China (ROC) proposed its ‘Productivity 4.0 Initiative’ in 2015, followed by ‘The 5+2 Industrial Transformation Plan’ in 2016 as part of its technology development strategy for being globally competitive in smart manufacturing. Indonesia initiated its own strategy and roadmap called ‘Making Indonesia 4.0’ to support smart manufacturing implementation. Likewise, manufacturing being a driving force in Thailand’s economy, the Thai Government established a national strategy ‘Thailand 4.0’ to encourage its manufacturing companies to migrate to advanced manufacturing by adopting connectivity, automation, robotics, artificial intelligence (AI), big data, etc. Vietnam’s Prime Minister also issued Directive No.16/CT-TTg for strengthening the country’s capacity to tackle challenges posed by Industry 4.0. Thereafter, Vietnam’s Ministry of Science and Technology issued Decision No. 2813/QĐ-BKHCHN, approving a crucial national science and technology program titled ‘Research support, development and technology application of industry 4.0,’ to be implemented by 2025. PR China has also promoted ‘Made in China 2025’ to enhance industrial structure and technologies to upgrade from being the world’s factory to becoming a global manufacturing leader.

The paradigms of global manufacturing networks and supply chains are shifting. An increasing adoption of AI, internet of things (IoT), analytics, cloud computing, and robotics is enabling unprecedented levels of intelligent manufacturing and smart production. However, most of the industry structures in emerging APO economies with huge populations may not be ready for direct migration to advanced cyber-physical manufacturing systems as proposed in Industry 4.0 [31]. Furthermore, small and medium enterprises (SMEs), which provide major job opportunities in Asia-Pacific, cannot undertake rapid expansion and direct migration to Industry 4.0. They are faced with many hurdles such as those pertaining to government resource allocation priorities, limited investments available for hardware and software, talent shortage, and steep learning curves. All these must be addressed before potential benefits of Industry 4.0 may be fully realized.

Countries in the Asia-Pacific region should combine regional resources to solidify strongholds in the global manufacturing networks and move up the industry value ladder. This will help them maintain competitive advantages in value chains of various business ecosystems. Simultaneously, they should also deal with other needs such as industrial infrastructure enhancement, regional planning, education and talent developments, and digital transformation for humanizing the industrial revolution [7].

This research project aims to assess and document the extent of policy planning, implementation, and adoption of smart manufacturing in member countries. It analyzes a number of industry segments and companies as case studies to derive and identify emerging areas where smart

manufacturing needs to be the focus to support member countries' needs. Indeed, the APO Coordinating Meeting, held in Taipei, the ROC, from 12 to 14 November 2019 (hereinafter called the APO Meeting on Smart Manufacturing Assessment) aimed to assess the needs of smart manufacturing in APO economies.

This report integrates related efforts based on the discussions at the APO Meeting on Smart Manufacturing Assessment, a factory visit to a leading intelligent solution provider (Nexcom.com) in the ROC, and previous relevant studies. In particular, the APO Meeting on Smart Manufacturing Assessment agreed to base this research on the Policy Modeling Canvas as a framework for assessment of various country policies for smart manufacturing. This framework considers, with respect to the policy and economic development of each country as a whole, the relationships among the priority industries and the specific development plans. It identifies the corresponding needs with respect to the country and the involved government agency and/or national productivity centers. Furthermore, a number of case studies of different companies in the APO economies are investigated to identify needs for smart manufacturing.

The APO Meeting on Smart Manufacturing Assessment confirmed that the assessment of smart manufacturing is crucial to empower industrial migration for smart manufacturing, talent development, and collaborations among the APO economies. Indeed, the APO has strived to serve its member countries via novel initiatives. Following the establishment of the Center of Excellence (CoE) on Business Excellence in Singapore, the CoE on Green Productivity in the ROC, and the CoE on Public-sector Productivity in the Philippines, the APO has been actively engaging in issues related to smart industry and encouraging member countries to hold events and forums related to Industry 4.0 and smart manufacturing. Therefore, the APO further established the CoE on Information Technology for Industry 4.0 in India and the CoE on Smart Manufacturing (CoE on SM) in the ROC [20]. The output of this research will help the CoE on SM and the APO in designing and implementing smart manufacturing activities that are relevant and attuned to the needs of APO member countries.

# SMART MANUFACTURING POLICY

Industry 4.0, proposed in the Hannover Fair in 2013, includes the implementation of cyber physical system (CPS), smart factory, IoT, and internet of services (IoS) [31]. Under the concept of Industry 4.0, CPS integrates the virtual and the real world so that real-time monitoring and collaboration can be achieved. To apply CPS, it is necessary to develop the embedded system, which includes the smart sensor network to collect real-time data from physical factories and the interface to analyze and manage the collected data. Through the application of IoT, all machines in the factories are connected as a network, which allows information exchange and collaboration to achieve a flexible and self-adaptive production system. Moreover, Industry 4.0 is able to fulfill mass customization through integration of information and technologies, to enable internet-based optimal decision making and diagnostics, and finally, to achieve self-learning, self-aware and self-optimizing manufacturing systems.

The challenges facing the national manufacturing strategies of leading industrialized economies have reemphasized the importance of advanced manufacturing. The APO economies have also developed strategies and policies to empower smart manufacturing and industrial migration. As noted earlier, the ROC proposed ‘Productivity 4.0 Initiative’ in 2015, followed by ‘The 5+2 Industrial Transformation Plan’ in 2016. Likewise, Indonesia has initiated a strategy and roadmap called ‘Making Indonesia 4.0.’ It is expected that manufacturers will have the potential to transform their operations, improve productivity and competitiveness, and adopt new business models to move up the value chain. Similarly, Thailand has established a national strategy called ‘Thailand 4.0,’ while Vietnam has issued Directive No.16/CT-TTg and Decision No. 2813/QĐ-BKHCHN to develop Industry 4.0 capabilities.

## Republic of China

The ROC proposed ‘Productivity 4.0 Initiative’ in 2015 as the technology development strategy to be globally competitive in smart manufacturing. There are two important drivers for the ROC. On one hand, there is a pull force coming from the global competition in the development of smart technology. On the other hand, there is a push force being caused by a declining employment population. In the fourth industrial revolution, the ROC aims to promote domestic industrial innovations and transformation, master key-technology autonomy, and maintain international competitiveness. We review the current situation of domestic industrial science and technology development, core technology research and development, and talent cultivation.

### ROC Industries’ Competitive Advantages and Challenges

The ROC has a small geographical area with a length span of 394 km, which facilitates technology development through an intense and tight-knit communication and cooperation.

It takes only 1.5 hours to travel from north to south of the ROC with high-speed rail. In the capital- and labor-intensive manufacturing industry, the 2018 total output value of the ROC’s manufacturing

industry approached NT\$18.93 trillion. The ROC, with such a large economic scale, plays a major manufacturing role in the world.

In fact, in the third quarter of 2019, the domestic manufacturing's additional purchase of fixed assets (excluding land) reached NT\$49.1 billion, with an annual increase of 12.3% and five consecutive quarters of growth [57]. Mainly due to the accelerated investment in advanced processes by the semiconductor industry, the cumulative domestic fixed-asset purchases in the first three quarters of 2019 increased by NT\$1,012.29 billion with an annual increase of 23.7%. In particular, for the type of fixed assets, the increase in purchases of machinery and miscellaneous equipment accounted for 82.7%. By industry, the chemical materials industry showed an increase of NT\$17.4 billion, mainly due to the purchase of the operating headquarters and some materials companies related to technology applications expanding their plants and increasing production capacities. For the metal products industry, there was an increase of NT\$14.5 billion in purchases due to continuous investments in building plants and offshore wind-power companies. The computer electronics and optical products sector showed additional purchases of NT\$13.3 billion. Mainly due to the impact of trade war between the USA and PR China, manufacturers kept expanding the domestic production capacity related to notebooks, optical components and netcom equipment. For the electronic component industry, the fixed-asset purchases increased by NT\$222 billion in the third quarter of 2019, accounting for 63.6% of the manufacturing industry and ranking first among all manufacturing sectors. This was mainly because semiconductor companies actively invested in advanced processes, and other electronic component companies also actively increased capital expenditure to expand production capacity and respond to the demand for 5G communication deployment.

High-tech industry builds one of the competitive advantages for the ROC. There are three main high-tech industry clusters with huge job markets: Hsinchu Science park (140,000 jobs), Central Science Park (50,000 jobs), and Southern Taiwan Science Park (90,000 jobs). Many upstream satellite suppliers and downstream system-integration vendors have developed around these science parks. These supporting networks build the ROC's high-tech industry clusters and contribute to the ROC's economic development in areas such as semiconductor industry, display panels, PCB, battery, IT hardware, IT software, biotech, thermal module, and electronic materials. In addition, several industry-academia research institutes are established and located surrounding these science parks. In 2016, there were about 189 domestic R&D and 63 international R&D centers including multinational corporations (MNCs) located around these high-tech clusters. The MNCs include Intel, ASML, Microsoft, IBM, Sony, NEC, and Fujitsu, among others. The science parks and institutes form big technology networks to drive the technology migration through an industry-academia cooperation. In fact, the ROC's IC industry plays a critical role in its global position [57]. For example, in 2016, the ROC's IC industry's output value ranked No. 2 in the world, accounting for 23.3% of the global market. The country's IC design industry also ranked No. 2 in the world with 19.8% of the global revenue in the area. Likewise, the ROC's foundry service also ranked No. 1 in the world with 75.9% of global revenue in the segment, while the country's memory industry ranked No. 4 in the world with 7.9% of global revenue in the area. Further, the ROC's IC packaging and testing service ranked No. 1 in the world with 56.4% of global revenue, and its brand IC product sector ranked No. 4 in the world with 8.1% of global market revenue. The powerful electronic industries are an engine that powers many important manufacturing and service sectors in the ROC.

### **Current Situation, Needs, and Challenges in Smart Manufacturing**

In 2015, manufacturing investment accounted for 44.9% of domestic fixed investment while ICT industry investment accounted for about 30%, which were higher than the industry's overall

industrial GDP ratio (30.1% and 16.5% respectively). Indeed, the ROC's industrial investments are dominated by hardware manufacturing. However, facing the rapid development of the new digital economy, software and system services are becoming increasingly important and need to be adjusted accordingly.

Some local needs and challenges exist in the ROC's manufacturing sectors [29]. First, a severe shortage of around 73,000 labors was reported in the manufacturing industry in 2015. Specifically, shortages were reported of around 16,000 labors in the electronic component sector, 9,000 in the metal products sector, and 7,000 in the machinery equipment sector. Second, imported equipment dominates the high-end market. Stability and precision improvement of machinery equipment is needed for upgrading machines made in the ROC. Thus, there is a need for development of high-end controllers and advanced software to counter global competition. Third, improvements in high-end robots and automation are required, especially for their applications in 3C and precision machining industries.

In addition, there are several global challenges for the ROC. First, there has been an emergence of various manufacturing nations. Following PR China, manufacturing industries in India, Indonesia, Vietnam, Turkey, eastern Europe, and other countries and regions have developed rapidly. This has impacted movements in the global manufacturing supply chain and machinery equipment markets. Second, an increasing competition among Asian countries in the global market has weakened the ROC's export competitiveness. For example, PR China, Japan, and ROK continue to maintain industrial competitiveness and national economic development through strategic industrial policies while also improving foreign trading conditions through bilateral and multilateral trade agreements. However, the ROC's exports keep decreasing due to a slow progress in the negotiation of bilateral trade agreements with other countries. Third, developed countries such as Germany, the USA, and Japan emphasize on the manufacturing industry as an important economic and industrial policy. They integrate ICT and advanced manufacturing technologies into the existing manufacturing systems, and promote the application and development of smart manufacturing. Based on a solid foundation of advantages in the fields of traditional precision machinery and high-end manufacturing equipment, they are currently leading the development of manufacturing services and smart machinery. Finally, the market competitiveness of Chinese machinery and equipment companies has gradually improved. PR China has proposed the 'Made in China 2025' plan, and listed several important policies such as smart manufacturing, high-end manufacturing equipment, and industrial robots. This worldwide competition challenges the ROC's competitiveness.

As a whole, the needs and challenges for smart manufacturing in the ROC are investigated and summarized as two key points [56]. First, due to a limited ROC market, achieving innovation breakthrough and scaleup faces the 0-to-1 and 1-to-N challenges. The 0-to-1 challenge pertains to developing advanced technology, innovated invention, or new business model for enhancing core competency (ROC promotes user-oriented technologies and encourage young startups to support innovation breakthroughs). The 1-to-N challenge refers to speed, economic scale, or globalization needed for expanding capacity, scale, and market (ROC promotes the user ecosystem and global market to support success duplication). Second, the technology gap is critical. Based on key technologies used in smart manufacturing, these technologies can be categorized into three layers: sensor layer (including intelligent sensor), network layer (including network infrastructure and data communication), and application layer (including horizontal networking professional analysis and vertical integration decision analysis). The technology gap points out the direction for technology development. Table 1 illustrates the technology gap of smart manufacturing in the ROC [9].

TABLE 1

## TECHNOLOGY GAP OF SMART MANUFACTURING IN ROC [9].

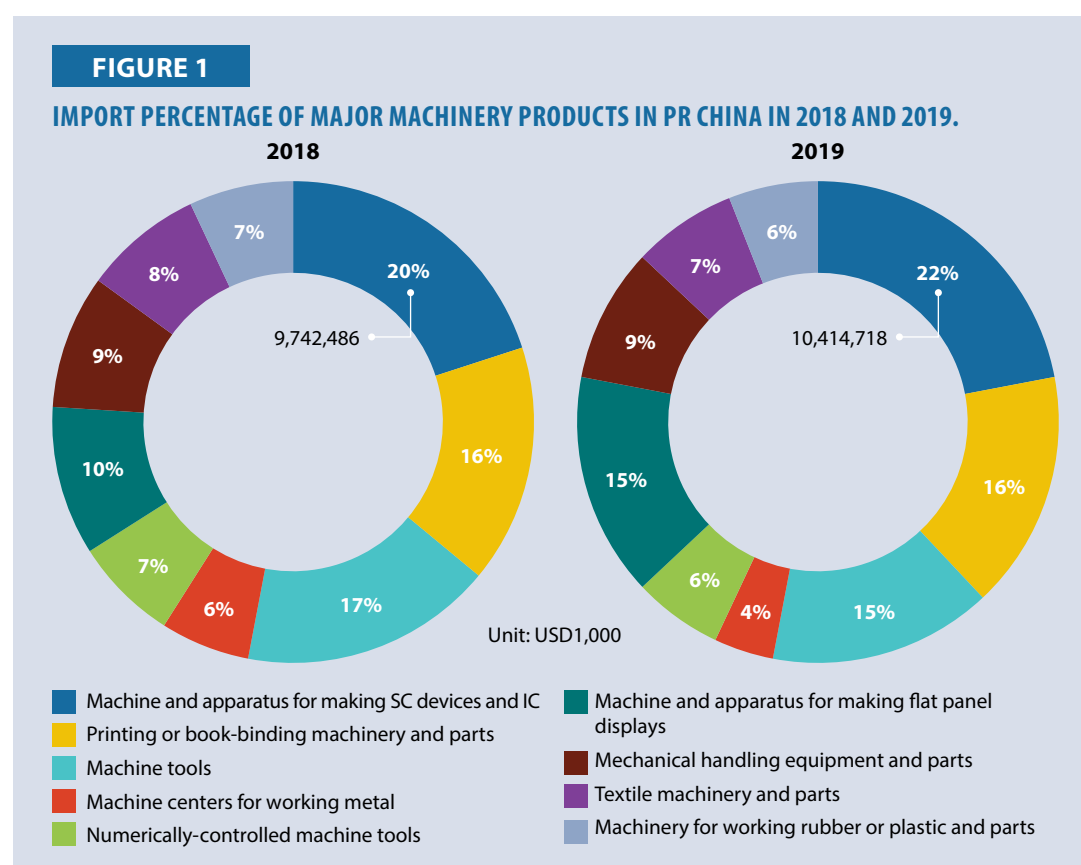
	Technology	Gap of technology development
Sensor layer	Intelligent sensor: temperature, acceleration, force, vibration, sound, etc.	<ul style="list-style-type: none"> <li>Industrial sensing module and drive control autonomy</li> <li>Sensing component intelligence</li> </ul>
Network layer	Network infrastructure: fixed, mobile, wireless local area, sensing network	<ul style="list-style-type: none"> <li>Open-standard netcom technology</li> <li>Machine communication and security technology</li> <li>Delay-tolerant and low-energy equipment networking</li> </ul>
	Data communication <ul style="list-style-type: none"> <li>Big data computation and analysis platform</li> <li>Human-machine interface and standards</li> <li>Vertical integration and data interoperability/compatibility</li> </ul>	<ul style="list-style-type: none"> <li>Human-machine intelligent interface technology</li> <li>Human-machine collaborative security and efficiency</li> <li>Machine-to-machine and machine-to-cloud communication interface standards</li> <li>Smart Networking Common Service Platform</li> <li>IoT data analysis</li> </ul>
Application layer	Horizontal networking professional analysis <ul style="list-style-type: none"> <li>Digital design simulation manufacturing</li> <li>Human-machine collaboration/cyber physical system (CPS) intelligence production line</li> <li>System management</li> </ul>	<ul style="list-style-type: none"> <li>CPS intelligent system needs to combine professional analysis model to improve accuracy and reliability</li> <li>Robot intelligence integration ability and quick response</li> </ul>
	Vertical integration decision analysis <ul style="list-style-type: none"> <li>Vertical integration of ERP, MES, and CPS intelligent production lines</li> <li>Supply- and demand-capacity prediction</li> <li>Solution integration services</li> </ul>	<ul style="list-style-type: none"> <li>Vertical integration of production systems</li> <li>Supply- and demand-capacity integration and decision system</li> </ul>

Affected by the USA–PR China trade war, the economic growth of global economy has declined. As a result, the 2019 export value and output value of the ROC's machinery products have decreased significantly. PR China is one of the major consumers of machinery and equipment, but its demand dropped in the trade war and caused a significant decrease in the amount of machinery products (including mechanical components such as ball screws) imported from the ROC. On the other hand, the trade war delayed capacity expansion and equipment investment in PR China, and forced international companies to reallocate their production bases. The direct and indirect manufacturing-related supply chains in PR China further shrank the overall domestic market for mechanical equipment.

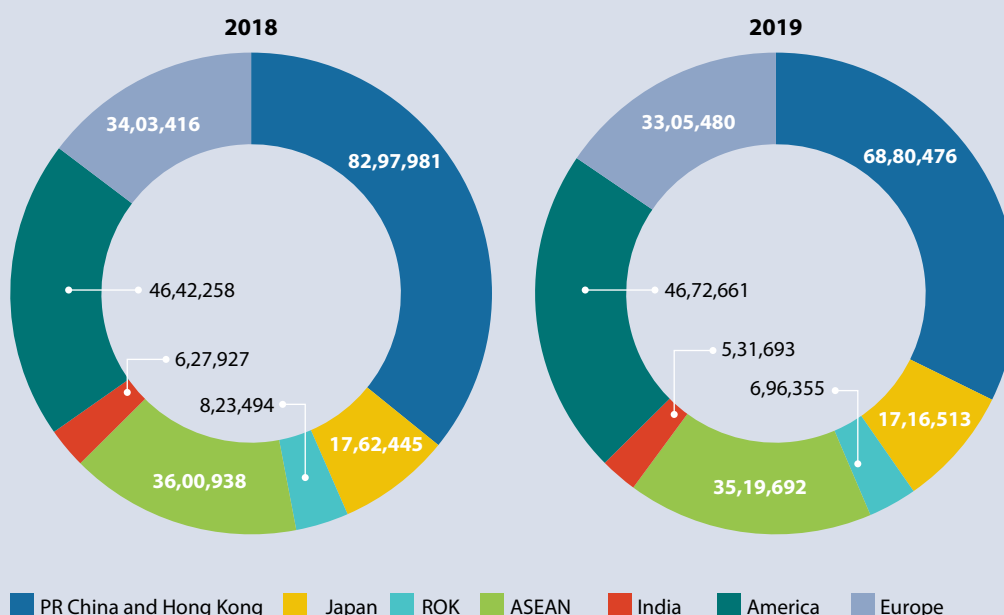
In addition, the backlog of global manufacturing inventories has become increasingly serious. In particular, the inventory in all worldwide regions has reached a relatively high level since the 2009 financial crisis. During July to September 2019, the average days of inventory turnover reached 57 days in Japan, 52 days in North America, and 55 days in Europe. Compared with 2018, this marked an increase of four days for Japan and two days each for North America and Europe. The inventory turnover days increased significantly for machinery, chemical industry, semiconductors and electronics, and automobiles industry sectors. Specifically, for the mechanical sector, the average of global inventory turnover days was 87, which was 21 days longer than in 2010.



According to the import and export report released by the General Administration of Customs of China, the import amount of machinery and equipment in PR China in 2019 was USD190.25 billion, a 5.9% decrease over 2018. Among the main machinery and equipment products, the import value of machine centers for working metal decreased by 27.0%, that of textile machinery and parts decreased by 14.2%, and that of machine tools decreased by 12.7%. However, the import value of the panel manufacturing equipment and devices increased by 48.4% due to the capacity expansion of large-size panel production lines. The import value of semiconductor components and IC manufacturing devices also increased by 6.9%. In fact, the share of semiconductor components in overall machinery imports increased from 20% in 2018 to 22% in 2019. Figure 1 describes the import%age of the machinery products in PR China in 2018 and 2019. As the second-largest economy in the world, the change of PR China's import amount directly affects the global supply chain.



In 2019, the ROC's machinery and equipment exports were significantly affected by the USA–PR China trade war. With the launch of 5G communication in PR China, the companies related to 5G base stations/cell sites, mobile phones, and components had purchased machinery and equipment from the ROC. The trade war caused the demand reduction in PR China and thus the ROC's machinery and equipment exports declined in 2019. According to the trade report of the ROC's Ministry of Finance, the export value of the ROC's machinery products in 2019 was USD23.9 billion, which marked a decrease of 8.13% when compared with 2018. Except for an increase of 0.65% in exports to the USA, the ROC's exports to PR China and Hong Kong, Japan, the ROK, India, the 10 ASEAN countries, and Europe all showed declines. The value of the ROC's machinery products exported to PR China and Hong Kong was USD8.30 billion in 2018 and USD6.88 billion in 2019, which amounted to a decrease of 17% over 2018. Figure 2 shows the export%age of the machinery products in the major regions in 2018 and 2019.

**FIGURE 2**
**EXPORT VALUES OF MACHINERY PRODUCTS IN MAJOR REGIONS IN 2018 AND 2019.**


As shown in a coverage of Nature magazine [45], the ROC is turning to smart machinery and artificial intelligence to improve the quality and flexibility of the products it makes (See Figures 3 and 4).

**FIGURE 3**
**A CHRONOLOGY OF POLICY REFORMS IN ROC TO BOOST TECHNOLOGY-BASED INDUSTRIES.**

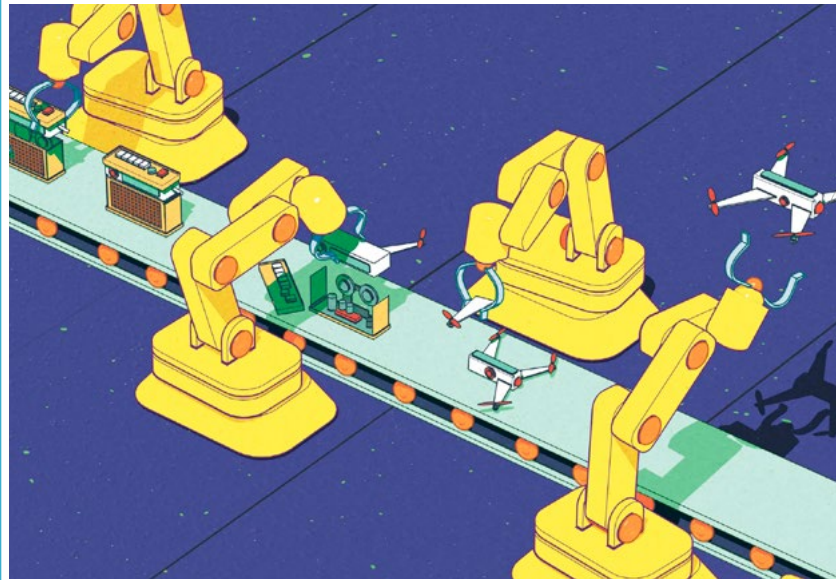
Non-stop reforms in ROC's policies aim to boost tech-based industries.

<b>May 2016</b> ROC's government announces its 'Five plus two' policy to innovate in the fields of biotechnology, defence, green energy, intelligent machinery, and the internet of things	<b>November 2016</b> Launch of the Digital Nation and Innovative Economic Development Program (DIGI+), an initiative to make ROC a smart digital region by 2025. Policies include investments in start-up firms and development of the cybersecurity industry	<b>February 2017</b> The Smart Machinery Promotion Program is introduced. It aims to develop smart-machinery applications by combining manufacturing expertise with information and communications technologies	<b>July 2017</b> The Ministry of Science and Technology (MOST) unveils plans to establish four research centers in artificial intelligence (AI). The initiative will cost USD33 million annually over five years	<b>August 2017</b> MOST announces a four-year, \$132-million semiconductor program to speed up the development of AI processor chips, and a five-year, \$517.5-million strategy to cultivate AI talent and research during 2017 to 2021	
<b>January 2018</b> The government rolls out its three-year AI Taiwan Action Plan to establish the island as an AI leader. It aims to prioritize AI innovation and implementation in the industry during 2018–21 and invest more than \$300 million in the area	<b>February 2018</b> ROC relaxes regulations for the employment of foreign professionals to encourage talent recruitment	<b>March 2018</b> The government promotes policies to incentivize investments in startups. The aim is to provide capital, relax visa and employment laws, encourage local and foreign cooperation and help investors to cash in on successes	<b>June 2018</b> MOST establishes the Taiwan Tech Arena to support startups in AI, semiconductors, and software development; and to help them to forge international links	<b>January 2019</b> Launch of a three-year scheme to relocate ROC businesses back to the region. Policies involve assisting firms with resources such as land, water, electricity, labor, taxation, and financing	<b>May 2019</b> ROC's cabinet approves a four-year, \$658-million spending plan for 5G technology to increase the region's digital competitiveness

**FIGURE 4**  
**COVERAGE OF ROC BY NATURE MAGAZINE.**

Taiwan

spotlight



## TAIWAN'S TIME TO TRANSFORM

The government is betting its manufacturing future on smart machinery and artificial intelligence to improve product quality and flexibility. **By Sarah O'Meara**

In 2016, industrial engineer Chen-Fu Chien was asked to lead a university research centre in Taiwan that would develop new manufacturing technologies using artificial intelligence (AI).

Rather than aiming to publish academic papers, his brief was to produce ideas that could be quickly transferred into industrial settings, says Chien. His research at the National Tsing Hua University (NTHU) in Hsinchu City uses big-data analytics to make machines smarter through AI that lets them take decisions without human control. It is one of several approaches

to creating 'smart factories' that use an interconnected, digital network of supply systems – part of Taiwan's push to improve the flexibility, quality and efficiency of its manufacturing.

"I am one of the few senior scientists in Taiwan who's worked extensively with business, as well as in public research. It's one of the reasons the government asked me to lead the project," says Chien, whose position at the NTHU is endowed by the US firm Micron Technology in Boise, Idaho, which develops computer memory and storage technologies. Chien's mission is a sign of how Taiwan's

government wants its manufacturing industry to change using technologies such as cloud computing, big data, the Internet of Things and smart robots – a shift in industrial practices that has been dubbed Industry 4.0. Once known as a hub for mass-produced cheap goods, such as toys and electronics carrying the ubiquitous 'Made in Taiwan' stamp, the island is looking to science to upgrade its image so it can become a destination for international companies searching for futuristic manufacturing solutions.

In 2018, Chien and his team opened the Artificial Intelligence for Intelligent

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It is worth noting that the trade war was originally expected to push enterprises in PR China to Vietnam and other southeast Asian or south Asian countries like India to set up a second production base. However, in fact, the ROC's machinery and equipment were exported to southeast Asian countries in 2019, and exports grew only for Singapore by 12% over 2018, while it decreased by 0.2% in Vietnam, 6% in Indonesia, 16% in Malaysia, 9% in Thailand, and 12% in India.

Furthermore, demand shrinkage and inventory turnover became even worse due to the COVID-19 situation as the worldwide supply chain got affected catastrophically. Indeed, Taiwan has strictly followed infection control measures to prevent spread of COVID-19. Nationwide surveillance data

in outpatient departments, positive rates of clinical specimens, and confirmed severe cases during the first 12 weeks of 2020 compared with the same period of 2019 has revealed drastic decreases in influenza diagnoses [36]. The obvious impact is that machinery equipment and component manufacturers in PR China or the ROC will see reduced revenues due to delayed starts, delayed capacity ramp-ups, insufficient manpower and raw material, delivery detours, and preventive/protection management measures, all of which will also increase overall costs. On the other hand, most of PR China's manufacturers are affected by COVID-19, which has led to investment reductions or delays as far as machinery and equipment are concerned. For example, Wuhan is a major city for automobile component manufacturing in PR China, so the closure of Wuhan city will severely affect the automobile supply chain and even cause production shutdowns for the related small- and medium-sized enterprises (SMEs). Moreover, it may reduce or delay the annual investment in machine tools and affect the amount of the ROC's machinery products exported to PR China.

PR China is also the world's major exporter of machinery and equipment. For example, in 2019, the export value of PR China's machine tools was USD4.40 billion. In fact, PR China's exports of machinery products focus on relatively low-end products. Although the ROC, Germany, and Japan focus on medium- or high-end products, this market may also be affected.

## **India**

The rise in expected investments not only within the country but also overseas is a signal of industrial reforms. At the time of her Independence, India faced socioeconomic obstacles such as unemployment, industrial lag, illiteracy, foodgrains shortage, and low per capita income. Thereafter, successive governments established many policies, rules, and regulations for industrial development. India's manufacturing sector has evolved through several phases, ranging from the initial industrialization and the license raj to liberalization and the current phase of global competitiveness (see Figure 5).

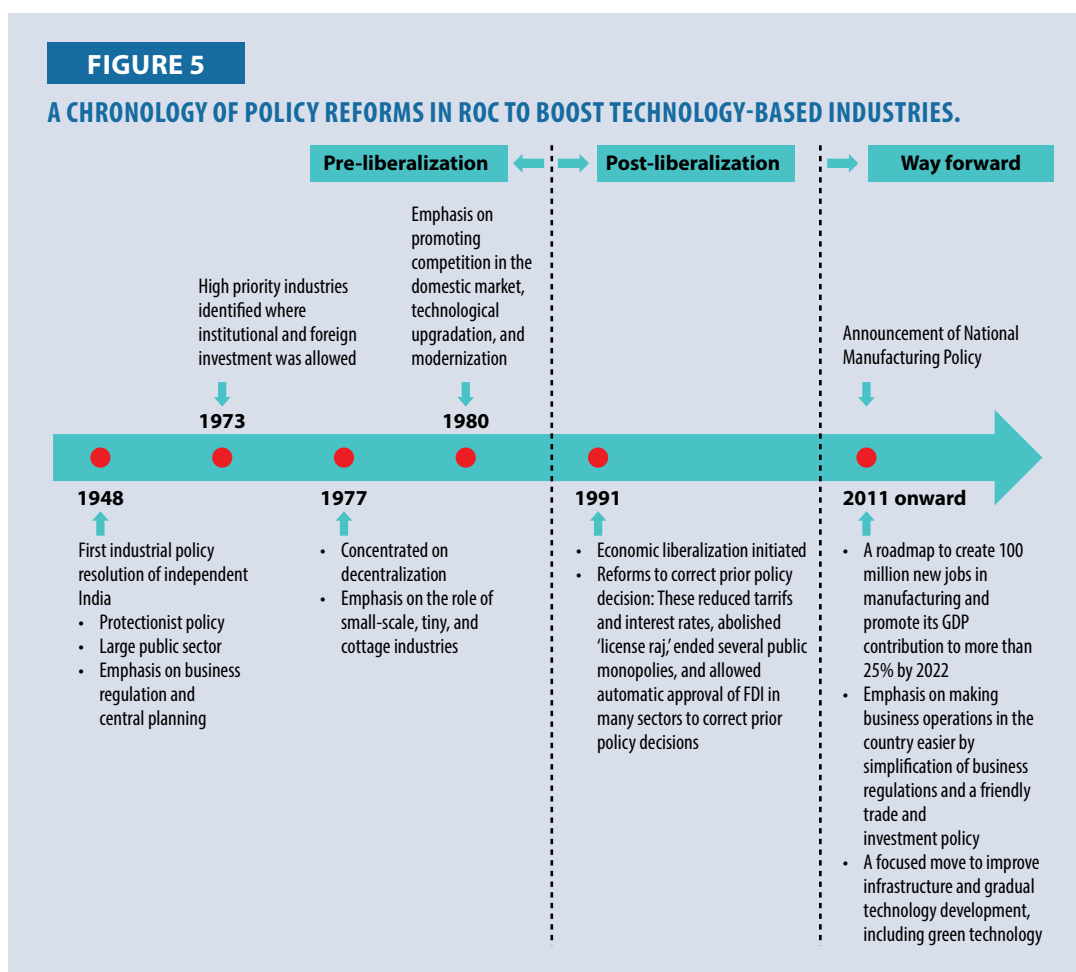
### **Need for New Manufacturing Policy**

In India, manufacturing has not been as a major contributor to the economy. More than 25 years after the economic liberalization in 1991, the manufacturing sector accounted for only around 16% of the gross domestic product (GDP) in 2017. By comparison, many other Asian countries highly promote and pay attention to the manufacturing sector. For instance, the percentages of the manufacturing sector to GDP in Malaysia and in Thailand were 24% and 33% (with a remarkable increase of 20% from 1960 to 2014), respectively.

### **National Manufacturing Policy of India**

In India, the economy is composed of three sectors, namely, primary sector, secondary sector, and tertiary sector. The primary sector pertains to agriculture, fisheries, and allied activities. The secondary sector includes the industries, with manufacturing industry being a subset of the sector. Lastly, the service sector is part of the tertiary Sector.

On 4 November 2011, the National Manufacturing Policy (NMP) was announced by The Department of Industrial Policy and Promotion (DIPP), which is under the Ministry of Commerce and Industry. In the wake of fierce competitiveness and industrial reforms, the purpose of this policy was to reinforce the importance of the manufacturing industry and drive a contribution of 25% to India's GDP by 2022. In addition, an objective was to achieve generation of about 100 million additional jobs. Thus, India is able to improve its competitiveness, technological depth, domestic value addition, and environmental sustainability of growth.



When compared with other Asia countries, the manufacturing sector's contribution to India's GDP is always lower than 20%, which is much below its ability and capacity. PR China is one of the world's manufacturing hubs, and the average manufacturing sector's value-added contribution to PR China's economy is around 34%. Thus, Indian policy makers have an ambition to build India into a manufacturing hub, so that the industrial growth could support long-term economic development and create more job opportunities.

The role of the government is to notify a policy framework as well as grant motivation for infrastructure improvement in a public private partnership (PPP) mode. Furthermore, the National Manufacturing Policy follows the principle of industrial development by encouraging partnerships between individual states of India. The strength of India is that over 60% of the population belongs to the working-age group, but a majority of them are without critical skills or high education and live in rural areas. Therefore, the National Manufacturing Policy, with an objective to enhance the growth of the manufacturing sector is a necessary way to generate jobs for around 100 million people in the manufacturing sector and over 220 million people in related sectors in the next 10 years. With this vision of stimulating the development of the manufacturing industry, authorization of the below listed regulations and rules is of paramount importance to generate an applicable environment for comprehensive growth of social and economic perspectives.

There are following six objectives mentioning qualitative as well as quantitative changes that Government of India has strongly promoted with the release of the National Manufacturing Policy:

1. In the medium term, the growth of the manufacturing industry is targeted at 12–14%, which is higher by 2–4% compared to the overall Indian economy. This is critical for economic expansion. In addition, the manufacturing sector's contribution to the national GDP is also predicted to be at least 25% by 2022.
2. There is a need to raise the rate of manufacturing job creation in order to generate 100 million additional jobs by 2022.
3. Programs should be created to provide necessary skills to the poor in rural and remote areas, thus leading to a uniform development across the country.
4. There is a need to enhance knowledge of deep technology and increase domestic value addition in manufacturing.
5. More standard frameworks and appropriate policies are required for Indian manufacturing companies in order to increase their competitiveness.
6. Economic development should be in compliance with environmental sustainability through reduced consumption of natural resources and utilization of renewable or ecofriendly materials.

There are 14 National Investment and Manufacturing Zones that have been created through a principal endorsement. These zones have been perceived as integrated industrial townships for the purpose of an environment-friendly view and sustainable development. The government is also likely to give special attention to the following industries:

1. **Employment-intensive industries:** Food processing industries, leather and footwear, gems and jewelry, and textiles and garments are four industries that have drawn high attention from Indian government. It is obvious that adequate support is an important engine to enhance and reinforce employment creation in intensive industries.
2. **Capital goods:** Capital goods form the mother or foundation sector for the manufacturing industry, but the growth of this sector is not as good as expected. Thus, it is crucial to give an appropriate consideration to heavy electrical, earthmoving, and heavy-transport equipment as well as machine tools and mining equipment. The strong expansion and continued improvement of India economy requires an intensive demand for capital goods. The public industries are strategically strengthened to enrich the private initiatives, whereas the advancement and enlargement of these private initiatives in research and development (R&D) facilities are promoted based on timebound programs.
3. **Industries with strategic significance:** The Indian government has launched many strategic programs to take advantage of national capabilities and focus on the development of various industries such as defense equipment, shipping, solar energy, IT hardware and electronics, aerospace, and telecommunication equipment. For instance, the National Action Plan on Climate Change is seen as a mission to utilize solar energy as an alternative energy source. In addition, there are three industries, namely, pharmaceuticals, automobiles, and medical equipment, which have large home markets due to advantages such as strong engineering base, cost effectiveness, and domestic experts. Special programs will be formulated for these industry segments.



4. **Small and medium enterprises:** The Ministry of Micro, Small and Medium Enterprises has released the National Manufacturing Competitiveness Programme, to create a separate fund to be provided by Small Industries Development Bank of India and strengthening of National Small Industries Corporation. With modification of lending norms, MSMEs will be given due regard for ‘priority sector’ lending.

In India, small and medium companies are important cornerstones of national economy, with contributions of around 40% and 45% to total export value and manufacturing outcomes, respectively. Furthermore, these enterprises also create huge job opportunities not only in direct manufacturing industries but also in related industries. Ease of access to capital funds, rapid implementation of modern information technology, development of skills and expertise, and reform and simplification of governmental paperwork are of paramount importance for the growth and sustainable development of these enterprises. They, in turn, will contribute to the growth of the overall manufacturing sector as well as of the growth of the Indian economy as a whole.

5. **Public-sector enterprises:** Energy and defense sectors play a critical and linking role in the development of manufacturing industries in particular and national economy in general. The establishment of an appropriate public-policy framework is significantly necessary to enhance the competitiveness of public-sector undertakings as well as to give them a functional autonomy. In east Asian countries, in the initial 1980s, the reduction in poverty, migration of labor from the agriculture sector, and rise in salaries were realized because of export-oriented manufacturing. This miracle output in east Asian countries derived from ‘five-year plans,’ which were very attentive, periodically outlined, and purposive. Thus, in order to reinforce the manufacturing of products domestically (e.g., more products with the tag ‘Make in India’), the formulation of industrial policy and appropriate frameworks are significantly necessary. Furthermore, the support of government and formulation of strategies for a manufacturing orientation can notably affect the growth of domestic firms through adoption of modern technologies and skill-intensive talent acquisition.

### Make in India

The ambition of the Indian government to participate in the global supply chain and to produce ‘Made in India’ products is very aggressive and determined. Thus, policy makers have launched many national programs to attract domestic and foreign investments and to promote modern technologies and innovation. In addition, protection of intellectual property or trademark rights as well as rapid development of manufacturing infrastructure are also accorded high priority to harmonize the overall development in India. The Department of Industrial Policy and Promotion (DIPP) under the Ministry of Commerce and Industry, Government of India, is responsible for the program ‘Made in India.’ The objective of this program is not only to raise the manufacturing sector’s contribution to India’s GDP but also to increase the amount of foreign investments. However, there are some barriers and burdens to these investments in the country. These include, (1) unwise and unnecessary legislations and laws; (2) blurred and faint governmental responsibility; and (3) complicated and time-consuming bureaucratic processes. The program ‘Made in India’ aims to make the necessary reforms to reinforce India’s ranking on parameters such as ‘ease of doing business’ and thus increase foreign-investment flow in the manufacturing industry. In addition, this program maximizes the potential of the young population, creates more job opportunities, and promotes the development of secondary and tertiary industries.

On India's Independence Day on 15 August 2014, Prime Minister Narendra Modi had given a speech to launch the program 'Make in India,' which was formally announced in the presence of big companies a month later at Vigyan Bhawan, New Delhi. The Prime Minister emphasized that there are 25 sectors in this program, including, IT and BPM, automobiles, ports, biotechnology, leather, chemicals, electronics systems, pharmaceuticals, thermal power, food processing, textiles and garments, media and entertainment, wellness, mining, construction, tourism and hospitality, aviation, railways, automobile components, renewable energy, space, electrical machinery, roads and highways, and defense manufacturing. The campaign of this program highlights India's many advantages such as a young workforce, skilled and talented labor, and a strong desire and discipline to develop. Thus, an energetic appeal was made to the whole world to come, manufacture, and make in India. After that, these products can go and sell everywhere in the world via global supply chains.

The website ([www.makeinindia.com](http://www.makeinindia.com)) provides helpful information about 25 industries in this initiative as well as other projects. Furthermore, data and information on foreign direct investment, new initiatives, intellectual rights, or national situation of the manufacturing industry are also released as useful tools for existing and potential stakeholders and investors. Interestingly, the integration of the Investor Facilitation Cell on this website facilitates investors to analyze data, information, environmental/contextual issues, etc. across different sectors before making any decision.

The continuous effort of Indian government has resulted in many achievements and outcomes. In December 2014, the global impressions on social media and the number of fans on the program's Facebook page surpassed 2.1 billion and 3 million people, respectively. The success of the program 'Make in India' has also been mentioned as a role model in many international meetings and even at the Annual Meeting of the World Economic Forum. Furthermore, the India Brand Equity Foundation (IBEF) has launched a strategic campaign as well as enhanced its brand name by setting up the 'Indian Lounge.' This communication campaign and the text for India's presence as Partner Country that was held in Hannover in 2015 are influenced by the program 'Make in India.'

A new survey on Industry 4.0, by Tata Strategic Management Group and industry body Federation of Indian Chambers of Commerce & Industry (FICCI), found some interesting trends. The objective was to "gauge readiness of Indian manufacturing to adopt advanced manufacturing trends." The survey considered four mega trends that form some of the important pillars of Industry4.0, e.g., additive manufacturing, robotics, industrial internet of things (IIoT), and augmented reality.

The stocktaking exercise found that one in 10 respondents had already adopted one of these trends. About 60% of the respondents who had not adopted these trends were planning to adopt them over the next three years. About 90% of the Indian industry would adopt advanced manufacturing by 2020 and a majority would spend up to 15% of their overall capital expenditure (CAPEX) on advanced manufacturing over the next five years. The survey polled board members, CXOs, and other senior leaders of over 50 engineering companies.

More interesting than this projection is the kind of industries that are adopting these trends and the reasons for adoption. Large- and medium-sized companies are the leaders, which is not a surprise. Within this group, the heavy engineering sector is adopting advanced manufacturing more, particularly IIOT. That is because heavy engineering firms generate significant revenue from aftersales services and spares. The study said that as IIOT helps them gain information about usage patterns, it enables them to provide more effective aftersales support, resulting in higher revenues.



The survey also found that the adoption was more because of peer pressure and less due to the opportunity for better topline and bottom line. The respondents perceived ‘remaining competitive vis-a-vis peers’ as a bigger driver than ‘access to new customer segment for growth’ for adoption of the advanced manufacturing trends. A large number of respondents also highlighted that demonstration of proven benefits in the developed markets prompted them to adopt, the study said.

### India's Manufacturing Sector

According to government estimates, manufacturing sector's revenues are likely to increase up to USD1 trillion by 2025. Nevertheless, in order to reach this status, Indian manufacturing companies need to apply information and communications technologies in production processes, overcome gaps as well as difficulties in manual work and resource availability, and move to the next stages of development.

Thus, the initiative ‘Make in India’ is launched by the Indian government to provide an appropriate framework not only for large firms but also for small and medium companies. In addition, some sustainable development programs such as smart cities and green corridors are considered as necessary interventions to improve the state-of-the art technology adoption across different sectors in India. The objective of this program is to create a new generation of employment with high value added for manufacturing industries.

One of the many requirements and targets of the Indian government is to increase the manufacturing sector's contribution to India's GDP increased from 16% now to 25% in 2022. Besides the creation of 100 million new and related jobs in the production process, Indian manufacturing companies are encouraged to build medium- and long-term plans to adapt to Industry 4.0 needs.

### Industry 4.0: Making India a Smart and Intelligent Manufacturing Hub

The government has a vision and desire to enhance awareness of Indian manufacturing companies. Thus, the Department of Heavy Industry has developed the Smart Advanced Manufacturing and Rapid Transformation Hub (SAMARTH) Udyog Bharat 4.0 in order to improve the competitiveness of capital goods industries in India.

The Department of Commerce, under Ministry of Commerce and Industry, has had the collaboration with Technology Centre as well as Ministry of Micro, Small and Medium Enterprises in order to take advantages of modern technologies in different industries. Although the export value of Indian engineering goods has increased by around 10%, its share in the ASEAN region as well as globally has remained very low in the past 15 years.

Due to the benefits of Industry 4.0, such as better flexibility, productivity improvement, and profitability enhancement, the country desires to make quick strides in a phased manner. EEPC India, in association of Department of Heavy industries (DHI), is raising awareness on the fourth industrial revolution to drive the shift toward smart and intelligent manufacturing.

The Common Engineering Facility Center (CEFC) projects are

1. Center for Industry 4.0 (C4i4) Lab Pune;
2. IITD-AIA Foundation for Smart Manufacturing;

3. I4.0 India at IISc Factory R&D Platform;
4. Smart Manufacturing Demo & Development Cell at CMTI; and
5. Industry 4.0 projects at DHI CoE in Advanced Manufacturing Technology, IIT Kharagpur.

The common features of SAMARTH Udyog Bharat 4.0 projects initiated by DHI are

1. awareness campaigns;
2. master trainers to be trained;
3. startup incubators to be provided;
4. handholding of SMEs to plan and implement relevant Industry 4.0 projects to be done through consultancy services on chargeable basis;
5. collaborating with neighborhood universities for student training/internship programs;
6. involving industry in SPV membership model for sustainability;
7. participating in a government-formed platform for Industry 4.0 on common agenda;
8. to make adequate provisions for e-waste management; and
9. involving as many clusters of capital goods as possible.

### Vision

To pursue Industry 4.0 and create an environmental sustainability system among manufacturing enterprises of large, medium, and small sizes in India

### Mission

1. **Awareness and announcement:** The primary objective and priority is to drive the attention and awareness on Industry 4.0 among Indian manufacturing enterprises by creating program contents and enabling cooperation between experts from institutions and businesses.
2. **Experience and demo centers:** The creation of a network in each manufacturing industry and classification of companies is of paramount importance. The reason is that followers are able to learn many useful lessons from experienced companies and apply those as per the individual firm's situation and environment for a quicker adoption of Industry 4.0.
3. **Training and skills:** Establishment of vocational courses or training classes with appropriate content and methodology is likely to create and enhance skillsets needed for the many complicated and difficult requirements of Industry 4.0.
4. **Industry and academia:** Development of a high-quality workforce with deep knowledge and necessary skills for the manufacturing industry is a key requirement. Toward this end,

building networks and partnerships between the industry and the academia at universities or research institutes is very important. Encouragement in startups or incubators, and strong support in continued learning for graduate students are useful methods to prepare for Industry 4.0 in India.

5. **Engineering research and application of high technology in the era of Industry 4.0:** Indian government requires many national institutes (e.g., Institute for Plasma Research) and research centers to enhance research activities/capacities and to implement programs related to Industry 4.0.
6. **International collaboration:** Development of cooperation and linkages between India and other countries about skills or knowledge relating to high technology and Industry 4.0 through appropriate programs would be a key step forward.

### Composition

Typical examples include the following:

1. **Government:** Central and state departments are working with industries. These include Ministry of Science & Technology, Ministry of Food Processing, Department of Industrial Policy & Promotion, Ministry of Skill Development & Entrepreneurship, Department of Information Technology, Department of Heavy Industry, Department of Small & Medium Enterprises, and Ministry of Petroleum.
2. **Industrial associations and individual industrial units:** These include Automation Association of India, Federation of Indian Chambers of Commerce & Industry, and Confederation of Indian Industry.
3. **Institutions:** The notable institutions are Council of Scientific & Industrial Research, Indian Institute of Technology, Institute of Science, Central Manufacturing Technology Institute, Defence Research and Development Organization, Departmental institutions, and private industrial R&D institutions.
4. **Support organizations:** These include VDMA (a German Engineering Federation), Global Innovation & Technology Alliance, and National Research Development Corporation.

### Benefits and Opportunities

Apart from building long-term competitiveness on the global stage, India stands to gain significantly from adopting Industry 4.0 (see Figure 6).

First, it will allow manufacturers to improve productivity, efficiency, safety, and performance; and help position India as a global manufacturing hub. For example, technology deployments across manufacturing methods, processes, and equipment will enable companies to track the production process from start to finish, analyze data across machines, and get real-time feedback on raw material availability, equipment condition, etc., thus resulting in efficient processes and higher-quality products at optimized costs.

Several Indian e-commerce companies are using advanced data analytics to gain insights on customer behavior and to improve business performance. Likewise, manufacturers can implement

data analytics to improve forecasting, predict and prevent manufacturing downtimes, manage supply chains, and enhance production capacity and quality. For instance, Rolls-Royce has more than 13,000 commercial aircraft engines in service around the world. Using a range of smart data analysis capabilities, predictive tools, and engineering expertise, it helps airlines monitor and reduce fuel usage, fly routes more efficiently, and ensure that the right teams and equipment are in place to service engines more quickly and maintain the highest levels of availability.

Second, small and medium enterprises (SMEs) that form the backbone of Indian manufacturing can leverage Industry 4.0 technologies to become more agile, enhance productivity, streamline costs, and reduce risks. The sooner they evolve to meet modern business needs, the more they will stay relevant and secure new business on a global scale.

Third, employers will be able to increase the skills of their workforce. While some jobs may be lost, new ones will be created in a new economy. Industry 4.0 technologies inadvertently require new skills and trained workforce, especially in areas of cognitive robotics, advanced automation and industrial ICT. Training in safety-related skills will also come into play with an increased level of human-machine cooperation.

Finally, Industry 4.0 could provide a pathway for Indian manufacturing to transform to an innovation-led and high-value manufacturing stage. Technology-intensive sectors such as the aerospace and defense, which is at the cusp of innovation and growth in India, will be clear beneficiaries.

At Rolls-Royce, Industry 4.0 is a critical aspect of business and strategy (using connected systems to make better decisions). This brings together a number of capabilities, such as IoT, intelligent manufacturing, digital product verification, and virtual design and simulation.

Opportunities for creating new business models will be another major advantage for advanced manufacturers. With real-time data insights, they can not only improve existing aftersales service but also drive revenue by offering more value-added services to customers. For example, Rolls-Royce is adopting a ‘power-by-the-hour’ business model when selling engines: customers pay a fixed rate per hour of operation and Rolls-Royce provides predictive maintenance services based on insights from its ‘connected’ engines that wirelessly send machine data to Rolls-Royce centers for monitoring and analysis.

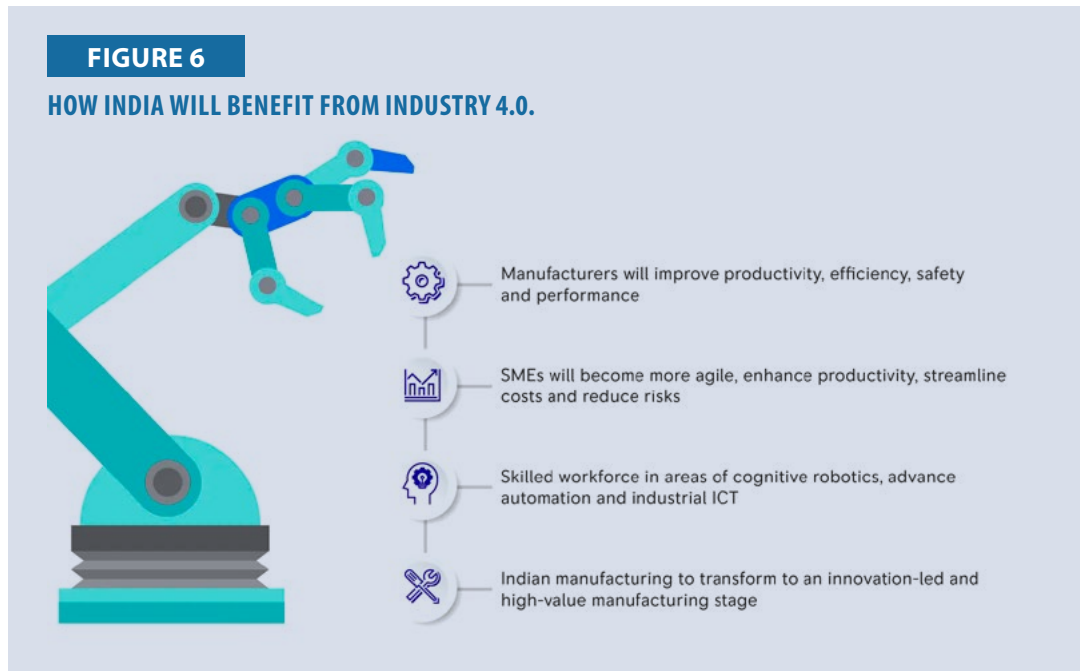
### Getting Started

Adopting Industry 4.0 is not a choice but an imperative for every industry. Here are some ways in which manufacturers can implement Industry 4.0 (see Figure 7):

1. **Clear roadmap:** Have a clearly defined plan to analyze gaps and determine the capabilities that are in place and the ones that are needed to support adoption of Industry 4.0.
2. **Start small:** Start small by creating dedicated cross-functional teams of business, operations, and IT, and scale up once the projects are validated.
3. **Talent development:** A qualified and skilled workforce will help implement new technologies quickly. Particular emphasis is needed for upskilling and reskilling existing workforce, given India’s dependence on low-cost manufacturing.

FIGURE 6

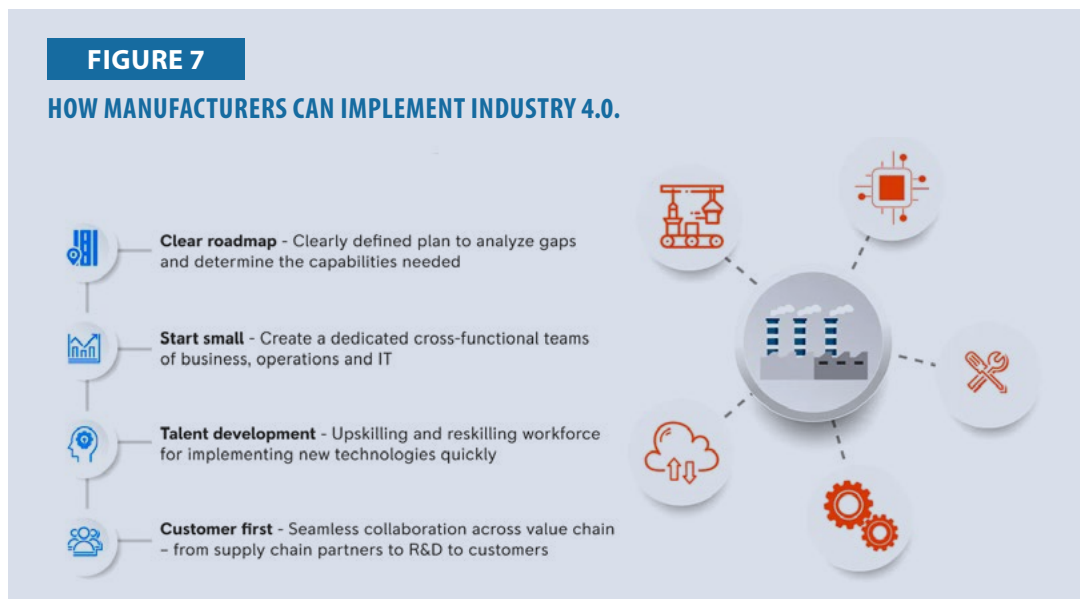
## HOW INDIA WILL BENEFIT FROM INDUSTRY 4.0.



4. **Customer first:** The ultimate goal for any manufacturer is to deliver a product or service that meets or exceeds customers' expectations. Collaborating seamlessly across the value chain, from supply-chain partners and R&D to customers, will help implement Industry 4.0 and accelerate its pace of adoption. Working with startups, universities, and industry organizations will also be advantageous.

FIGURE 7

## HOW MANUFACTURERS CAN IMPLEMENT INDUSTRY 4.0.



## Next Steps

Different geographies and economies are continuing to shift to Industry 4.0 at their own pace. In fact, the declining costs of maturing technologies are making this transition easier. Lower computing costs, cheaper storage, and less costly bandwidth are making it possible for companies to invest less and still reap the benefits of digital technologies. Companies that fail to develop these capabilities will struggle to retain their competitive edge in the long run.

As India pursues manufacturing-led growth, it needs to move away from low-cost manufacturing and align with the global trend of embracing Industry 4.0 to boost its competitive edge.

While the government has launched several initiatives such as Make in India, Smart Cities, Digital India, and Skill India to encourage adoption of Industry 4.0, it needs to create a more enabling ecosystem. For example, incentivizing industrial clusters and creating dedicated financing options will help manufacturers, especially SMEs, to expedite implementation of Industry 4.0. Ensuring data integrity, cyber security, and IoT security guidelines will be another important area of focus. Encouraging vocational education and training programs should become a priority to ensure a continuous supply of highly qualified talent. Finally, a more collaborative effort across multiple stakeholders, i.e., academia, public and private industries, and service providers, will be important to drive faster deployment of these new technologies.

With a calibrated approach, India will be able to leapfrog traditional phases of development, usher in a new era of growth, and sustain its economic wellbeing. According to global research and advisory firm Gartner, about 20.4 billion connected things will be utilized all over the world by 2020. 'Make in India' program is considered a critical enabler for the development of connected factories in India.

With regard to the first industrial revolution, steam is considered an important invention. The second and third eras of industrialization correspond to the appearance of electrical energy and information technology, respectively. Nowadays, information and communication technologies have a positive influence on industrial production, with advantages such as reduction in manual work and lowered costs. Now, the arrival of digital technologies and cognitive computing is a certainty. The phenomenon of fourth industrial revolution (Industry 4.0) is about intelligent manufacturing and smart factories by leveraging many new technologies such as big data, 3D printing, IoT, augmented reality, and so on.

Nowadays, intelligent manufacturing and automation are hot topics and draw attention from numerous enterprises that are likely to make the transition from traditional producers to smart manufacturers. The changing requirements of customers, rising complexities in manufacturing systems and environments, growing costs of manual works, lack of sources and capacities, and fierce competitiveness are some factors that are driving companies to innovate and use state-of-the-art technologies. Indian companies are not exceptions to this general situation all over the world, and disruption of existing paradigms is necessary for their survival.

Industry 4.0 is a global trend that leverages the digital revolution toward automation of production processes and creation of smart manufacturing platforms. This industrial revolution involves intertwining technologies that can integrate physical, biological, and digital elements. Data across machines is gathered and analyzed using technologies such as IoT, cyber-physical systems (CPS), cognitive computing, cloud computing, and artificial intelligence. In addition, the concept of smart factories where various machines with sensor attachments can communicate with automated devices and technicians is an alternative way for large landscapes that remarkably depend on manual work.

Today, more and more companies are trying to use algorithms or technology applications to connect all means of manufacturing processes in order to make real-time decisions. Initially, automated robots were used just for performing repetitive manual tasks. However, the new phenomenon of

intelligent manufacturing and automation pertains to use of industrial robots that can autonomously work, make decisions, and seamlessly coordinate with the overall production system. Thanks to modern technologies like machine learning and artificial intelligence, the interactions and interfaces between technicians and machines are easy to use, adaptable, and simplistic enough to lead outcomes in the form of increased productivity and efficiency in production lines.

## Major Industries in India

### Textile Industry

Textile manufacturing involves a complicated process, starting with the collection of raw materials or natural ingredients such as cotton, wool, jute, and silk, and ending with the creation of final complete products such as readymade garments. The contributions of this industry to India's GDP and total export income were 2% and 15%, respectively, during 2017–18. In addition, there are over 45 million people working for the textile industry, so the industry is considered as an important part of Indian economy.

### Food Processing Industry

In India, some leaders in the food-and-grocery market are: PepsiCo, Nestlé, Mapro Foods, Haldiram, Frito-Lay, Glaxo-SmithKline (GSK), Dabur, and Parle. About 1.85 million people have a job in the food processing industry, and the number is expected to rise to 37 million people by 2025. Furthermore, this industry contributes around 14% to the GDP and shares about 13% of the overall food-export income. India ranks sixth in the food and grocery market globally, and it is obvious that the contribution of this industry to Indian economic growth is significantly huge and extensive. Thus, Indian government has also paid attention and encouraged the development of this 'sunrise sector.'

### Chemical Industry

India is the third-largest chemicals producer in Asia. This diversified industry includes many fields such as pharmaceuticals and bulk drugs, petroleum and petrochemicals, chlor-alkali, crop protection chemicals, and specialty chemicals. It is the oldest domestic industry and covers over 80,000 commercial goods. In 2016–17, alkali chemicals accounted for nearly 69% of overall production.

Within the petrochemicals segment, polymers accounted for 59% of total production. The petrochemicals industry is predicted to grow to a value of USD100 billion by 2022. In addition, the toiletries and pesticides industry was approaching USD7.5 billion by the end of 2019. Indeed, the development of chemicals industry stands to benefit from a rise in foreign investments and policy incentives. Indian government has implemented some incentives such as duty reductions or tax decreases on material inputs (e.g., oil, naphtha, and coal) and acceleration of paper-based processes to enhance and simplify the flow of foreign direct investment in India.

### Cement Industry

There are around 10 large and 115 medium cement plants with a combined capacity of 148.28 million tons per annum, and around 300 small cement plants with a total capacity of 11.10 million tons per annum, controlled and monitored by the central and state governments. The domestic cement requirement was around 280 million tons while overseas demand was around 5 million tons. It is expected that the demand will be 550–600 million tons per annum by 2025. India is home to many big names in the cement industry. These include JK Cement, Ultratech Cement, Ambuja Cement, Aditya Cement, and L&T Cement. These large companies play a critical role in making India the second-largest producer of cement in the world.



### Steel Industry

India ranks No. 2 in steel production globally, with 106.5 MT of steel produced in 2018. The utilization of steel products in India was about 96 million tons in 2018, with an increase of 5 million a year later. India's strength in steel production is due to availability of cheap labor and abundant materials/resources. There are many big players in this industry, including Durgapur Steel Plant, Steel Authority of India (SAIL), Rourkela Steel Plant, Bokaro Steel Plant, and Bhilai Steel Plant.

### Software Industry

In the last 10 years, the expansion of the software industry has been incredibly fast. The growth of this sector approached USD181 billion from 2018 to 2019. The IT industry in India is predicted to have a growth rate of around 9%. The domestic value of the software industry was USD44 billion while the export revenue, at USD137 billion, more than three times the domestic number.

### Mining Industry

There are less than 1 million workers in the mining industry. The small-scale mining sector accounts for 6% of the overall expense of mineral manufacture. The mining industry's contributions to the industrial sector and to India's GDP are around 10% and 3%, respectively.

### Petroleum Industry

The first oil field was discovered in 1867, so the petroleum industry is seen as one the oldest industries in India. Oil and Natural Gas Corporation, Hindustan Petroleum Corporation Limited, Bharat Petroleum Corporation Limited, and Indian Oil Corporation Limited are four large national firms that have attained massive expansion and development at the global level in the last few decades. Following PR China and the USA, India is the third-largest consumer of energy and oil. India is also the fourth-largest importer of liquefied natural gas.

### Fisheries in India

Fishing industry is extremely essential because this sector is able to provide food sources for a huge number of Indian people while also creating many job opportunities for local residents. A 'blue revolution' has resulted in significant growth of fisheries in India, and holds the potential to make India the third-largest fish producer in the world. This industry accounts for around 5.37% of the agricultural sector and 1.21% of India's total GDP. In addition, the fishing industry has a big chance to develop continuously, so the sector is considered as a promising avenue for overseas export.

## Indonesia

### Manufacturing Activity in Indonesia

Manufacturing still plays a vital role in Indonesia's economy, employing more than 14 million people. It is considered an engine of growth for Indonesia, and the government is aware of the importance of industrialization as a key to national economic development. According to National Development Planning Agency (BAPPENAS) report (2019), 1% growth in manufacturing output is associated with 0.35% higher growth in nonmanufacturing output. The manufacturing sector is closely linked to the rest of the economy. Its value added represents about 40% of gross output, with the value being added divided into 11% wages and 29% surplus [59].

Moreover, it is important to understand the dynamics of Indonesia's potential growth, as labor productivity growth is considered to be a key determinant of productivity growth. In terms of

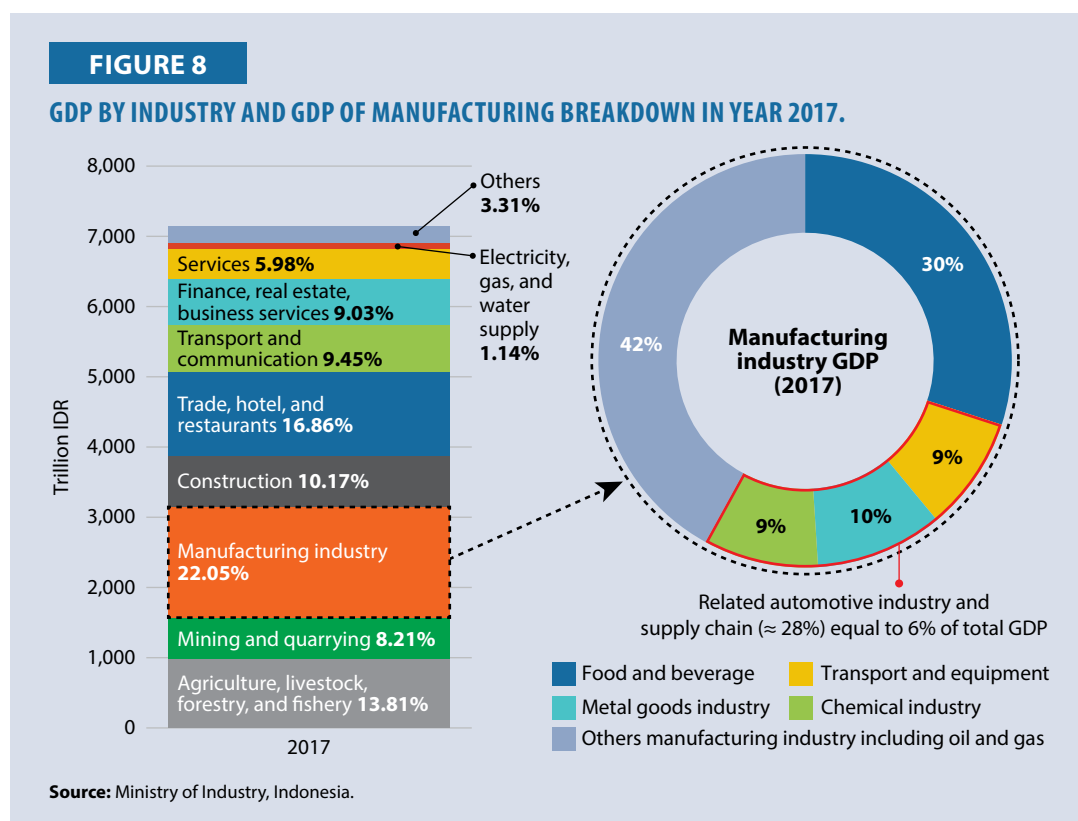


human capital, 21% of the local workers were involved in the industrial sector (including manufacturing sector) in 2014. Indonesia's labor pool is estimated to be around 120 million people and is growing annually by approximately 2.4 million. Indonesia's manufacturing sector faces some challenges including intense international competition, particularly from PR China. Moreover, rising labor costs, high transportation and logistics costs, difficulties in obtaining credit, varying levels of transparency, and clarity in regulations are among various challenges faced by this sector.

There are 10 common issues mentioned in Ministry of Industry report in 2018:

1. Underdeveloped upstream and midstream industries: Indonesia still has a high dependence on imports of raw materials and several important components, for instance in electronics and automotive industries.
2. Underleveraged geographical potential: Indonesia needs to plan a comprehensive industrial zoning plan, for example in the oil, gas, and petrochemicals industry. In addition, maximizing the economic-zone function is necessary to utilize the geographical potential that Indonesia has.
3. Inevitable global sustainability trends: In this situation, Indonesia needs to pay more attention to sustainable business opportunities.
4. Left-behind SMEs: In fact, around 62% of the workers in Indonesia are working at SMEs firms with low productivities.
5. Must-have digital infrastructure: The digital platforms in Indonesia are still underdeveloped. For example, the average internet speed is less than 10Mbps, there is a limited cloud infrastructure, and 5G-readiness is not yet in place.
6. Limitation of domestic funding and technologies: This needs to be addressed.
7. Abundant but undertrained manpower: Although Indonesia is considered the fourth-largest working population in the world, it has a very limited proportion of trained talent.
8. Absence of innovation centers: It is true that R&D is important for industrial development in a country. Therefore, the government needs to spend more in R&D or innovation centers.
9. Inertia to stay in status quo: Comprehensive incentives are needed to promote technology adoption for fourth industrial revolution.
10. Regulation and policy roadblocks: The government needs to build regulations that bring more coherence through cross-ministry collaborations.

As shown in Figure 8, manufacturing industry contributed 22.05% to Indonesia's GDP in 2017. However, the sector, which used to be a leader in net exports, is in decline, faced with deteriorating conditions. Also, the growth of the service sector in Indonesia has influenced the manufacturing sector's contribution to the GDP. According to A.T. Kearney, manufacturing sector's contribution to GDP had declined from its peak of 29% in 2001 to 20% in 2016.



Due to the trade war between the USA and PR China, the slowdown in trade performance has affected the manufacturing industry in Indonesia. Indeed, Indonesia still has a high dependence on import of raw materials for manufacturing industry. The Ministry of Industry noted that around 60% of the total import of raw materials and auxiliaries by the Indonesian manufacturing industry was from PR China.

Further, the USA-PR China trade war has resulted in global economic uncertainty, which has influenced Indonesia's trade balance. Indonesia has experienced a trade balance deficit of USD3.3 billion due to volatility in commodity prices, decrease in demand, and trade protection. This issue also brings a multiplier effect on export-commodity producing regions. The USA-PR China trade war has not only affected the economic growth but has also led to a rise in unemployment and poverty rates.

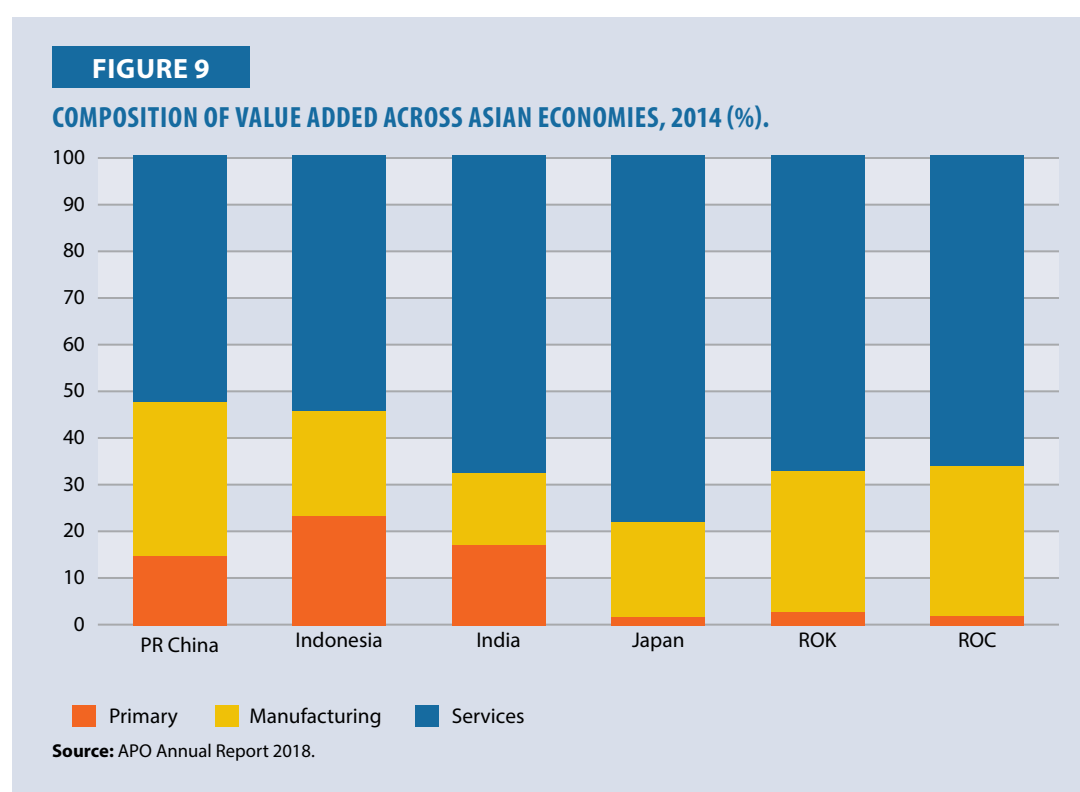
The slowdown in Indonesia's manufacturing industry will continue due to the COVID-19 breakout. The pandemic is profoundly affecting global economic conditions including Indonesia. This unprecedented issue has brought economic uncertainty to the nation. According to The World Bank report 2020 [28], the economy of Indonesia is expected to decline significantly. It is also predicted that if the pandemic breakout gets worse, the number of poor people in east Asia and Pacific will increase to 11 million. On the other hand, before the pandemic spread, 35 million people were expected to move above the poverty line by 2020.

Indonesia needs to learn from this shock. Starting with the recovery from COVID-19 until 2045, Indonesia needs to focus on producing products with value added based on local/domestic raw materials. Moreover, in order to overcome this issue, direct investments in the labor-intensive industrial sector, domestic natural resources, and export base need to be encouraged.

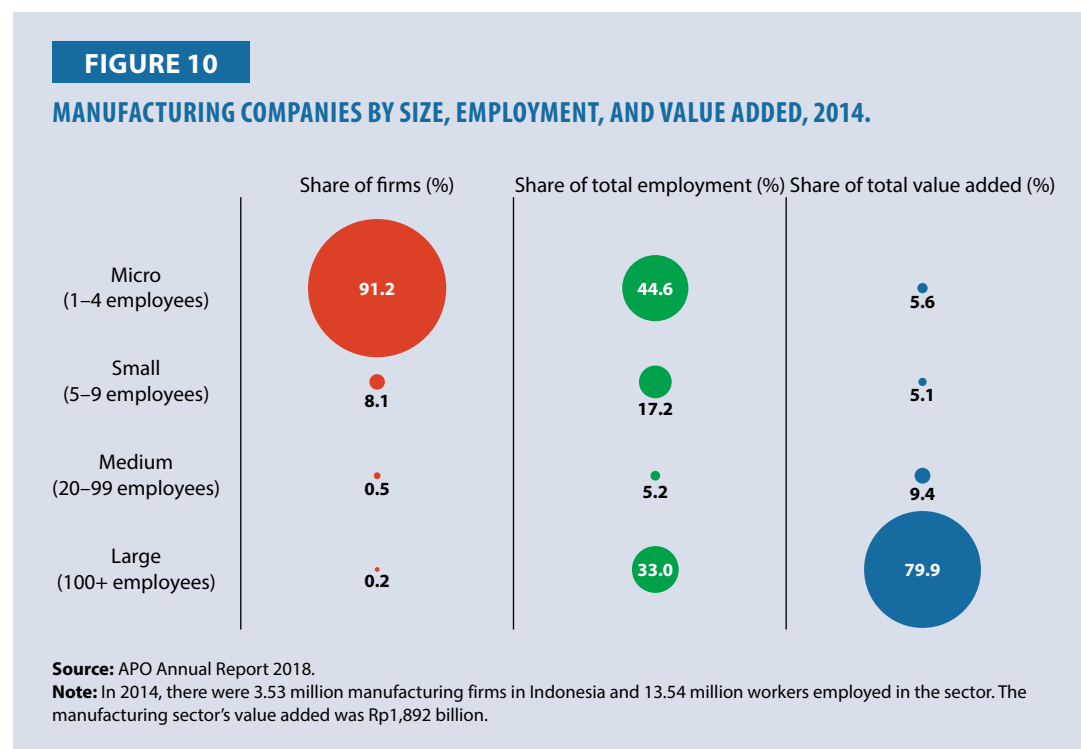
For example, in Bangka Belitung Islands Province, the potential of essential oil developed by SMEs is quite promising. Production of oil from clove leaves needs to be encouraged to meet global demand. In Kalimantan, pure coconut oil is developed by many SMEs. The quality of this product can be improved and exported because it has demand in 165 countries. In this regard, improvement in the quality of domestic products can be supported by digital technologies, and the role of smart manufacturing can be useful. It is important to understand that Industry 4.0 leverages not just automation to replace the human role but also employs technologies that help improve product quality and marketing.

Harnessing technologies such as artificial intelligence, IoT, augmented and virtual reality, 3D printing, and robotics can help manufacturers boost employee productivity and increase share in global exports. It can provide new job opportunities and reinvigorate the entire sector. Automation and logistics are important parts of the manufacturing process. Haryono [22] mentioned that the potential of automation is not only in its impact on the sectors but also on the countries as a whole. Indonesia is at a nascent stage of digitization. According to McKinsey [26], digital technologies provide great opportunities to encourage productivity across sectors and expand participation in the economy to all segments of the population. If Indonesia embraces digitization, an estimated USD150 billion in growth (10% of GDP) can be achieved by 2025 [26]. In order to support this estimate, several strategies can be implemented. These include improving digital infrastructure by strengthening connectivity in western and central Indonesia and expanding into eastern Indonesia; increasing internet penetration; and leveraging big-data systems to address real-time decisions across the value chain.

The overall value added in the manufacturing sector tends to be affected by a small number of low-tech manufacturing subsectors. In terms of labor productivity, Indonesia may be low in comparison with other Asian economies (see Figure 9).



In addition, small and micro firms dominate Indonesia's manufacturing landscape, accounting for 99.3% of the companies in the sector. The medium and large companies comprise less than 1% of all manufacturing companies in Indonesia. Small and micro firms account for 61.8% of total manufacturing employment, while large firms account for 33% and mid-sized firms just 5.2% of total manufacturing employment (see Figure 10). In case of value added, large firms, and to a lesser extent mid-sized firms, are found to dominate. While the large firms contribute around 80% of total manufacturing value added, mid-sized firms contributed another 9.4%. Small and micro firms thus account for just over 10% of value added [20a].

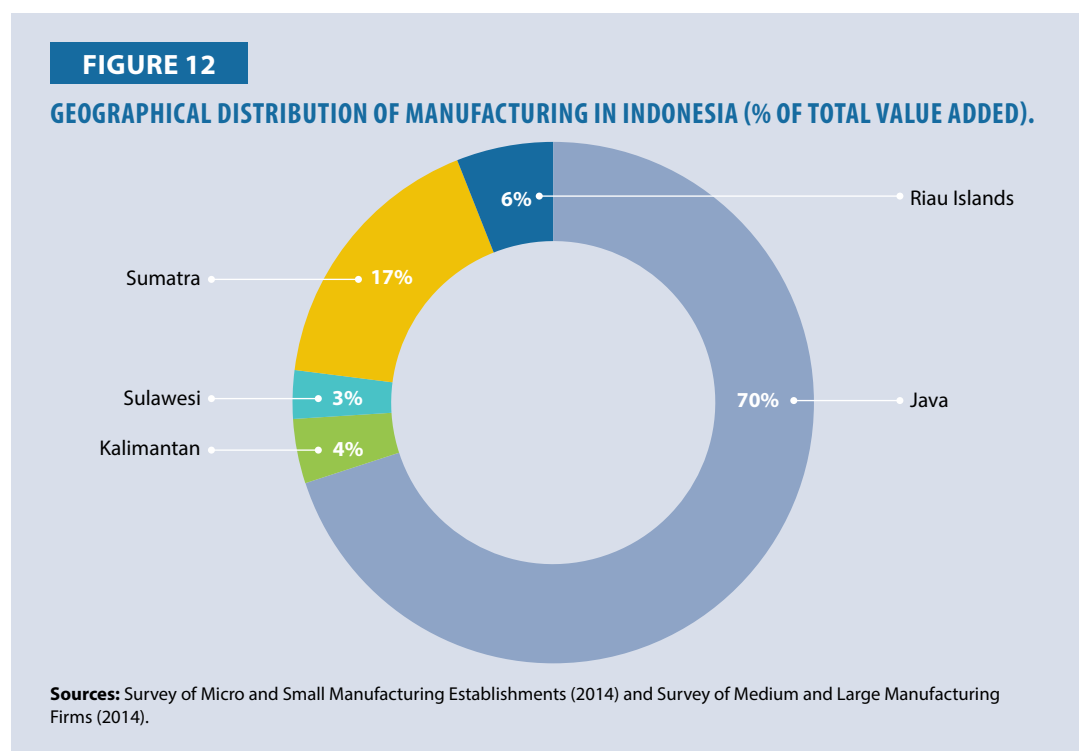
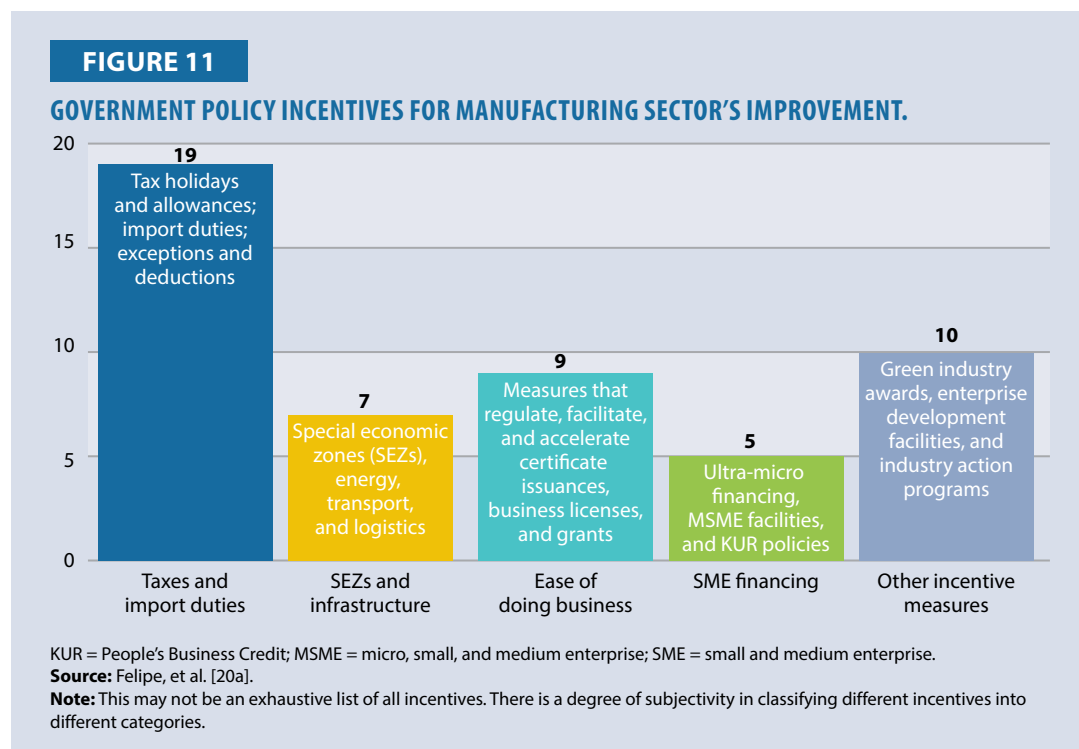


The food, textiles, and wearing apparel industries together comprise around 44% of Indonesia's manufacturing companies and account for around 39% of the sector's employment. Food sector is the largest manufacturing segment by the number of companies, with a share of 24.5%. Food production also accounts for the largest share of value added, while textiles and wearing apparel contribute relatively lower in terms of value added. Other sectors such as chemical production and motor vehicles account for relatively large shares in value added. High-tech sectors also produce a significant part of the manufacturing sector's total value added.

Improving infrastructure in electricity, transport, trade, and other logistics can help accelerate economic development in Indonesia, including its manufacturing industry's development. Therefore, government effort is required in creating an appropriate policy to address infrastructure-related issues. The government needs to reduce logistics costs to facilitate trade. Moreover, improving access to electricity is a key effort needed to scale up infrastructure. Indonesia is facing power quality and energy efficiency issues on the supply as well as demand side. About 20% of the population amounting to 50 million people are without access to electricity. Furthermore, the government continues to regulate some policies regarding this issue. According to Energypedia.info, 2020, the Ministry of Energy and Mineral Resources has announced a regulation 'ESDM No. 38 year 2016,' which provides a framework for private companies to supply electricity to unelectrified

regions. The government also continue to raise awareness on making use of renewable energy to meet the current demand from the industrial sector.

Furthermore, increasing credit access to micro and small firms can trigger the growth of enterprises. Figure 11 shows various policy incentives to promote manufacturing. The skew in current geographical distribution of manufacturing in Indonesia (see Figure 12) also needs to be addressed.



### Deindustrialization Phenomenon in Indonesia: Premature Deindustrialization

Deindustrialization, or shrinkage of the manufacturing sector, has been a major concern even in advanced economies for various reasons [51]. Some of the developing economies in recent times have also been experiencing declining share of the manufacturing sector before achieving full industrialization. To illustrate this phenomenon, a term ‘premature deindustrialization’ is used. As manufacturing is a dynamic sector, the deindustrialization issue may affect developing economies as well during their economic development.

In order to maintain and push the growth of the manufacturing sector, an improvement is required and should be taken in a serious manner by the government. A decline in industrial competitiveness also has an impact on unemployment rate due to the relocation of industries and factories. Moreover, there is also a shifting of investment to other countries with more competitive advantages. The manufacturing sector in Indonesia is experiencing a downward trend, though it is still counted as the biggest contributor to GDP growth.

### Making Indonesia 4.0

Fourth industrial revolution (4IR) is an opportunity for Indonesia to revitalize the manufacturing sector and support Indonesia’s vision to become the tenth-largest economy in the world (see Figure 53). Therefore, the government has committed to support smart manufacturing by initiating a strategy and roadmap called ‘Making Indonesia 4.0.’ This roadmap involves various stakeholders, ranging from government institutions, industry associations, executives, technology providers, research institutes, and education institutions. It plays an important role in fulfilling government’s ambitions to increase economic activity, exports, and employment. The government aims to raise the nation’s net export-to-GDP ratio up to 10% by 2030 via ‘Making Indonesia 4.0.’ Moreover, the manufacturers will have the opportunity to transform their operations, improve productivity and competitiveness, and adopt new business models to move up the value chain.

‘Making Indonesia 4.0’ is part of the government’s effort to overcome the challenges of a 4IR era. The program was initiated in early 2019, and is expected to bring various economic benefits, including new jobs. By having the government support, companies can expect to maximize their potential. With the right business solutions and fresh perspectives, Indonesia and its companies can take an important step toward realizing the promises of a global transformation. A promise of Industry 4.0 is to improve overall performance and management, with productivity improvement being a key outcome.

Innovation will play an important role in ‘Making Indonesia 4.0,’ so the government aims to increase focus on R&D to actualize Indonesia’s vision of being among the top 10 economies of the world by 2030. This will entail increasing productivity by twofold, among other things.

The Indonesian government, through the Ministry of Industry, keeps focus on supporting R&D activities that can trigger productivity and competitiveness. The government continues to encourage innovation so that the national industry can continue to advance and have global competitiveness. This strategic step is in line with the priority programs in the ‘Making Indonesia 4.0’ roadmap.

In addition, the emergence of new industrial investments is a part of the government’s concern. The government is concentrating on providing tax holidays and other facilities needed by investors, particularly in sectors that can open up many jobs, become import substitutions, and increase exports. Needs in these sectors are a consideration to invest in the country. The collaboration

offered by the ROC presents an economic opportunity for both the countries. The potential sectors are shipping, metal processing, ICT and smart-city industries, and food technology.

The manufacturing sector stands to gain by shifting from a centralized, traditional structure to a more diversified group of smaller, agile, and technologically advanced firms. The Indonesian government will need to work closely with the private sector to ensure that the conditions for competitiveness are in place. Only then can the industrial internet truly transform Indonesia. An integrated relationship between the government and the private sector is needed to build a supportive environment for better implementation of smart manufacturing. The roles of the Ministry of Industry, the Ministry of Manpower, the Ministry of Cooperatives and SMEs, the Ministry of Trade, Investment Coordinating Board (BKPM), Agency of Industrial Research and Development (BPPI), local governments, associations, and universities are key to making a proper regulation and adapting quickly to the technological change:

1. Government: A national industrial committee, Komite Industri Nasional (KINAS) was set up to facilitate cross-ministerial and institutional cooperation among the ministries and other bodies listed above.
2. Cooperated company: Schneider, Toyota, and other companies that have applied the smart factory concept (mentioned in the corresponding case study discussed ahead).

The competitiveness of a nation is determined by many factors, including the readiness in the implementation and mastery of technology and the ability to innovate. Through innovation, technology transfer, and commercialization of R&D results, this plan will make a significant contribution in increasing industrial competitiveness and productivity for people's welfare. R&D is an important component in the industrial world, especially in the value chain. Innovation is related to products as well as involving in the field of production processes, marketing, and in environmental management. R&D is a requirement for long-term investment, and is the engine of development. It can be used as an instrument for accelerating the progress of a region or a nation to make it advanced and prosperous.

The government continues to improve the role of manufacturing in the industrial sector as the main driver for national economic growth. A number of strategic steps should be taken to spur productivity, competitiveness of export products, and strengthening of the manufacturing structure.

To create these targets, we need to create a conducive investment climate, conduct R&D activities, mobilize the potential of the economic sector, and maintain macroeconomic conditions in order to remain stable. Nevertheless, an integrated relationship in cross-ministerial synergy and collaboration with all relevant stakeholders is very much needed. This must be carried out collaboratively in order to accelerate the digital transformation toward Industry 4.0. As noted earlier, a collaboration between the government, universities, and the public sector is important for more innovation. This will lead to better results while implementing the needed strategies.

### Navigating Geographic Distances

Indonesia has a large land mass and therefore geographical distances between the facilities may impede collaboration and resource sharing. Secure cloud-based communications can be an option to enable specialists and engineers to collaborate on a problem and achieve better teamwork across distances. If not, the geographical situation in Indonesia can be an obstacle to availability of specialists and engineers when needed. The following considerations can be useful:

1. **Talking machine parts:** A happening technology trend is ‘digital twin,’ which uses sensors from real-world objects like industrial equipment to create a digital model. Moreover, digital twin would have access to market information, current demand and supply conditions, and market pricing.
2. **Eye on the factory:** Industry IoT can enhance economies of scale. Digital Thread, a software developed by GE Brilliant Factories, is essentially a system of electronic sensors and software analytics that connect every element on the factory floor, including workers and machinery. Each factory is linked to the full supply chain, to ensure that delays in both production and deliveries can be tracked. With data such as cost and process consequences, factories can adapt effectively to market conditions or disruptions. If an additive manufacturing facility is disrupted by machine failure, the system can provide solutions.
3. **The road ahead:** In order to support the implementation of smart manufacturing in Indonesia, it is important to place some key enabling conditions. Infrastructure for transportation, energy, healthcare, and communications has to be in place to make full use of technology. Workers need to become familiar with technology or have opportunities for retraining or on-the-job learning. The business environment also needs to improve. While Indonesia ranked 91st out of 190 countries in The World Bank’s 2016 Ease of Doing Business report, it ranked a distant 151st on ‘ease of starting a new business’ parameter.

## Outcomes

The key outcomes are

1. leading packaged food producer;
2. regional F&B export hub;
3. strong SME support along the value chain;
4. self-sufficient local production of raw materials and key components;
5. leading automotive export hub;
6. regional leader in EV production;
7. attracting leading global manufacturers;
8. highly skilled and innovative workforce;
9. advanced manufacturing capabilities beyond assembly;
10. highly capable domestic champions;
11. improved productivity across the value chain;
12. leading biochemical manufacturer;
13. enhanced basic chemical production;



14. leader in functional clothing production and innovation; and
15. improved cost-competitiveness through increased labor productivity and effective industrial zoning.

In 2020, the Ministry of Industry will also continue the development program through vocational channels. The Ministry of Industry will also build a Digital Innovation Center (PIDI) 4.0 to add industrial HR development facilities in preparation for the Industry 4.0 era.

## Philippines

### Introduction

Industry 4.0 plays an important role in the developing world since the sweeping positive changes are possibly the next logical step toward a technologically advanced economy [34, 53]. However, there exists a gap for the Philippines to access the corresponding advancements [6]. This can be summarized as four main issues. First, being a developing country, the Philippines is lagging in technologies, capabilities, and knowledge, including physical, human, organizational, institutional, and other capital assets [18]. Second, there is a weak implementation of policies, which is a deterrent to focused, collaborative, and incentivize R&D. Third, high cost of power, water, communications, and transport utilities, due to lack of infrastructure, are obstacles in the path of Industry 4.0. Fourth, there exists a weak link between the government and private programs and the community sectors in the Philippines.

If we concentrate on solving these defined problems, we will be able to identify the smart manufacturing needs of the Philippines. Experience has shown that advancements in science and technologies bring along not just benefits and opportunities but also risk and challenges. As the Philippines is in the midst of a manufacturing resurgence, there is a risk of its progress getting hampered and its development plan to reduce poverty to zero by 2040 being disrupted [19]. The effect of disruption will not be the same on all sectors and in different geographic areas. Changes can also be so rapid that they may affect the existing social, economic, and political system, and lead to a disorder. It is imperative that the nation needs to prepare and anticipate these changes to take advantage of the upcoming opportunities and mitigate the risks by developing relevant policies, building necessary infrastructure, and adopting a new mindset.

### Industry 4.0 Policy

In order to construct the value chain that provides strong forward and backward linkages worldwide, the vision of Philippine Inclusive Innovation Industrial Strategy (i3S), Department of Trade and Industry (DTI), is to develop worldwide competitiveness and seek potential innovation across manufacturing, agriculture, and services industries. The i3S policy is conducted based on the Philippine Development Plan roadmap from 2017 to 2022 by expanding economic opportunities among industries and services via ‘Trabaho at Negosyo.’ The infrastructure will lay down the foundations for achievement of inclusive growth in the country. The focus on innovation will provide the opportunity to advance science, technology, and innovation. These factors are fundamental to driving productivity improvements and long-term economic growth in the country.

To confront with the coming challenges, the new industrial policy will focus on more comprehensive aspects. It will emphasize stronger and close linkages across agriculture, industry, and services sector, along with the integration of innovation and inclusiveness in the process [19]. The government is currently implementing Manufacturing Resurgence Program (MRP) comprising

projects and subprograms that will enhance the competitiveness of the manufacturing industry. Led by DTI, MRP aims to reconstruct the existing capacities of the key industries, maintain comparative advantages, and simultaneously enhance the competitiveness of domestic manufacturing industries. This way, SMEs could be integrated more comprehensively for higher value added in the ASEAN industry supply and value chains [3]. In this report, Canvas Modeling Framework is applied to better formulate the policy on smart manufacturing in the Philippines.

### Problems and Issues

In the report, we have summarized the problems and issues into six main areas and analyzed the main constraints (see Table 2) including infrastructure and logistics, governance and regulation, SME development, human resource development, innovation, and supply/value chain.

**TABLE 2**  
**MAJOR CONSTRAINTS.**

Major area	Main issues and constraints
Infrastructure and logistics	High cost and unpredictability of power High cost of domestic shipping
Governance and regulation	Smuggling, corruption, bureaucracy/red tape Lack of streamlining/automation of business procedures
SME development	Lack of access to finance, technology, upgrades, and inability to comply with product standard regulations
Human resource development	Lack of skilled workers and training
Innovation	Paucity of industry-academia linkages, new product development, and R&D facilities
Supply/value chain	Lack of raw materials and intermediate parts and components manufacturers in the domestic market

The above issues lead to the following problems:

1. Due to the lack of skilled workers and training, and inadequacy of industry-academe linkages, new product development, and R&D facilities, the Philippines is lagging in technology, knowledge, and capabilities in areas of human, physical, institutional, organizational, and other capital assets.
2. Due to corruption, bureaucracy/red tape, and lack of streamlining/automation of business procedures, the implementation of government policies is weak, which results in a lack of focused, collaborative, and incentivize R&D. It also results in a weak link between the government and private programs and the community sectors.
3. Insufficient infrastructure and logistics also lead to high costs of power, water, communications, and transport utilities. It also causes insufficient supply of raw materials and components in the domestic market, which negatively affects the value chain.

### Goals/Objectives

The key goals/objectives are to

1. assess the adoption of the smart manufacturing approach in different sectors in member countries;

2. identify the priority of different sectors in member countries and recommended specific actions for prompting and adopting the smart manufacturing approach;
3. review smart manufacturing promotion and implementation in member countries to focus on the institutional framework, key institutions/organizations involved, and the corresponding programs;
4. assess the implementation of smart manufacturing approach in different settings to focus on smart manufacturing tools and techniques and their level of adoption by companies/enterprises and communities; and
5. prioritize needs in different settings in member countries to develop or strengthen capacities for smart manufacturing promotion and implementation.

### Governance (Suppliers and Partnerships)

The characteristics classified as nascent/emerging [50] include

1. reflecting on policies, strategies, and plans to implement;
2. inadequate resource investments in advanced technology, talent, infrastructure, and institutional development (focus on legacy systems), which amount to a high risk of disruption;
3. imitating, locked into foreign technology, labor intensive, and over reliance on old paradigm of competition;
4. one-sided, uncoordinated, and patchy partnerships;
5. weak technology development and knowledge transfer; and
6. inappropriate regulatory architecture for the digital economy.

Besides, the government has continuously provided policies for science and technology, ICT, higher education of human capital investment and development, labor market and social protection. The current industry roadmap and strategies are (i3S is based on five major pillars)

1. building new industries, clusters, and agglomeration;
2. capacity-building and human resource development;
3. MSME growth and development;
4. innovation and entrepreneurship; and
5. ease of doing business and investment environment.

### Industry 4.0: Impacts and Opportunities

1. **Labor market:** We consider the following three impacts conceptually in this report (1) substitution of labor issues; (2) complementary labor issues; and (3) job creation in industries.
2. **Education and human capital:** Flexibility and modularity play important roles in catering to the changing needs, diverse talents, passions, and interests of researchers.

3. **Implications for social protection:** The social protection system of the future must recognize two challenges that the fourth industrial revolution brings (1) the various forms of existing and emerging work engagements; and (2) the threat of a widening inequality. These require finding smart solutions to address current needs and prepare for tomorrow's challenges. These also require finding new and better ways of distributing income more equally.
4. **Trade and investment worldwide:** Baldwin [5] points out that globalization can be characterized as an 'unbundling of things.' The first unbundling was brought about by the reduction in transportation costs, which made it economical to locate factories away from consumers. The second unbundling was triggered by a reduction in communication and coordination costs, which facilitated the relocation of various production stages to different parts of the world. Also called vertical specialization, slicing up the value-added chain, and fragmentation, the second unbundling shaped the configurations of both factories and offices.
5. **Sustainability:** The issue of sustainability has brought special attention to the role of technology in achieving the Sustainable Development Goals (SDGs). SDGs have been stated by 193 UN member states, and the Philippines government has committed to attain the goals by 2030. Indeed, Industry 4.0 is fundamentally different from the three previous industrial revolutions in that it fuses the fields of physics, biology, computer science, and many more, thus affecting all disciplines, industries, and the world's economy. New technologies are developing at an exponential pace and it is expected that by 2030, many more new technologies will emerge, while currently nascent or immature technologies will reach the commercialization stage, which could help achieve some of the SDGs.

#### Activities of DTI

The economic structure is summarized in Table 3.

1. **Macroeconomic performance and industrial structure:** According to DTI, from 2011 to 2018, the economic growth of the Philippines was quite remarkable at an average of 6.1%. The manufacturing industry led the country's growth with an average of 6.9% while services posted an average growth of 6.6%. The performance of the primary industry, including agriculture, hunting, fishery, and forestry, has remained lackluster, lagging behind services and industry with an average growth of only 1.9%.
2. **High-tech stakeholders and regional workshops:** A workshop intended to support this report was held in September 2017, which aimed to bring together targeted stakeholders as participants at an event titled, Industry Innovation Needs: Call to Action Workshop. Specifically, the participants collectively considered the results of the workshop and worked together to identify tactical steps related to future policies, programs, actions, and commitments. Workshop participants represented the high-tech industry, academia, and associations in approximately equal proportions.

Some commonly observed themes include the following:

1. Innovation efforts are needed for a wide range of industries, depending on the regions where workshops are held. Although Industry 4.0 and high-tech sectors were the focus, many examples cited were of food and agribusiness.

2. Policy and program needs are seemingly preferred to be driven by regional offices of government agencies, along with local government units. This may indicate policy requirements and local difficulties that may not be addressed through national efforts.
3. There is a strong demand for shared services facilities or innovation hubs for ICT-type activities, along with agricultural products predominant in the region.
4. Human capital development needs for innovation are commonly expressed, with a seemingly systemic lack of training programs and facilities along with academic research in most of the sectors being represented.

**TABLE 3****ECONOMIC STRUCTURE, 2013–16.**

Major sectors	Share of total gross value added (%)				Growth rate (%)			
Year	2013	2014	2015	2016	2013	2014	2015	2016
Agriculture, forestry, and fishing	10.5	10.0	9.5	8.8	1.1	1.7	0.1	-1.3
Industry	32.9	33.3	33.4	33.8	9.2	7.8	6.0	8.0
Manufacturing	22.8	23.2	23.2	23.2	10.3	8.3	5.7	7.0
Construction	5.7	5.7	5.9	6.2	9.6	7.2	9.4	12.6
Services	56.7	56.6	57.1	57.5	6.8	6.2	6.8	7.5
Trade/repair of vehicles, motorcycles, and personal, household goods	16.6	16.5	16.7	16.8	6.2	5.8	7.1	7.3
Financial intermediation	7.1	7.2	7.2	7.3	12.6	7.2	6.1	7.7
Real estate, renting, and business activity	10.9	11.2	11.3	11.6	8.9	8.7	7.2	9.1
Others	10.3	10.1	10.3	10.4	4.9	4.0	7.9	7.5

**Thailand**

Thailand (formerly known as Siam) is at the center of southeast Asia. It consists of 76 provinces. It is the world's fiftieth-largest country by area (513,120 sq km) and twenty-second-most populous country with around 68 million people. Bangkok is the capital of the country.

It is bordered by Myanmar and Lao PDR on the north, Lao PDR and Cambodia on the east, and Malaysia and Gulf of Thailand on the south. Thailand is a founding member of Association of Southeast Asian Nation (ASEAN). With a high level of human development, this second-largest economy in southeast Asia is classified as a newly industrialized economy, with manufacturing, agriculture, and tourism being its leading sectors.

Thailand's GDP and GDP per capita were THB16,318 billion and THB240,586, respectively, in 2018. In terms of per capital GDP, the country ranks after Singapore, Brunei, and Malaysia in southeast Asia. Its GDP growth was 4.1% in 2018, but only 2.4% in 2019, according to National Economic and Social Development Council (NESDC) as shown in Table 4. The percentage of people below the poverty line had gone down from 65.26% in 1998 to 8.61% in 2016, as per

NESDC. The average inflation was 1.06% in 2018 while the unemployment rate was 1% in 2018, which was the lowest globally. Exports play an important role in Thailand's economy, accounting for more than two-thirds of the country's GDP. The industrial and service sectors contribute substantially to the country's GDP, accounting for 35% and 57%, respectively and employing 16.7% and 51.5% of the labor force, respectively. The agricultural sector contributes around 8% to the GDP, employing 31.8% of the labor force.

**TABLE 4**
**THAILAND'S ECONOMY.**

Measure	2017	2018
GDP (at current prices: THB billion)	15,452	16,318
• GDP per capita (THB/year)	228,398.3	240,568.7
GDP (at current prices: USD billion)	455.3	505
• GDP per capita (USD/year)	6,729.8	7445.4
GDP growth (%)	4	4.1
Investment (%)	1.8	3.8
• Private (%)	2.9	3.9
• Public (%)	-1.2	3.3
Private consumption (%)	3	4.6
Government consumption (%)	0.1	1.8
Export value of goods (USD billion)	233.7	251.1
• Growth rate (%)	9.5	7.5
Import value of goods (USD billion)	220.1	228.7
• Growth rate (%)	13.2	13.7
Trade balance (USD billion)	32.6	22.4
Current account balance (USD billion)	44.1	32.4
Current account to GDP (%)	9.7	6.4
Inflation (%)		
• CPI	0.7	1.1

Source: National Economic and Social Development Council.

**Contribution of Manufacturing to Thailand's Economy**

As indicated earlier, the industrial sector accounts for around 35% of the GDP. The most important industrial subsector is manufacturing, which accounted for around 27% of the GDP in 2018. The World Bank provides data for Thailand from 1960 to 2018. The average value for manufacturing in Thailand during that period was 23.45% with a minimum of 12.54% in 1960 and a maximum of 31.07% in 2010. However, this number has been on decline. The two most important manufacturing sectors in Thailand are automobiles, and electrical and electronics.

**Smart Manufacturing for Thailand 4.0**

During 1952 to 2005, the average GDP growth was approximately 6.3%. As a consequence, Thailand jumped into the upper middle-earnings group of countries in 2011. This was largely due to the manufacturing sector that rapidly expanded the exports of goods. Thus, manufacturing has been a driving force for Thailand economy for so many years. However, the recent growth of GDP has been 3–4%. Opportunities for growth in manufacturing look uncertain because of competitive pressures arising from technology advancement, and low labor costs from countries like Vietnam and PR China.

Thailand is no longer able to compete with low-labor-cost countries. To make the matter worse, it does not possess the skills, research, and innovation to compete with advanced countries that have strong bases in the high-value markets. To move into high-income countries, Thailand must focus on the higher-value products and services, as well as create more high-quality careers. Thus, Thai Government came up with an initiative called Thailand 4.0 to enhance the competitiveness with other advanced and developing countries. This program aims to encourage manufacturing companies to make use of advanced manufacturing concepts such as innovation, connectivity, automation, robotics, AI, and big data. Of these, the promotion of advanced manufacturing, enabled by innovations in connectivity, data, and automation is a central point of Thailand 4.0.

The integration of sensors, machines, and IT systems is significant necessary in the entire supply chain. Application of advanced digital production systems in manufacture of high-quality products lead to speed, flexibility, and efficiency. IT helps in decreasing production costs, improving productivity, and enhancing competitiveness. Thai government has set a goal of increasing R&D expenditure to 4% of GDP, enhancing annual GDP growth rates to 5–6% within the next five years, and raising the national income per capita from USD5,470 in 2014 to USD15,000 by 2032.

### Status of Smart Manufacturing in Thailand

Low labor costs made Thailand a global center for manufacturing in the past. It provided more incentives for international investments to raise the Thai manufacturing competitiveness. However, the cost competitiveness is no longer a strength of Thailand because it moved into a group of upper middle-income nations. Thus, several Thai manufacturing companies have automated production and introduced new manufacturing techniques and technologies in order to maintain their competitiveness. Many large companies apply these techniques and technologies with the aims to improve quality and speed to market and for meeting customer demand. These enable them to compete with innovative competitors in developed countries. The implementation of new manufacturing techniques and technologies varies significantly across the manufacturing sectors. While large manufacturing companies have been relatively quick to implement, many small and medium manufacturing companies are lagging. Based on a study conducted by Federation of Thai Industries (FTI) in 2016, 75% of Thai companies were in the situation below the Industry 3.0 level as shown in Table 5 [27].

**TABLE 5**

### LEVEL OF INDUSTRIAL DEVELOPMENT IN THAILAND.

Level of industry	Main component	% of industry
Industry 2.0	<ul style="list-style-type: none"> <li>Utilizes electrical energy</li> <li>Utilizes conveyor belts for transportation</li> <li>Utilizes machinery that derives power from electricity sources</li> </ul>	40%
Industry 2.5	<ul style="list-style-type: none"> <li>Operates through mass production process, operates with conveyor belts for installation</li> <li>Operates through electrical system controlled by semi-automation relay</li> <li>Operates by controlling machines through a numeric control system</li> </ul>	35%
Industry 3.0	<ul style="list-style-type: none"> <li>Utilizes computer numerical control (CNC)</li> <li>Utilizes programmable logic controller (PLC) and microelectronics for controlling machine operations</li> <li>Utilizes robots for supporting production process</li> <li>Enables communication between machines on the production line</li> <li>Operates with enterprise resource planning (ERP) system</li> </ul>	20%

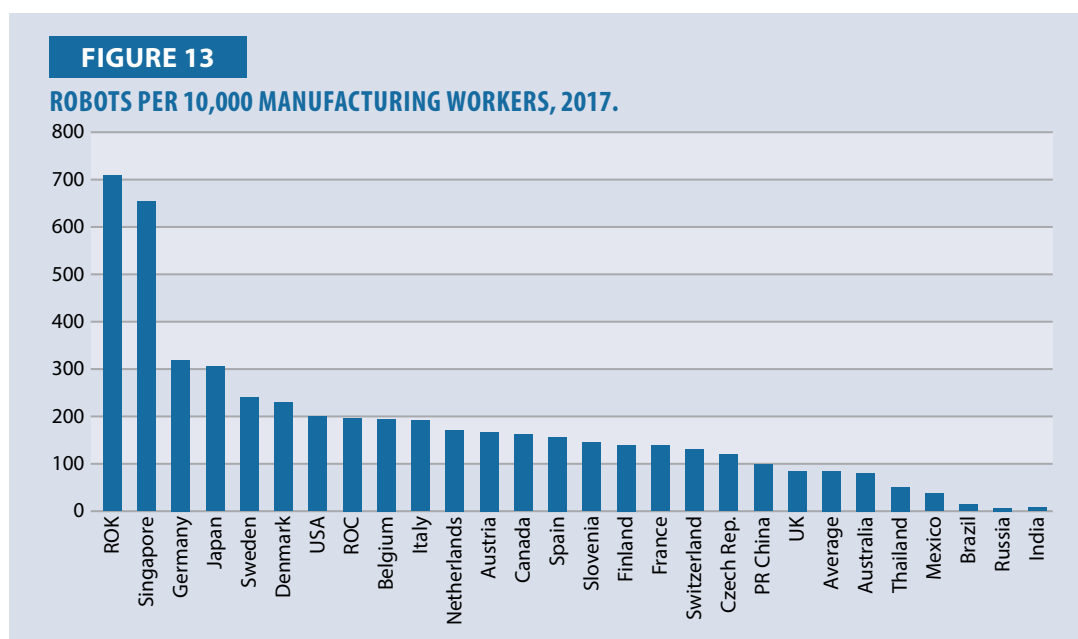
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Level of industry	Main component	% of industry
Industry 3.5	<ul style="list-style-type: none"> <li>Operates with a computer that controls the entire operating system of the organization</li> <li>Uses barcodes or radio frequency identification (RFID) to introduce itself for system acknowledgement</li> <li>Operates through material requirement planning (MPR) system</li> <li>Communication is conducted through internal network system of the organization</li> </ul>	5%

**Source:** Federation of Thai Industries, 2016.

It is obvious that companies operating at Industry 3.5 and below levels have constraints in the utilization of interconnected digital communication systems, robotics, new manufacturing technologies, and automation. Furthermore, the survey implemented by International Federation of Robotics (IFR) indicated that the usage rate and the purchase of industrial robots in Thailand was really lower than other relevant countries in the Asian region. For instance, the robot density (number of industrial robots for every 10,000 workers) was 47 in Thailand, while in the ROK, Japan, and PR China, it was 710, 308, and 97, respectively (see Figure 13). However, the adoption of industrial robots will increase in Thailand.



According to studies of FTI [27] and IFR, Thai manufacturing companies are not earnest to achieve the level of connected system and industrial automation. A survey by the Global Competitiveness Report, 2016–17 confirmed the results of the studies done by FTI and IFR. This survey showed that the Thai technological readiness ranked it 63rd out of 138 countries.

There are many reasons preventing Thailand from smart manufacturing and realization of the Thailand 4.0 vision, including (1) low awareness of the government's investment incentives; (2) large capital requirements for setting up new factories and equipment; and (3) shortage of skilled or quality labor. Indeed, the demand for investment in automation, quality control, human resource capability development, and industrial applications of information and communication technologies are significantly high.



Besides the study done by FTI, other studies from many different perspectives have also investigated the readiness of Thai manufacturing for Industry 4.0. Meechamna [42] investigated Thai automotive industry's readiness for Industry 4.0, used a survey as a research tool and descriptive statistics to analyze the data. A quantitative questionnaire based on readiness self-assessment of PWC [47a] was used in this assessment. According to the PWC online Industry 4.0 assessment, four dimensions including business models, products and services, market and customer access, value chains and processes, and IT architecture are considered. There are four levels of Industry 4.0 readiness as shown in Table 6. Of the total automotive firms in Thailand, 332 manufacturing companies were surveyed. Of these, 209 were large firms (63%) with more than 200 employees, 102 were medium firms (30.7%) with 51–200 employees, and only 21 were small firms (6.3%) with 50 employees or less. There were 204 firms (61.4%) with annual incomes of BHT5 million or more (204 firms, 61.4%), 92 firm (27.7%) with annual incomes of BHT500,000 to BHT5 million (27.7%), and only 36 firms (10.8%) with annual income of less than BHT500,000. Five-point Likert scale was used for the assessment, and 'current' and 'target' measures were assessed, with levels based on means. The analysis was conducted including descriptive statistics.

**TABLE 6****SUMMARY OF INTERPRETATIONS OF MEANS.**

Mean score	Industry 4.0 readiness level	Interpretation
1.00 to 2.00	Digital novice	The firm has a separate online and offline presence, product focus, and fragmented IT infrastructure and processes.
2.01 to 3.00	Vertical integrator	The firm is developing a digital product and service portfolio, multichannel communication and distribution, data and process integration, and homogenous IT systems.
3.01 to 4.00	Horizontal collaborator	The firm uses integrated customer solutions, individual customer processes, and integrates IT architecture, data flows and processes with external partners and customers.
4.01 to 5.00	Digital champion	The firm has an integrated customer journey and fully integrated partner system and can develop disruptive business models.

**Business Models, Products, and Services**

Firms were asked five questions about their business models, products, and services (see Table 7). These items were ranked as either a vertical integrator or a horizontal collaborator. This indicates that while firms have not, on average, implemented Industry 4.0 principles in their business models, products, and services, they are in the process of implementation. The digitization is less advanced than developing customer focus and collaboration. Firms are targeting the digital champion level for all items.

**Market and Customer Access**

There were six questions regarding the market and customer access (see Table 8). Once again, the firm's current performance falls into the vertical integrator and horizontal collaborator categories. In terms of future performance, firms aim to be at the digital champion level for all market- and customer-access aspects in five years. Overall, these results indicate that firms are developing their channel integration, digital enablement of sales, and customer focus, and have strong goals for improvement.

TABLE 7

## DESCRIPTIVE STATISTICS: BUSINESS MODELS, PRODUCTS, AND SERVICES.

Statement	Actual			Target		
	Mean	SD	Level	Mean	SD	Level
How would you rate the contribution of digital features, products, and services to the overall value of your portfolio?	2.86	0.990	Vertical integrator	4.01	0.947	Digital champion
To what degree is the average product in your portfolio digitized? (e.g., RFID, sensors, IoT connection, smart products)	2.94	0.995	Vertical integrator	4.04	0.982	Digital champion
To what degree can your customers individualize their products?	3.32	0.981	Horizontal collaborator	4.30	0.796	Digital champion
To what degree are the life cycle phases of your products digitized? (digitization and integration of planning, engineering, production, services, and recycling?)	2.85	0.998	Vertical integrator	4.03	0.939	Digital champion
How important is the usage and analysis of data for your business model?	3.40	0.989	Horizontal collaborator	4.27	0.810	Digital champion
How intense is your collaboration with partners, suppliers, and clients for development of products and services?	3.55	1.057	Horizontal collaborator	4.43	0.776	Digital champion

TABLE 8

## DESCRIPTIVE STATISTICS: MARKET AND CUSTOMER ACCESS.

Statement	Actual			Target		
	Mean	SD	Level	Mean	SD	Level
To what extent do you use multiple integrated sales channels to sell your products?	3.10	0.991	Horizontal collaborator	4.16	0.837	Digital champion
How far do you integrate multiple channels into your customer interactions for communicating news, receiving feedback, etc.?	2.99	1.063	Vertical integrator	4.11	0.959	Digital champion
How advanced is the digital enablement of your sales force?	2.99	1.037	Vertical integrator	4.01	0.99085	Digital champion
How dynamic and customer-tailored is your pricing system?	3.24	0.910	Horizontal collaborator	4.20	0.784	Digital champion
To what extent do you analyze customer data to increase customer insight?	3.24	0.947	Horizontal collaborator	4.26	0.826	Digital champion
How far do you collaborate with partners regarding your approach of accessing customers?	3.29	0.969	Horizontal collaborator	4.22	0.809	Digital champion

## Value Chains and Processes

Five items were addressed in the value chains and processes (see Table 9). This area showed the strongest development, with all items being in the horizontal collaborator category. Unsurprisingly, the mean target goal within five years for these items was the digital champion level. The value chains and process focus are the areas that may have received the most attention during preparation for Industry 4.0, as it is the strongest area.

TABLE 9

## DESCRIPTIVE STATISTICS: VALUE CHAINS AND PROCESSES.

Statement	Actual			Target		
	Mean	SD	Level	Mean	SD	Level
How would you rate the degree of digitization of your vertical value chain from product development to production?	3.12	0.983	Horizontal collaborator	4.17	0.852	Digital champion
To what extent do you have a real-time view of your production and ability to dynamically react to changes in demand?	3.12	0.865	Horizontal collaborator	4.14	0.802	Digital champion
To what degree do you have an end-to-end IT-enabled planning and steering process, from sales forecasting over production to warehouse planning and logistics?	3.20	1.009	Horizontal collaborator	4.23	0.893	Digital champion
How advanced is the digitization of your production equipment?	3.07	1.036	Horizontal collaborator	4.22	0.821	Digital champion
How would you rate the degree of digitization of your horizontal value chain from customer order over supplier, production, and logistics to service?	3.13	0.991	Horizontal collaborator	4.17	0.860	Digital champion

## IT Architecture

Six items addressed IT architecture (see Table 10). The firms' mean actual performance falls between vertical integrator and horizontal collaborator performance levels in this area. Unsurprisingly, given the firms' performance goals for other Industry 4.0 focuses, the mean target goal for five years falls entirely into the digital champion performance level.

TABLE 10

## DESCRIPTIVE STATISTICS: IT ARCHITECTURE.

Statement	Actual			Target		
	Mean	SD	Level	Mean	SD	Level
To what extent does your IT architecture address the overall requirements from digitization and Industry 4.0?	3.00	0.977	Vertical integrator	4.17	0.796	Digital champion
To what extent do you use a manufacturing execution system or similar to control your manufacturing process?	3.00	1.037	Vertical integrator	4.15	0.906	Digital champion
How mature is your IT and data architecture to gather, aggregate, and interpret real-time manufacturing, and product and client data?	3.02	1.008	Horizontal collaborator	4.14	0.875	Digital champion
How important are new technologies like social media, mobility, analytics, and cloud computing for enabling business operations?	3.2139	1.082	Horizontal collaborator	4.20	0.879	Digital champion
To what extent is your IT organization able to fulfill business requirements in the requested time, quality and cost?	3.0994	1.027	Horizontal collaborator	4.18	0.858	Digital champion
How advanced is your IT integration with customers, suppliers, and fulfillment partners?	3.0994	0.951	Horizontal collaborator	4.23	0.790	Digital champion

In conclusion, while the Thai automotive industry is not yet prepared for Industry 4.0 implementation, it is moving toward the horizontal and vertical integration of systems, workflows, processes, and

operations. Currently, firms are mainly occupied with vertical and horizontal integration of systems and processes (including IT systems), customer and market access, and business processes and workflows. While some firms may have advanced systems, others will only be beginning to implement these processes. There are some possible barriers that could prevent full implementation of Industry 4.0, e.g., a lack of skilled human resources and the reliance on SMEs with limited financial resources for investment in new systems.

## **Vietnam**

### **Orientations and Policies of the Party and the State**

On 22 March 2019, on behalf of the Political Bureau, General Secretary and President Nguyen Phu Trong signed Resolution No. 23-NQ/TW on the National Industrial Development Policy until 2030 with a vision for 2045. Resolution No. 23-NQ/TW has an important goal that Vietnam will become a modern, industrialized country by 2045.

In this Resolution, mechanisms and policies will be created to promote the internal restructuring of the industrial sector toward higher value-added and smart levels. It is necessary to accelerate the integration of information technology and automation in industrial manufacturing to create smart manufacturing processes and intelligent factory models and to develop smart products and smart devices. Smart technology standards and manufacturing techniques will be developed and issued. Besides, the textile, and garment and footwear industries will be further developed, but focusing on high-value-added creation phases with smart and automated manufacturing processes [44]. Tax reduction and exemption at reasonable levels and for appropriate periods will be granted for priority industries and smart industries. This Resolution document also focuses on the implementation of technical regulations. Standards in the industrial sector applicable to protect domestic production and consumers will be built and implemented, while smart technology standards and manufacturing techniques will be developed and issued.

On 27 September 2019, Party General Secretary and President Nguyen Phu Trong signed Resolution No. 52-NQ/TW on several guidelines and policies to actively participate in Industry 4.0. Vietnam has stepped up the application and development of science, technology, and creative innovation, and enhanced the ability to access and participate in Industry 4.0. Resolution No. 52 states that two guidelines and six significant policies need to be implemented, including, innovating thinking and unifying perception, perfecting institutions to facilitate proactive participation in Industry 4.0, and the process of national digital transformation.

The Prime Minister has issued Directive No. 16/CT-TTg on strengthening capacity to tackle challenges posed by Industry 4.0. This Directive focused on reviewing the strategies and action plans, and proposing and formulating targeted plans and tasks that are implemented following the development trend of Industry 4.0. On the other hand, Vietnam is also working to develop the strategies for digital transformation and smart administration; prioritize digital technology industry, smart agriculture, tourism, and urban areas; and review and select national vital products and strategic competitive products to apply new production technologies and integrate new technologies as the focus of investment and development.

On 27 September 2018, the Ministry of Science and Technology had issued Decision No. 2813/QĐ-BKHCN approving the crucial national science and technology program for 2025, “Research support, development and technology application of industry 4.0.” The program was built with the

goals of applied research, development, and transfer of some key technologies of Industry 4.0 that Vietnam has advantages to create products for socioeconomic development; and support to pilot innovation of some corporate governance models and manufacturing-business models in some critical areas in the direction of digital transformation. The program content focuses on some key technologies of Industry 4.0 to create products and services in areas such as medicine, economy, tourism, finance-banking, agriculture, processing and manufacturing, educational and vocational training, transport, construction, and information-communication; research and application of several digital transformation solutions in enterprise management and management; development of policies to promote credit for businesses investing in research; and research support, development, and application of Industry 4.0 technologies.

On 12 August 2019, the government issued Decision No. 999/QĐ-TTg, approving the Project on Promoting Sharing Economic Model. This encompasses specific steps to implement and realize Resolution No. 52, for creating a breakthrough in socioeconomic development. In 2019, some contents related to Industry 4.0 were actively enforced by the government. Functional agencies were tasked with preparing a draft national strategy on the Fourth Industrial Revolution through 2030, a draft national digital transformation plan, and a draft on a project for establishing the National Innovation Centre.

#### **Research and Development on Issues Related to Industry 4.0**

Vietnam is a country that is in the process of industrialization, modernization, and international integration. Industry 4.0 opens many opportunities in improving its technology level, production capacity, and competitiveness in the product chain; creating a significant change in the service business form; developing opportunities for innovative startups; significantly reducing transaction and transportation costs; and creating attractive and potential investment opportunities in the fields of digital technology and internet. It is also an excellent opportunity for industrial manufacturing at advanced scientific and technological levels.

However, if Vietnam cannot catch up with the development pace of the world and the region, the country will face challenges and negative impacts such as technological lag; manufacturing and business decline; and a surplus of skilled and low-skilled labor disrupting the traditional labor market and affecting the country's socioeconomic situation. Other challenges would include insecurity, information security threats, copyright infringement, and shortage of highly qualified human resources. Moreover, there is a possibility of a wave of outdated technology moving from developed countries to developing and underdeveloped countries.

The revolutionary changes in science and technology have led to dramatic changes in structures, economic models, state and social management systems, and operating models of enterprises. Industry 4.0 also presents challenges to many specific industries and fields. These include requirements for technological innovation in information technology; analysis and management of big data to create new knowledge, support decision making, and create competitive advantages; renewing of management models and optimizing business models; establishing supply chains and intelligent logistics in the global value chain and new tariff models; developing intellectual property management system for the digital age; and ensuring safety and security of network information systems.

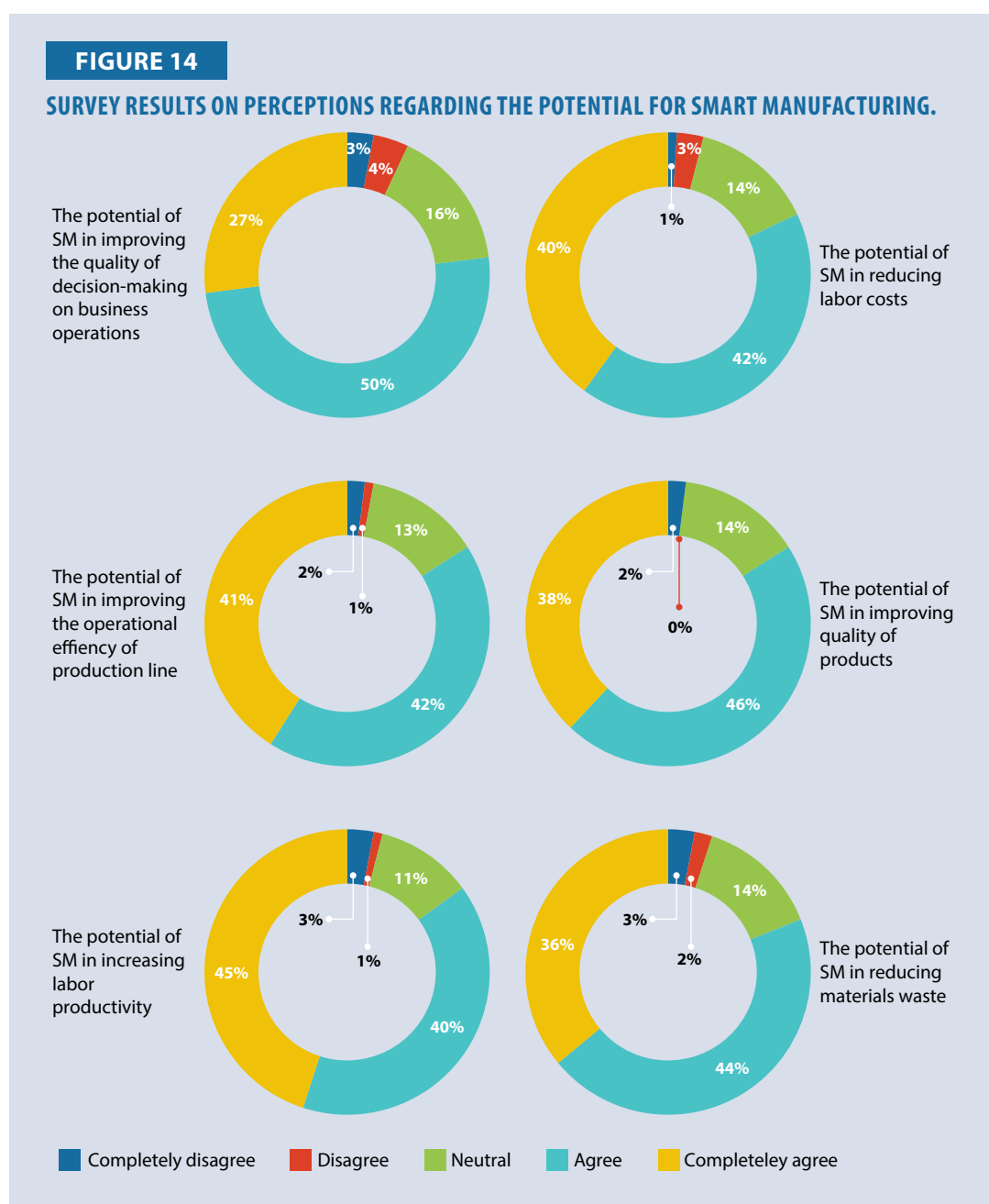
#### **Vietnam Standards (TCVN) Related to Manufacturing**

There are around 500 Vietnam standards, called Tiêu chuẩn Việt Nam (TCVN), relevant to production. These include over 200 TCVN of IT, 35 TCVN of network security and ATTT; 16

TCVN of automation; 5 TCVN of robotics, 9 TCVN of smart agriculture, 5 TCVN of smart transportation, over 74 TCVN of waste control and environmental pollution control, 67 TCVN of traceability, over 30 TCVN of advanced management systems, 70 TCVN of services, and 5 TCVN of human resource management and development.

### Assessment and Training Needs of Enterprises

The authors conducted a preliminary survey of 215 enterprises in the northern, central, and southern provinces on the current situation and the ability to apply smart manufacturing in Vietnam. As per the survey data, about 77% of respondents agreed that smart manufacturing played a role in improving the quality of business management decisions (with 27% surveyed enterprises fully agreeing with the view), while 7% of the enterprises said smart manufacturing did not play an essential role in improving the quality of executive decision making (see Figure 14).



Besides, 82% of the surveyed respondents agreed or strongly agreed with the idea that smart manufacturing played a role in reducing labor costs (40% of survey respondents fully agreed with this view).

About 83% of the enterprises that participated in the survey agreed or wholeheartedly agreed with the view that smart manufacturing played a role in improving the efficiency of production line's operation. Only 1% of the respondents said that smart manufacturing did not improve this efficiency at all. Indeed, 84% of surveyed respondents agreed or strongly agreed with the point that smart manufacturing played a role in increasing product quality (38% of survey respondents fully agreed with this view). Also, 85% of survey respondents agreed or strongly agreed that smart manufacturing played a role in increasing labor productivity (45% of survey respondents fully agreed with this view), while 80% of the respondents agreed or strongly agreed that smart manufacturing played a role in reducing material waste (36% of survey respondents fully agreed with this view).

Productivity assessment tools to develop smart manufacturing help enterprises to know where they are and what needs to be improved to reach the goal of sustainable smart manufacturing. These tools include questionnaires that help analysis and assessment of views on smart enterprises; assessment of factory capacity and factory automation capacity; and use of information technology in the enterprise, including integrated management system. In particular, assessment tools help enterprises identify issues themselves and decide if they want to improve and innovate in smart ways or not.

Based on the assessment results, enterprises can make their improvement plan on (1) organizational aspects (assigning persons in charge, participating in training tasks, etc.); (2) effective management aspects (identifying KPIs, testing international standards, etc.); (3) information connection aspects (identifying input/output data, checking international standards, etc.); and (4) ICT aspects (checking the essentials and functions of product lifecycle management, supply chain management, enterprise resource planning, manufacturing execution system, etc.)

### Spreading Awareness on Industry 4.0

It is a vital task to raise the awareness of committees and authorities at all levels on the urgent need to proactively, actively, and effectively participate in Industry 4.0. The objectives and functions of participating in Industry 4.0 need to be aligned with goals and tasks at every level and in every sector for socioeconomic development, environmental protection, and national defense and security assurance.

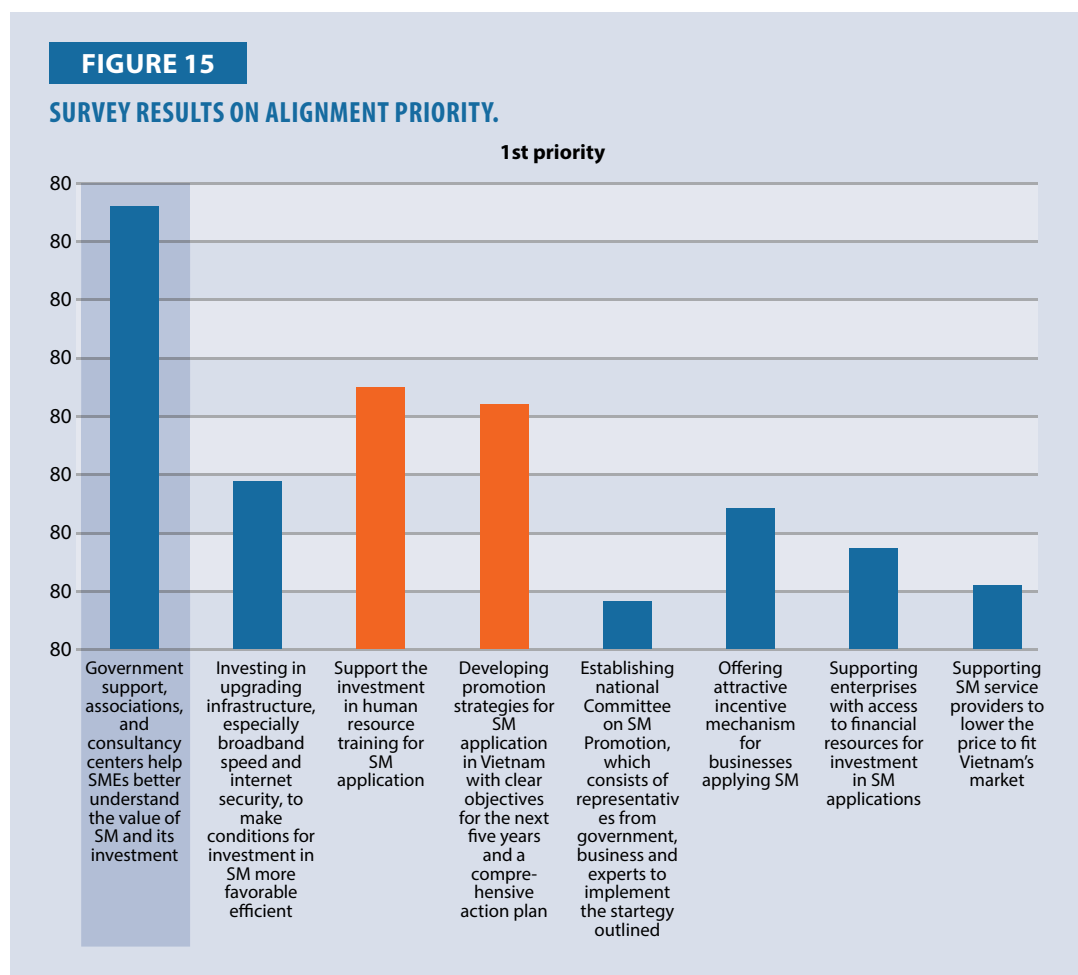
By 2030, Vietnam will strive to be among the top 40 countries in the world in the GII rankings. It aims to have affordable broadband access for all its people, a digital economy that accounts for over 30% of the country's GDP, and an increase in labor productivity that averages at around 7.5% per year.

Thirty technological solutions using key technologies such as AI, blockchain, big data, IoT, 5G, robotics, and cloud computing are widely applied in areas such as healthcare, tourism, finance-banking, agriculture, manufacturing, educational and vocational training, transportation, construction, and information-communication. Ten models of management, manufacturing, business and digital transformation solutions in enterprise management and management were developed to support at least 50 enterprises investing in research and development activities, application of technologies of industry 4.0.



### Smart Manufacturing Assessment Tool and Training

The survey of 215 enterprises discussed above shows that the top policy expectation of enterprises was to have support for better understanding of the value and method for investing in smart manufacturing. After that, the participating enterprises wanted the government to support investment in training human resources for smart manufacturing applications; formulating a smart manufacturing application promotion strategy in Vietnam with clear goals to be achieved over the next five years, and a comprehensive action plan (see Figure 15).



Over the past two years, Directorate for Standards, Metrology and Quality (STAMEQ), which is a governmental body under the Ministry of Science and Technology, has collaborated with international organizations to assess the smart manufacturing capacity for nearly 20 Vietnamese enterprises. On that basis, Vietnam is planning to research and develop a new tool to assess the smart manufacturing capacity for Vietnamese enterprises that is suited for the socioeconomic development conditions in Vietnam.

Over the past 20 years, STAMEQ has successfully implemented the National Program called 'Improving productivity and quality of products and goods of Vietnamese enterprises by 2020,' according to Decision No. 712/2010/QĐ-TTg of the Prime Minister. The program has supported the development of 11,500 Vietnamese standards for 98 fields with an international harmonization of about 54%; built 30 training programs, 40 sets of curriculum, and 200 training courses for 15,000 students; supported tens of thousands of enterprises by disseminating information, advising, and guiding to build and apply systems, models, and tools; organized 70 popular conferences on



productivity and industry 4.0; and provided guidelines for 5,000 organizations and enterprises to formulate grassroots standards. In 2019, STAMEQ (MOST) was preparing a draft to submit to the Prime Minister for approval of a new national program, in which support and training for Vietnamese enterprises engaged in smart manufacturing was an important part.

### Initiative for Startup Ecosystem in Vietnam

Currently, Vietnam is developing an innovative startup ecosystem. A national program to “Support Innovative Startup Ecosystem in Vietnam until 2025” was approved by the Prime Minister under Decision 844/QĐ-TTg. It marked a specific move of the government for the development of an innovative startup ecosystem. The Initiative for Startup Ecosystem in Vietnam (ISEV) scheme was formed to create a favorable environment to promote and support the process of formation and development of high-growth enterprises. This is based on the exploitation of intellectual property, technology and business models; creation of a legal system to support innovation; and establishment of a national innovation and innovation startup portal. By 2025, the ISEV Project is expected to support the development of 2,000 startups projects; enable 600 startups to start innovation; and facilitate 100 enterprises participating in the project for availing investment capital from venture capitalists or through mergers and acquisitions, with a total estimated value of VND 2,000 billion.

The Smart Manufacturing Ecosystem is a mission that Vietnam looks forward to implementing in future. The ecosystem will support enterprises to plan their own manufacturing transformation, and share and collaborate with other businesses, especially consulting enterprises and solutions providers, in order to advance the smart manufacturing model.

### Summary

In order to transition to Industry 3.5 or move to Industry 4.0 directly, national policies and long-term strategic plans, including the upgradation of industrial infrastructure, integration of hardware and information technologies, educational reforms, and training to incubate cross-discipline talents to enable the migration are crucial for APO economies.

- International collaborations and benchmarks among APO member countries will contribute the following benefits to empower smart manufacturing competencies:
- Information dissemination and experience sharing will broaden the horizons of all APO member countries via different perspectives and awareness on the latest trends in smart manufacturing. For example, the ROC’s SMEs, with strong capabilities in fast turnaround time and production flexibility, may act as pilot studies and mentors to the partner SMEs in member countries during a transition process.
- Joint-study projects and technology exchanges among APO member countries could cover areas such as smart machinery, IoT, big data, and cloud computing, through expert visits, smart manufacturing forums, and international consulting services. The training and development of cross-interdisciplinary industry professionals should be facilitated with practical experience in the field.
- Smart manufacturing technical manuals and technology roadmaps should be developed with readiness evaluation and assessment systems for smart manufacturing. These would serve as reference frameworks and models for APO member countries for identifying the best course of migration to improve their priority industries.

- The APO will serve as the primary platform for multinational collaborations to develop the smart manufacturing industry value chain in the Asia-Pacific region. The CoE on Smart Manufacturing can work alongside APO member countries to construct smart factories that meet the specific needs of local industries, spreading digitalization and smartization throughout the vertical and horizontal networks on the value chain, thereby improving national productivity. Through their collaboration and endeavor, APO member countries will be able to integrate the resources and events available from their respective smart manufacturing ecosystems.

# PRIORITY INDUSTRY, DEVELOPMENT PLAN, AND NEEDS

In Industry 4.0, the vision of smart manufacturing is enabled by high levels of automation and integration of cyber-physical systems (CPS), IoS, and IoT to develop an adaptable, flexible, and self-learning system. Through advanced process-and-equipment controls, real-time diagnosis and decisions can be made to achieve dynamic optimization in a smart factory. This could be done by leveraging the adaptive ability and appropriate setting of manufacturing parameters in different conditions by leveraging IoT and IoS in tandem with smart mobility, smart logistics, or smart grids.

Although government agencies, companies, and universities in APO member countries are working on different aspects of Industry 4.0, it is still in the future. Enablers such as high levels of automation, vertical and horizontal integration of the value network, and development of CPS and IoT technologies, form the basis of Industry 4.0. Furthermore, identification of priority industries to be focused for resource allocation, the corresponding development plans to enable migration with feasible technology roadmaps, and needs such as upskilling of workforces are recognized as important issues and challenges on the way to Industry 4.0.

## Republic of China

In 2018, the machinery industry in the ROC had 17,836 companies with production value of USD39.1 billion and export value of USD27.4 billion [55]. To describe the current issues and challenges more specifically, we take machine tools as an example. The machine tools industry in the ROC has around 1,100 companies with 55,000 employees. The production output value of the ROC's machine tools in 2015 was about USD4.49 billion (seventh-highest in the world) and the export value was about USD3.185 billion (fourth-largest in the world), with mainly mid-priced models. The average price of export to the USA was NT\$2.4 million.

Generally, export is the main market, which mainly relies on agents to provide application services. The product returns are low, and it is difficult to clarify the customers' needs. In addition, the majority of domestic manufacturers are small and medium enterprises (SMEs), and those with less than 200 employees account for more than 95%. SMEs are lacking in IT personnel, and show limited energy for technology upgrades and value-added application services. We list the challenges from different aspects, as shown in Table 11.

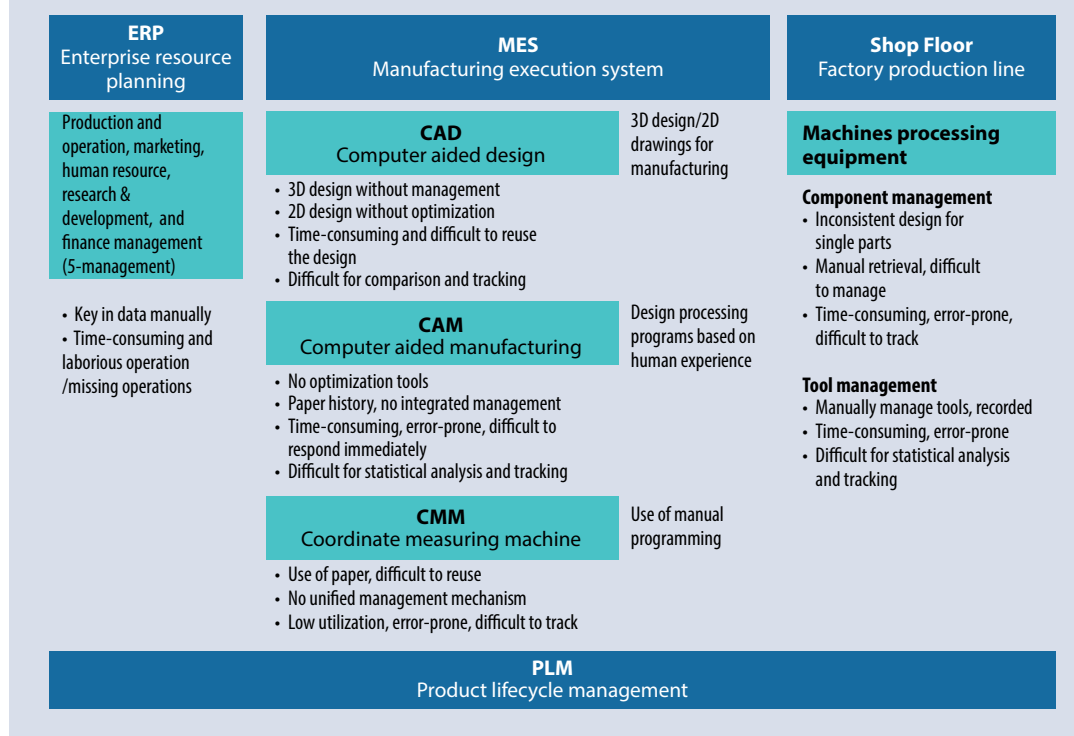
In addition, to be specific, the production data of the domestic machinery industry are mostly recorded. Real-time big data analysis has not been developed well, which challenges the core competence of smart manufacturing. Figure 16 summarizes the challenges and needs of the machine tools industry in the ROC. Some potential solutions are proposed to overcome these issues, e.g., integration of R&D improvements and talents between businesses and academia and use of government resources to build industry leaders or pilot sites for developing total solutions to alleviate the needs of manufacturers.

**TABLE 11**  
**CHALLENGES AND NEEDS OF MACHINE TOOLS INDUSTRY IN ROC.**

Aspects	Challenges and needs
R&D design	<ul style="list-style-type: none"> <li>• Lack of coordination mechanism with customers and partners</li> <li>• Industrial clusters make products homogeneous</li> <li>• Product technology migration evolves slowly</li> <li>• Products are mainly designed in 3D and then transferred to 2D drawing for manufacturing. 2D drawing is noted manually without optimization</li> </ul>
Product manufacturing	<ul style="list-style-type: none"> <li>• Difficult to plan the production progress of the supply chain</li> <li>• In order to meet customers' emergency maintenance, the whole machine factory needs to reserve higher inventory levels of key modules, which cause high operating risks</li> <li>• Production methods and quality rely on inheritance of experience</li> <li>• Production scheduling and tool management is manual</li> <li>• ERP developed in a factory relies on human operation without system integration</li> <li>• Virtual-physical integration and its related dataset are recorded manually on paper</li> </ul>
Production promotion	<ul style="list-style-type: none"> <li>• Low return on agency business model</li> <li>• Overall marketing capabilities need to be strengthened</li> </ul>
Aftersales and value-added services	<ul style="list-style-type: none"> <li>• Foreign markets rely on agent services</li> <li>• In the domestic market, the on-site model is for VIP customers while the on-call or available-at-all-time model is for general customers. Human resources present heavy loadings</li> <li>• Current remote services are limited to security issues and analysis techniques</li> <li>• Processes from product design to service are not well connected</li> <li>• Personnel experience inheritance</li> </ul>

**FIGURE 16**

**CHALLENGES AND NEEDS OF MACHINE TOOLS INDUSTRY IN ROC.**



In order to accomplish the digital transformation of manufacturing sectors in the ROC and to cater to their high-value, high-end application requirements (such as those in aerospace and automotive industries), the use of remote manufacturing services and intelligent value-added applications will be effective.

### Smart Manufacturing Ecosystem in ROC

The ROC's smart manufacturing ecosystem involves solution development and industrial applications, and includes several organizations and institutions such as the industry, the government, schools, and research institutions [8]. These units diversely interact with private companies to build a sustainable industrial ecosystem.

The smart manufacturing solution providers form the core of the ecosystem that includes parts-and-equipment suppliers, hardware and software suppliers, system integrators, information service providers, and consulting companies. In this ecosystem, besides the core solution suppliers, also included are R&D organizations, academic universities, standards organizations, public associations and industry alliances, and central and local governments (see Table 12).

**TABLE 12**  
**SMART MANUFACTURING ECOSYSTEM IN ROC [35A].**

Members of ecosystem	Purpose and activity	Organization or unit
Standards organizations	<ul style="list-style-type: none"> <li>• Development of standards</li> <li>• Maintenance of standards</li> <li>• Authorization</li> <li>• Certificate/verification</li> <li>• Educational training</li> </ul>	<ul style="list-style-type: none"> <li>• Bureau of Standards, Metrology and Inspection (MOEA)</li> </ul>
Public associations and alliances	<ul style="list-style-type: none"> <li>• White paper on technology</li> <li>• Cooperative platform</li> <li>• Industrial alliance</li> <li>• Educational Training</li> </ul>	<ul style="list-style-type: none"> <li>• Taiwan Association of Machinery Industry (TAMI)</li> <li>• Taiwan Machine Tool &amp; Accessory Builders' Association (TMBA)</li> <li>• Taiwan Automation Intelligence and Robotics Association (TAIROA)</li> <li>• Taiwan Electronic Equipment Industry Association (TEEIA)</li> </ul>
Government	<ul style="list-style-type: none"> <li>• Policy support</li> <li>• R&amp;D investment</li> <li>• Industrial environment</li> <li>• International cooperation</li> </ul>	<ul style="list-style-type: none"> <li>• Department of Industrial Technology (DoIT)/ Industrial Development Bureau</li> <li>• Ministry of Economic Affairs (MWA)</li> <li>• Ministry of Science and Technology (MOST)</li> </ul>
R&D organizations	<ul style="list-style-type: none"> <li>• Technology transfer</li> <li>• Spinoffs</li> <li>• Commissioned research</li> <li>• Cooperative research</li> <li>• Laboratory</li> <li>• Educational training</li> </ul>	<ul style="list-style-type: none"> <li>• Industrial Technology Research Institute (ITRI)</li> <li>• Institute for Information Industry (III)</li> <li>• Metal Industries Research &amp; Development Centre (MIRDC)</li> <li>• Precision Machinery Research &amp; Development Center (PMRDC)</li> <li>• Research institutes/centers</li> <li>• Multinational corporations</li> </ul>
Academic universities	<ul style="list-style-type: none"> <li>• Industrial and academia cooperation</li> <li>• Technology transfer</li> <li>• Proactive research</li> <li>• Talent pool development</li> <li>• Educational training</li> </ul>	<ul style="list-style-type: none"> <li>• Automation, electrical engineering, mechanical engineering, or computer science-related departments in universities</li> </ul>

In particular, there are five key activities in the ecosystem of smart manufacturing. First, build industry alliances and cooperation between supply and demand. Alliances among legal persons, schools, and enterprises are more efficient to promote some specific industries and integrate resources to establish a platform between the two sides of smart manufacturing. Second, encourage industry–academia cooperation. The development of innovative technologies and application solutions through the industry–academia cooperation can essentially be applied to the industry practice more quickly. Third, make the industrial policy. Various industrial policies proposed by government departments help enterprises to solve technical development issues, set up application trial fields, cultivate professional and cross-disciplinary talents, promote overseas markets, access R&D subsidies and investment offsets, avail company financing, etc. Fourth, support talent training. Sufficient talent pool is an important requirement for successful R&D or smart manufacturing applications. The industry, government, and institutes must accelerate the development of students’ professional skills through various channels, and also enable on-job personnel to strengthen their skills and establish cross-domain integration capabilities. Fifth, build international cooperation. International partnership can help improve technical capabilities, shorten R&D schedules, establish diverse trial fields, and expand overseas and regional markets to meet the customized needs. The development of a diverse culture makes a successful and healthy ecosystem having a worldwide resources and perspectives.

#### Recent Innovation Programs for Smart Manufacturing

In July 2016, the ROC’s Executive Yuan supported and funded the ‘Smart Machinery Industry Promotion Program’ proposed by the Ministry of Economic Affairs. The program encompasses two strategies, namely, (1) industrialization of smart machinery, which represents the development of smart machinery products and solutions; and (2); industry adoption of smart machines, which promotes the diffusion of smart machinery solutions in a variety of manufacturing applications. Smart machinery products and solutions mainly include intelligent components, single equipment, production lines, and factories.

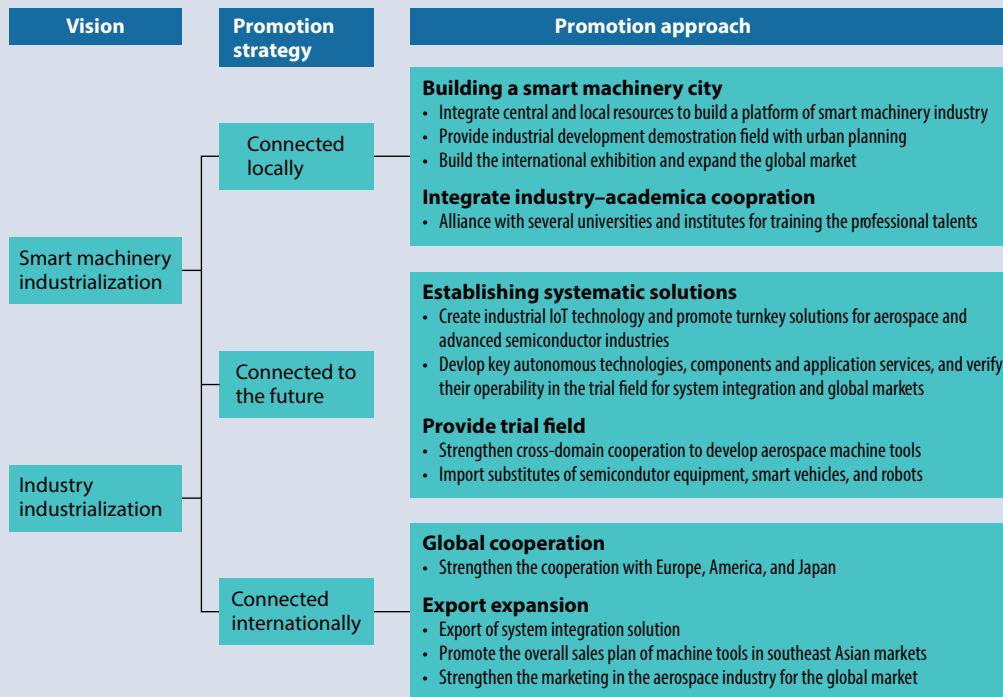
Under industrialization of smart machinery, a smart machine integrates various smart-technology elements, so that it has intelligent functions such as fault prediction, accuracy compensation, automatic parameter setting, and automatic scheduling; and also serves the function of providing turnkey solution and establishing differentiated competitive advantages. This strategy includes the establishment of equipment, components, robots, IoT, big data, CPS, sensors and other industries.

Industry smart mechanization is defined to introduce smart machinery to the industry, build smart production lines (with high efficiency, high quality, and high flexibility), and quickly connect with consumers through cloud to provide a large number of customized products and to form a networked manufacturing service system. This strategy includes aerospace, semiconductors, electronic information, metal carriers, machinery and equipment, food, textile, retail, logistics, agriculture and other industries. Figure 17 shows the vision, promotion strategy, and approach in smart machinery industry in the ROC [54] .

Through the strategy of industrialization of smart machinery, the primal work is to build the ecosystem for smart machinery industry as shown in Figure 18 [54]. The ecosystem is categorized into four items: parts intelligentization, machine intelligentization, line intelligentization, and factory intelligentization.

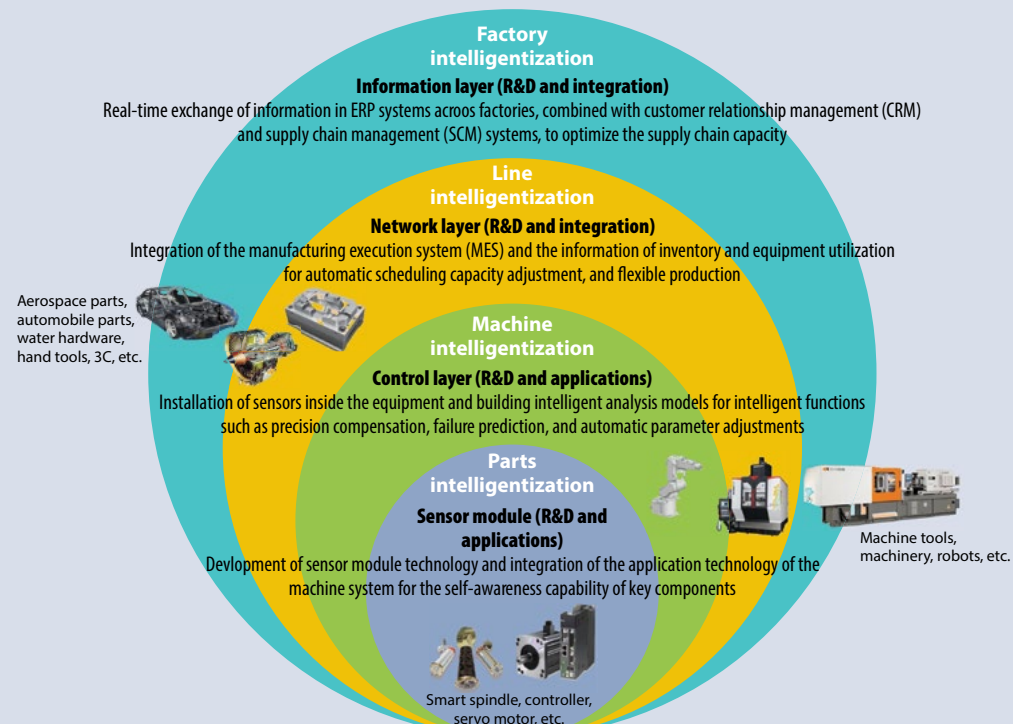
**FIGURE 17**

**VISION, PROMOTION STRATEGY, AND APPROACH IN SMART MACHINERY [54].**



**FIGURE 18**

**ECOSYSTEM FOR SMART MACHINERY INDUSTRY [54].**



## India

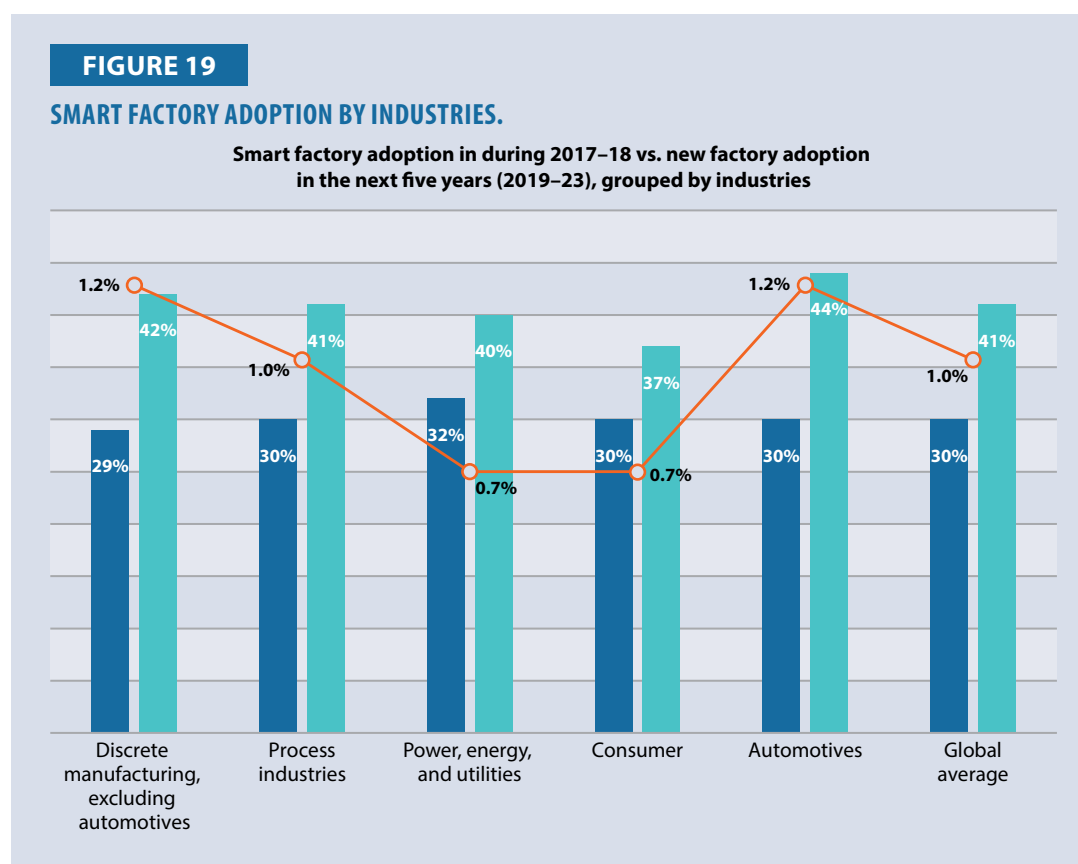
Indian government has identified 25 priority sectors as shown in Table 13. The government considers these sectors to be more attractive for foreign investment.

**TABLE 13**  
**PRIORITY SECTORS IDENTIFIED IN INDIA.**

Textiles and garments	Railways	Defense manufacturing
Automobiles	Food processing	Renewable energy
Electrical machinery	Ports	Roads and highways
Aviation	Leather	Space
Biotechnology	Media and entertainment	Chemicals
Automobile components	Mining	Thermal power
Construction	Oil and gas	Tourism and hospitality
IT and BPM	Pharmaceuticals	Wellness
Electronic systems		

### Auto Sector

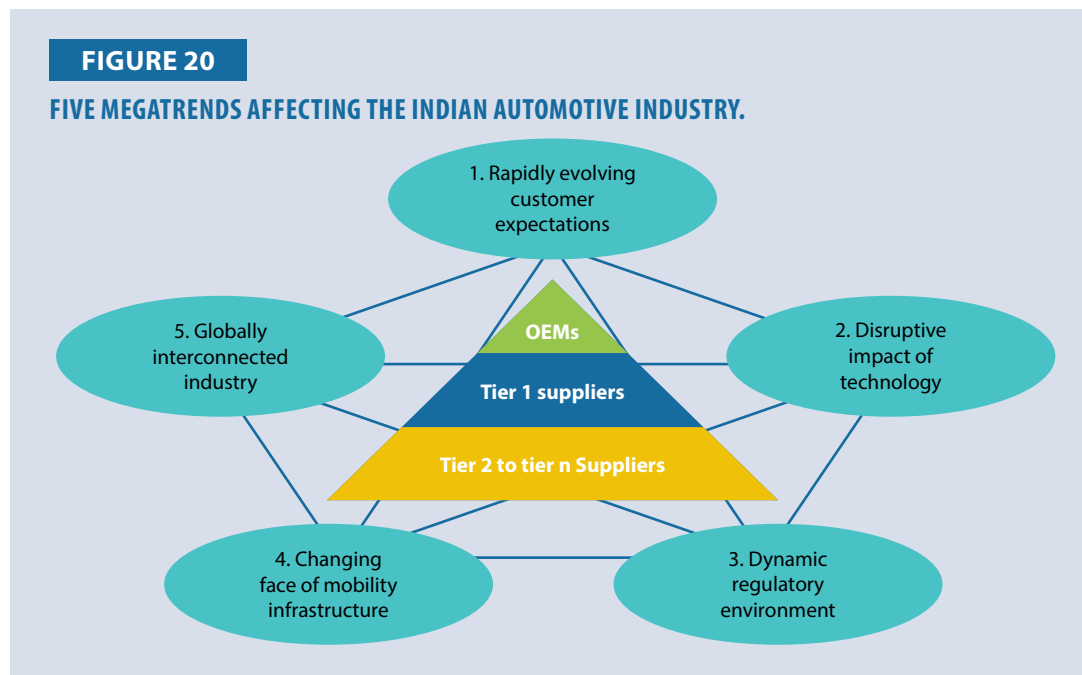
As per a Capgemini Research Institute report, productivity will increase up to \$167 billion in the next three years. Smart manufacturing is important for the automotive industry because technologies can improve productivity, reduce human error, and enable mass customization. Around 30% of the automobile industry (Figure 19) is invested in the latest technologies such as 3D printers, robots, and driverless floor conveyors.



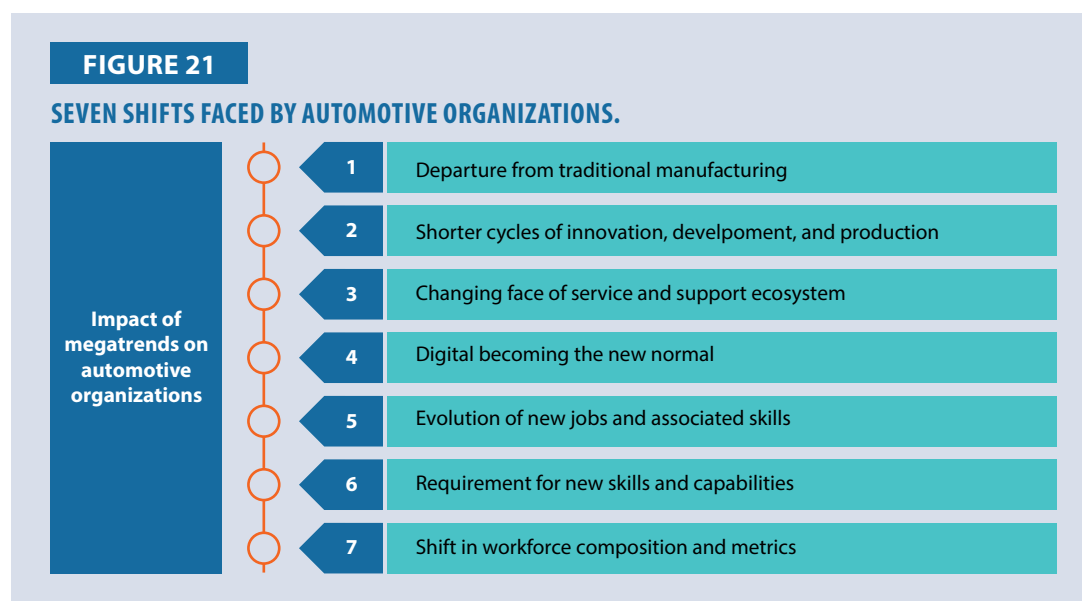


### Impact of Megatrends on Automotive Organizations

Utilization of IT and incorporation of technological research on manufacturing merchandise and procedures will not be something new for the automotive industry. Nevertheless, IoT, AI, robotics, and machine learning are part of the Industry 4.0 evolution and constitute the next step of progression.



Due to various megatrends impacting the automotive industry (see Figure 20), interruptions and new methods of working are required to drive irrevocable changes in the automotive industry, which will likely create substantial prospects for the country as a whole. Based on the Automotive Mission Plan 2016–26 (AMP 2016–26), the automotive industry is set to become the most significant industry for creating jobs in India, with the rollout of around 65 million jobs in the coming years. This ought to play an important role in the country's development. However, there could be unexpected challenges as well. Seven crucial challenges should be considered, as shown in Figure 21.

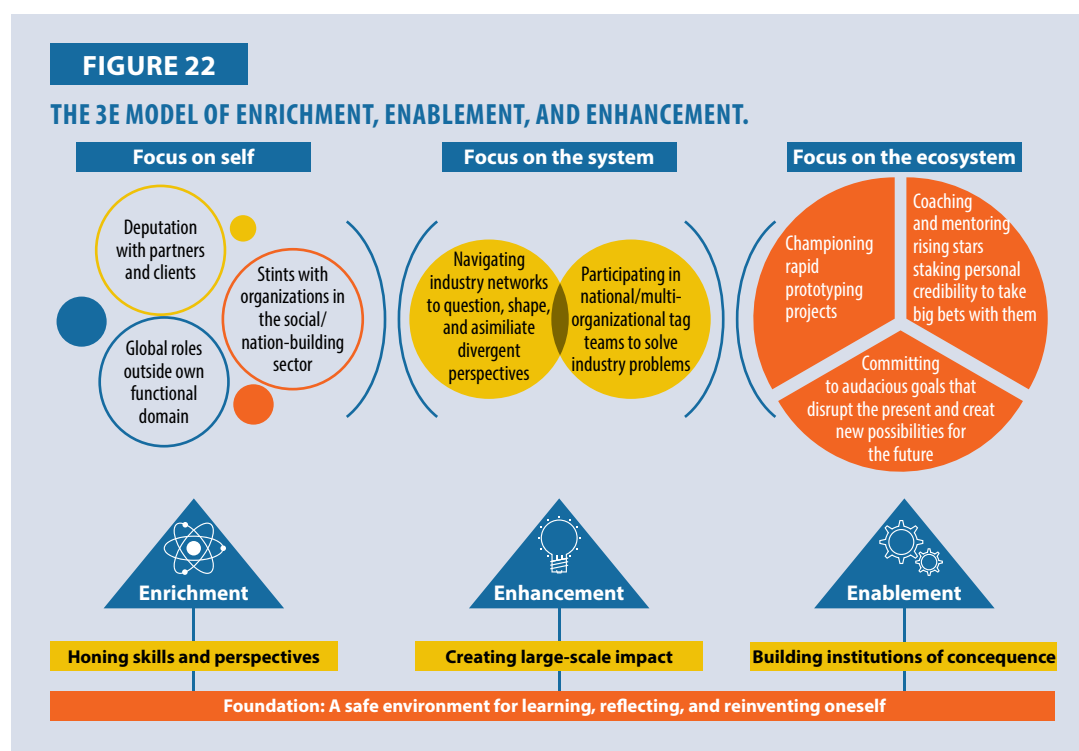


### Future Skills in the Automotive Industry

Careers within the industry and related abilities are rapidly developing. While many new careers are expected to appear in the coming years, skills-related demands from existing jobs will also be different. The industry has been investing heavily in automation and digitization for the past several years, which will continue to be a pattern.

### Meeting the Ability and Capacity Gap

In the near future, an achievement will be a distinctive amalgamation of the expertise that organizations provide and what the ecosystems offer and need. Therefore, improvement will actually be gauged by a three-dimensional perspective focusing on three pillars of enrichment, enablement, and enhancement for continual growth (see Figure 22).



Indeed, it is not easy to determine exactly how the automotive industry in future will pan out in India and around the world. We should therefore prepare ourselves, based on knowledgeable forecasts to deal with the challenges ahead and prosper amidst ambiguity and mayhem. The achievements of automotive organizations will be based not on the quantum of sources they could use to accurately determine the future, but on how well they could ready themselves to deal with difficulties that are still unidentified. In this situation, it will likely be essential for executives to produce problems where organizations, as well as the individuals, can constantly learn, develop, and take actions at speed. Most significantly, the automotive industry will need to fix the problems of today and be prepared for the long run.

Isolated, organization-level techniques and equipment will no longer permit organizations to deal with the difficulties caused by disruptive forces. The necessity to develop options with an ecosystem perspective, leveraging cross-organizational techniques and performance programs, can become more significant than in the past. An equilibrium between methods and treatments and a focus on quality during any function that various teams perform will be important for organizations to

address gaps in quality and timelines. For the automotive industry to achieve success, it should set up an agile, nimble, and motivated workforce. These measures will equip it to realize its aspirations and achieve expansion goals.

### Apparel and Textiles Industry

India is one of the world's most significant suppliers of textiles and apparel. Around 2.3% of the country's GDP, 13% of industrial production, and 12% of export revenues come from the textiles and apparel industry. This industry is definitely the next-largest in the country and offers jobs to 45 million individuals. It is anticipated that this number will grow to 55 million by 2020. FDI in textiles and apparel reached approximately \$3.1 billion during 2018–19. Exports from the industry are aimed at USD300 billion by 2024–25, with a view to tripling India's market share from 5% to 15%.

The apparel manufacturing industry all over the world has been witnessing a change in demand as well as in the method of manufacturing. This is said to disrupt the conventional ways of apparel manufacturing. While some seem to proactively work towards the change, others fear it owing to lack of knowledge. In such times, steady preparedness, along with the right knowledge and right resources, will help the industry to sail smoothly despite the rough tides.

Millennials and their ever-changing demands and hunger for 'newness' are the reasons behind the industry requiring to be 'disrupted.' The growing trend of customization and expectation of faster delivery times has made us arrive at a point where manufacturing does not even start until the customer places an order.

Dr. Mike Fralix, Technology Evangelist at Soft Wear Automation, which creates autonomous worklines for sewn goods, points out that millennials' ever-changing demands and hunger for 'new' is the reason behind the fashion industry requiring to be 'disrupted.' According to him, the growing trend of customization and expectation of faster delivery times has made us arrive at a point where manufacturing does not even start until the customer places an order. Producing near to the consumer will shorten the gap between the manufacturer and the customer, all of which is possible through technology.

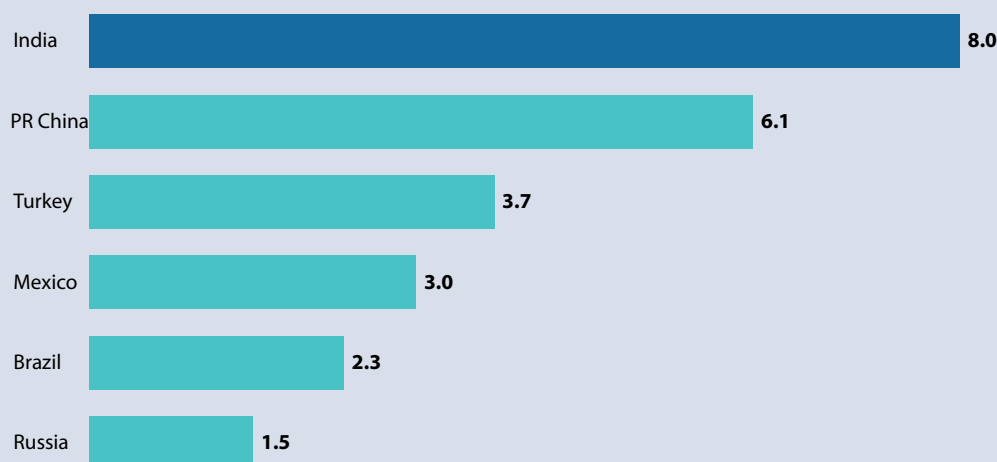
Dr. Fralix opines that single operation is dead, and the path forward is automation from roll to finished goods. He sums up Industry 4.0 as the "integration of technologies for customer satisfaction through advanced manufacturing system."

As shown in Figure 23, it was predicted that India's GDP would grow 8% annually during the period 2018–22. Accordingly, India will become an extremely attractive consumer market in Asia.

Retailers in India have improved customer in-store experience by introducing digital marketing displays as well as self-checkout services, and malls are expanding the size of entertainment centers and food courts.

In the year 2018, the smartphone users base in India stood at 355 million while the internet user base was 460 million. These figures are estimate to reach 900 million by 2021. The apparel industry is also going to benefit from this transformation.

Nowadays, artificial intelligence is playing a key role in e-commerce. "Personalization and curation based on personal taste will become a lot more important," says Ananth Narayanan, who earlier

**FIGURE 23****OUTLOOK FOR INDIA'S GDP GROWTH.****Real GDP compound annual growth rate, 2018–22 forecast, %****Source:** Economist Intelligence Unit

served as the CEO of fashion and lifestyle e-marketplaces Myntra and Jabong. “It’s not about having the largest selection; it’s about presenting the most appropriate selection to the customer involved,” he states.

The average labor costs in India are lower than those in both PR China and Vietnam, especially in the textiles and apparel industry. Additionally, the ‘Make in India’ program brings many benefits, especially in terms of creation of more jobs. As The World Bank has noted in the ‘World Development Report, The Changing Nature of Work,’ the work is shifting with technology. Specific skills are required for new jobs, so how the next generation responds to the changing nature of work has become a key challenge for India. The government should invest more in good, formative education and healthcare for the poorest to reduce inequalities and make sure that all in the next generations obtain the opportunity to change their lives. The rise of new technologies is rapidly affecting India, and relevant government agencies should respond quickly and flexibly to formulate long-term plans for various needs.

In Industry 4.0, machines will be able to adapt, configure, and optimize themselves while using CPS to make decentralized decisions. Industry 4.0 will be the goal of future factories. Most industries have a long way to go before achieving these objectives. Thus, it is crucial for APO member countries to select priority industries and allocate more resources for pilot projects through joint efforts of government agencies and national productivity centers (NPOs).

Furthermore, international technical service teams should be formed to integrate related efforts and domain experts in various industries to deliver information sessions in member countries and address their interests and needs in implementing smart manufacturing projects via customized solutions.

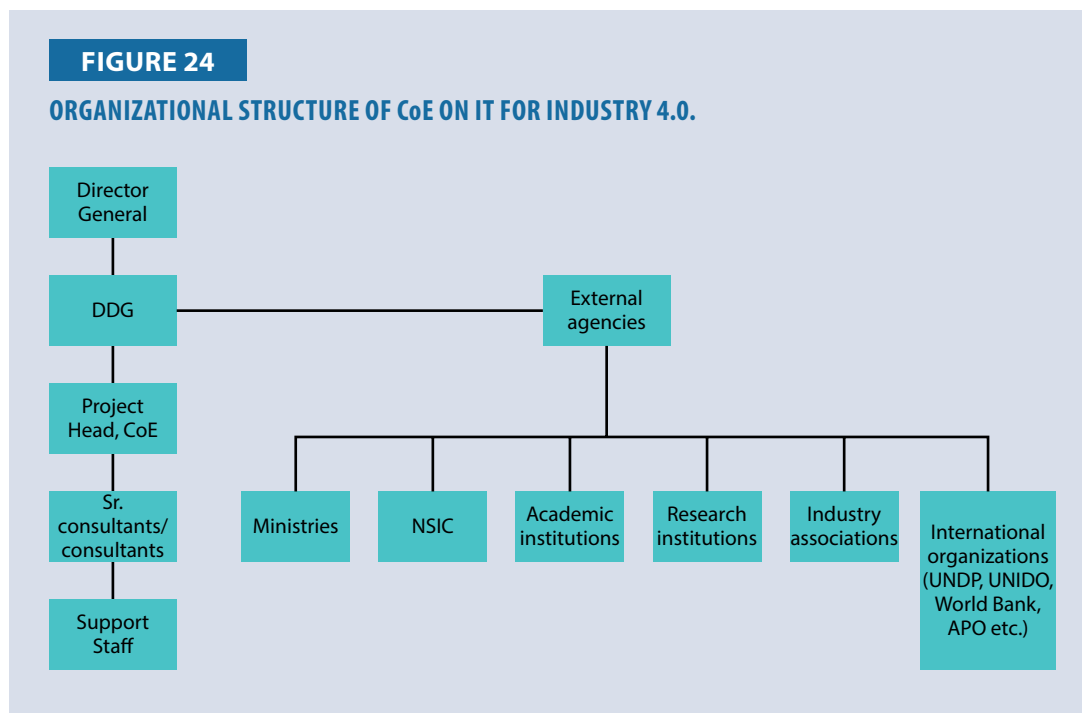
In particular, the CoE on Smart Manufacturing should continue to strengthen its operations, promote its achievements across various industries, share its experiences with member countries, and engage in the consensus-forming processes to promote smart manufacturing for APO economies continuously.

### CoE on IT for Industry 4.0

The National Productivity Council (NPC) in India was established in 1958 in order to enhance the competitiveness and manufacturing capability of the country. In 2017, the APO established a CoE on IT for Industry 4.0 in India.

#### Organizational Structure

- The CoE team consists of dedicated staff and draws experts from other organizations within India and across the APO to assist in specific initiatives. The CoE will engage external experts as needed, both in the current startup phase and in the upcoming implementation phase. In addition, the CoE will utilize staff in the NPC's network of regional offices. The organizational structure is given in Figure 24.



- As the organization chart illustrates, the CoE will utilize the strong network that the NPC has established with various stakeholders comprising consultants and other organizations, government agencies, industry associations, and international organizations, including the UNDP, UNIDO, and The World Bank. It is also supported by the APO's technical advisors. In addition, the CoE will be establishing a hub-spoke delivery structure linked with the NPC's network of 13 regional offices across India.

#### CoE's Focus

The NPC India has outlined the following directions for the CoE:

**Purpose:** To bring a paradigm shift in manufacturing strategies

**Vision:** To be the knowledge center in India and to provide support to Asia-Pacific on I4.0, showcasing the success stories of digital transformation for improving manufacturing competitiveness

**Mission:** To help in transforming manufacturing processes of SMEs with I4.0 technologies

The broad objectives of the CoE are to

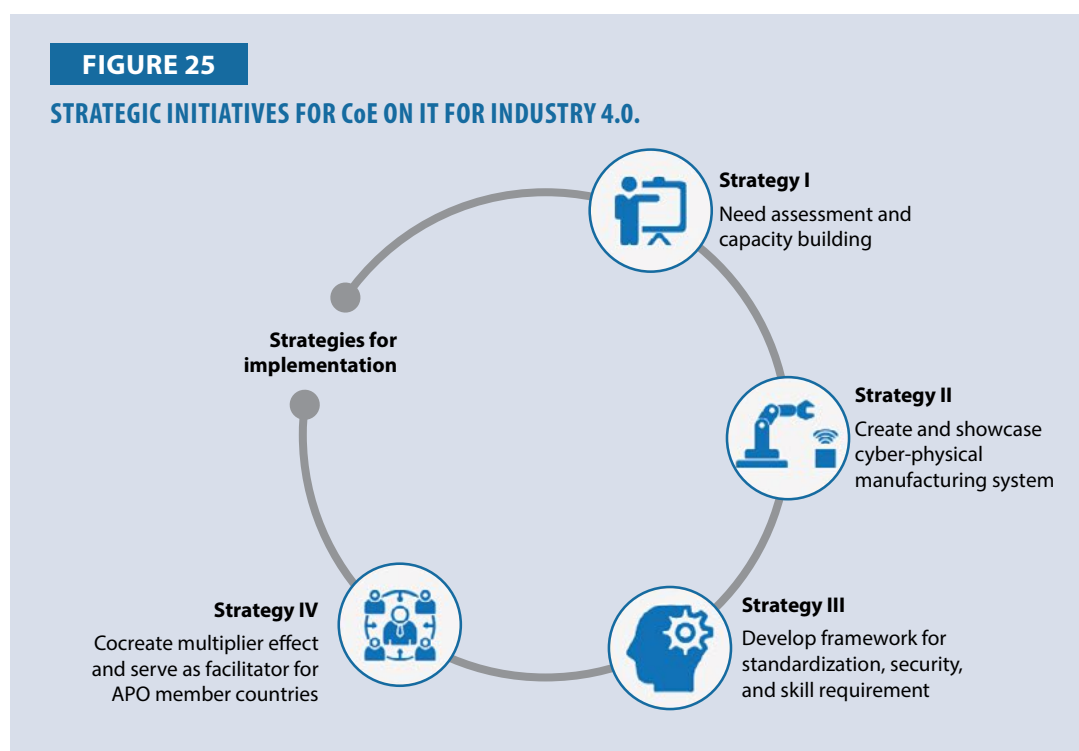
1. create awareness and develop knowledge base on I4.0;
2. showcase connected industries using I4.0 technologies; and
3. disseminate knowledge to various stakeholders.

**Functions:** The key functions of the CoE are to

1. group technical and domain experts to work together with APO member countries;
2. lead MSMEs and startups into latest technologies; and
3. establish industry–academia linkages to solve the productivity issues.

The NPC has identified four strategic implementation initiatives that it should undertake in a stepped manner over its first three years of operations. As shown in Figure 25, these are

1. conducting needs assessment and capacity building (2019);
2. creating and showcasing a cyber-physical manufacturing system (2019–20);
3. developing framework for standardization, security, and skill requirement (2020); and
4. cocreating multiplier effect and providing the facilitator’s role to APO member countries (1920–21).



**Resources (finances):** The CoE reported a projected budget for the initial five years on an approximately 50/50 cost-sharing basis between the CoE and the APO. However, the forecast predicated some fluctuation over the period (see Table 14). The CoE has an aggressive strategy to ensure the financial sustainability of the CoE as the program delivery ramps up.

**TABLE 14**  
**BUDGET PROJECTIONS AND SHARING BETWEEN APO AND CoE, 2017–21.**

Agency	2017–19	2020 (Projected)	2021 (Projected)
APO	USD208,340	USD57,000	USD125,000
CoE	INR8,825,000 (USD119,257)	INR15,000,000 (USD202,703)	INR18,700,000 (USD252,703)
Total	USD327,597	USD259,703	USD377,703
APO%	63.5%	22%	33.09%

#### Marketing and Communications

The CoE has established a web portal, <https://coeindustry4.in>. Here, all activities related to CoE on IT for I4.0, e.g., Demonstration Project on Industry 4.0, outcome videos and reports, reports of activities of CoE, etc. are being uploaded on regular basis.

#### Planning and Implementation

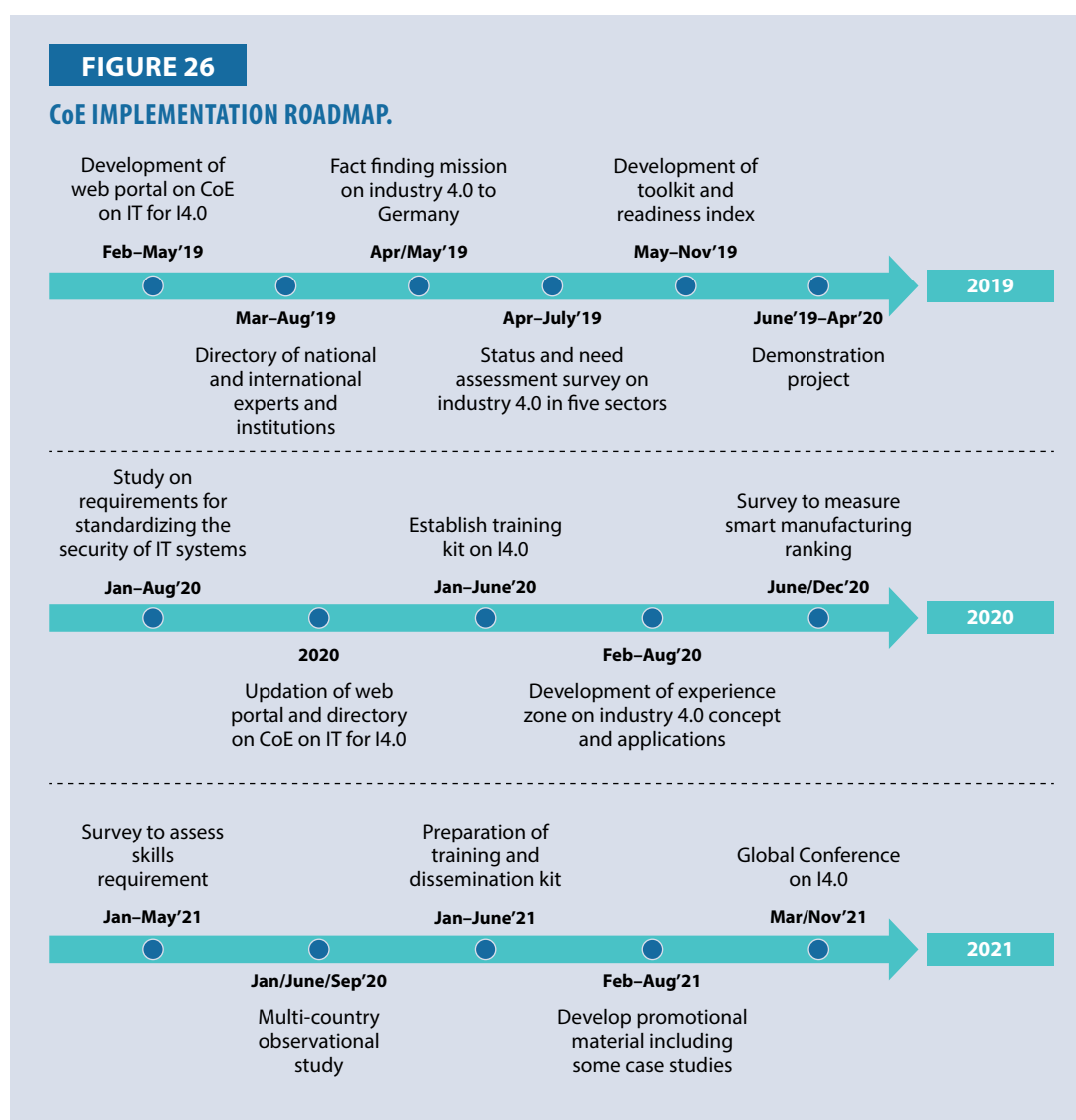
Figure 26 illustrates the CoE's roadmap for three years (2019–21), which is aligned with achieving its objectives.

The CoE is striving to create the digital ecosystem for augmenting the capabilities and capacities of manufacturing SMEs and startups at an enterprise/unit level. The CoE aims to create and highlight cyber-physical manufacturing systems through creation of experience zones in key industrial sectors, and by undertaking a demonstration project that will provide information about complete cycle of implementation of Industry 4.0 technologies besides productivity improvement. Some of the major activities completed, planned, or ongoing are discussed next.

In order to highlight the real-time benefits through application of smart technologies, the CoE has undertaken a demonstration project in association with the APO on 'Application of Smart Technologies' at Vibgyor Automotive Ltd, Chennai and an auto component manufacturer. The smart transformation of value chain in business process, use of smart technology and smart solutions, and empowerment of workers has shown very positive results with quality improvements, enhanced overall equipment effectiveness (OEE) monitoring, and improved inventory turnover ratio (ITR) that amounted to total savings of INR5 million per year.

Further, the CoE is also leading the implementation of the Demonstration Project on IT for Industry 4.0 in five SME companies in the Delhi–NCR region in association with the APO. These demonstration companies will serve as lighthouses and training centers for further propagation of Industry 4.0 among SMEs and other companies.

A research study spanning five sectors (automotive, food processing, agriculture machinery, pharmaceutical and healthcare, and textiles and garments) is underway to assess the current level of digitization and the readiness for Industry 4.0 in these sectors. The outcome of the research study will form the basis for further policy interventions required to bridge the gap for adoption of Industry 4.0 on a wider scale in the manufacturing sector.



A directory of national and international expert and institutions to create a robust pool of technology pioneers working on the latest concepts and technologies related to Industry 4.0 is currently under development. This will serve as a basis for reaching out to a wider gamut of experts to make them part of the knowledge chain for sharing, learning, collaboration, and cocreation for mutual benefits.

As per the roadmap, the CoE is also developing an experience zone at the NPC's headquarter in Delhi in the form of a studio for digital display of storyboards with cases, etc. on the walls. It will also incorporate virtual reality (VR) displays of use cases in the forms of films and other multimedia to create a virtual manufacturing environment.

An I4.0 assessment model is being developed to assess the current level of digitization and readiness for Industry 4.0 among the manufacturing industries/SMEs. It will also be able to identify gaps and critical requirements and strategies for the industries, including SMEs, to transform and rise to the next level of 'connected industry.'

The CoE's strategy, as noted above, is to propagate the concepts and applications of I4.0, and develop the analytical tools and information materials. To educate and demonstrate the potential



and impact of I4.0, the CoE is creating experience zones at its headquarters. The CoE is also working with best-practice Industry 4.0 implementers to recognize some existing I4.0-enabled highly productive organizations as demonstration sites. Once these are established, the CoE will encourage industries/SMEs in India and other APO member countries to visit these sites to learn more about Industry 4.0. As other NPOs indicate their interests, the CoE will work with them to undertake in-country needs assessments on a sector-to-sector basis.

#### Framework for Industry 4.0 Implementation

In order to upgrade the activities of the CoE on a wider scale, it has taken up a new initiative and developed a framework for developing academic-industry linkages comprising the following components:

**Empanelment of academic institutions and consulting companies:** Five academic Institutions and six consulting companies are the implementation partners of the CoE.

**Outreach CoEs (OCoE) as E-Grow centers:** The overall objective of this initiative is to transform OCoEs established at the empaneled universities into E-Grow centers to support industries, enterprises and academia through project implementations and helping the SMEs to grow. At the OCoEs, three verticals will be set up under the overall umbrella of CoE on IT for I4.0. These three verticals will be augmented by the 3M concept, encompassing **Man** (Enterprise 4.0), **Machine** (Industry 4.0), and **Market** (Marketing 4.0).

Marketing 4.0 adapts to the wave of the new industrial revolution, which in turn adapts to the new consumer behavior by introducing intelligent production systems. These systems allow to know in advance the tastes and needs of users and to overcome the limitations of the traditional mass-market approach in delivering personalized consumer experiences. Industry 4.0 enables technological interventions through IoT, data analytics, 3D printing, AI, etc. Enterprise 4.0 focuses on the human empowerment (new skills) required to manage highly skilled business operations.

The CoE, NPC will oversee the transformational processes of the OCoEs to align with the above model through detailed studies of existing human skills, infrastructure, and industrial ecosystems in their vicinity and will chart out development roadmaps for each OCoE.

**Functions of Outreach CoEs:** These OCoEs at universities will act as partners of the CoE and coordinate for conducting the following activities:

- Industry awareness programs under the banner of CoE Cell, NPC: The aim is to enlighten the industry, including SMEs on latest concepts on I4.0, innovation, and growth model for generating interest and selection for project implementations in those SMEs.
- Implementing Industry 4.0 projects at SMEs: The CoE Cell, NPC, and the empaneled academic institutions and consulting companies will combine to form a triparty wherein CoE Cell, NPC will function as the hub, while the academic institutions and consulting companies will work as spokes. A designated team termed I4.0 Taskforce, consisting of professors and students/research associates will be formed and attached to a chief consultant from the consulting company empaneled with the CoE Cell, NPC to form an I4.0 Implementation Group. This group will take the Industry 4.0 projects to manufacturing industries/SMEs present in and around the regions of each OCoE. The CoE

Cell, NPC will be the focal point for coordinating the overall implementation of the I4.0 projects, apart from carrying out the initial assessment to check the readiness of SMEs for Industry 4.0, along with the I4.0 Implementation Group.

- Development of entrepreneurship: This will be done through the Real Time Entrepreneurship Program under Enterprise 4.0 and Marketing 4.0.
- Development of two credit systems per year at empaneled universities: The development of both faculty and students will be undertaken through participation in real-time projects on Industry 4.0, Enterprise 4.0, and Marketing 4.0.

As a pilot, a workshop on ‘Innovative Business Transformation Tools’ was organized at Sharda University in Greater Noida on 13 March 2020, where SME owners from the Noida and Greater Noida region participated. A needs assessment survey was also conducted during the workshop. The industries appreciated the impact and recognized the need for implementation of innovation in their businesses through Industry 4.0, Enterprise 4.0, and Marketing 4.0. Most of them have shown willingness for NPC-led detailed assessments at their respective plants to ascertain the major pain areas and chart out implementation roadmaps for their industries.

## Indonesia

Indonesia needs to address several challenges related to smart manufacturing implementation. These issues range widely from underdeveloped and upper to midstream industries. Although ‘Making Indonesia 4.0’ has been taken up seriously by the government, the country’s readiness is deemed low. A lack of adequate access to finance, underleveraged geographic potential, inadequate digital infrastructure, overcomplicated regulations, an absence of innovation centers, and a lack of trained workers despite having the fourth-largest working population globally, are constraints for the program. These barriers result from the inability to upgrade products due to capacity limitations, limited R&D, and shortage of skilled workforce to upgrade their skills. These issues are common with SMEs. The government regulation plays a critical role in licensing and allocation of sites because a complex regulation is considered a significant constraint.

In general, Industry 4.0 opens up a great opportunity for Indonesia’s manufacturing sector in order to boost productivity and enhance its competitiveness in the global market. However, Indonesia’s productivity improvement looks slow because of growing labor costs that can result in weakness against competitors in the global market.

Indeed, Indonesia has abundant working population because of demographic dividend, but in contrast, it has a limited pool of trained talents. Indonesia’s R&D expenditure is merely about 0.1–0.3% of GDP, which is considerably low. Additionally, national spending on information and communication technology (ICT) is deficient. Recognizing these challenges, the government took the initiative to create a concrete strategy to help the manufacturing sector reap the benefits of the industry 4.0.

To address the challenges, Indonesia should focus on its strengths, e.g., utilize the multiple resources including a large working population, a strong demand from foreign markets, stable economic growth, and abundant natural resources. These challenges range from poor infrastructure to complex regulatory environments.

TABLE 15

## PATH TO ACHIEVING INDUSTRY 4.0 IN FIVE PRIORITY SECTORS.

Food and beverages	<ul style="list-style-type: none"> <li>• Improve upstream agri sector productivities by adopting new technologies</li> <li>• Empower SME segment by funding and technology support</li> <li>• Improve supply chain efficiencies</li> <li>• Enhance modern packaged food productions by product innovations</li> <li>• Scale up the industry by leveraging domestic demand</li> <li>• Accelerate export and be the regional food and beverage powerhouse</li> </ul>
Textile and garments	<ul style="list-style-type: none"> <li>• Improve upstream capabilities locally</li> <li>• Enhance productivity by adopting technologies</li> <li>• Build functional clothing design and production capabilities</li> <li>• Establish textile industrial clusters and promote vertical integration</li> <li>• Scale up and leverage economies of scale to be competitive in the global market</li> </ul>
Automotive	<ul style="list-style-type: none"> <li>• Enhance raw material and key component productions</li> <li>• Improve productivity by adopting technology and building infrastructures</li> <li>• Align with global OEMs to boost support for specific vehicle type (MPVs, SUVs)</li> <li>• Cultivate EV production capabilities starting with e-motorcycle</li> <li>• Build EV industry ecosystem</li> </ul>
Electronics	<ul style="list-style-type: none"> <li>• Attract top global manufacturers</li> <li>• Build advance manufacturing capabilities beyond assembly</li> <li>• Nurture skilled labor force</li> <li>• Enhance innovation capabilities locally</li> <li>• Cultivate domestic champions</li> </ul>
Chemicals	<ul style="list-style-type: none"> <li>• Enhance domestic petrochemical capacity and reduce reliance on import</li> <li>• Optimize industrial zones to leverage domestic natural gas and oil resources</li> <li>• Improve productivity by adopting 4IR technologies</li> <li>• Accelerate R&amp;D activities to establish next generation biofuel and bioplastic capabilities</li> <li>• Build and export position by leveraging economies of scale</li> </ul>

4IR=fourth industrial revolution; EV=electric-powered vehicle; MPV=multipurpose vehicle; OEM=original equipment manufacturer; R&D=research and development; SME=small and medium enterprise; SUV=sport-utility vehicle.

Source: Ministry of Industry, Government of Indonesia.

TABLE 16

## NATIONAL PRIORITIES TO ACHIEVE INDUSTRY 4.0.

National Priorities	Key Strategies
1. Reform material flow (enhance domestic production of inputs)	<ul style="list-style-type: none"> <li>• Enhance domestic upstream material production; e.g., 50% of petrochemicals are imported</li> </ul>
2. Redesign industrial zones	<ul style="list-style-type: none"> <li>• Build a single nationwide industry zoning roadmap; resolve zoning inconsistency challenges</li> </ul>
3. Embrace sustainability	<ul style="list-style-type: none"> <li>• Grab opportunities under global sustainability trend; e.g., EV, biofuel, renewables</li> </ul>
4. Empower SMEs	<ul style="list-style-type: none"> <li>• Empower 3.7 million SMEs through the use of technologies; e.g., build SME e-commerce and technology park</li> </ul>
5. Build nationwide digital infrastructure	<ul style="list-style-type: none"> <li>• Advance network and digital platforms; e.g., 4G to 5G, fiber speed 1 gigabyte, data center and cloud</li> </ul>
6. Attract foreign investments	<ul style="list-style-type: none"> <li>• Engage top global manufacturers with attractive offers and accelerate technology transfer</li> </ul>
7. Upgrade human capital	<ul style="list-style-type: none"> <li>• Redesign education curriculum under 4IR era</li> <li>• Create professional talent mobility program</li> </ul>
8. Establish innovation ecosystem	<ul style="list-style-type: none"> <li>• Enhance R&amp;D centers by government, private sector, and universities</li> </ul>
9. Incentivize technology investment	<ul style="list-style-type: none"> <li>• Introduce tax exemption/subsidies for technology adoption and support funding</li> </ul>
10. Reoptimize regulations and policies	<ul style="list-style-type: none"> <li>• Build more coherent policies/regulations through cross-ministry collaborations</li> </ul>

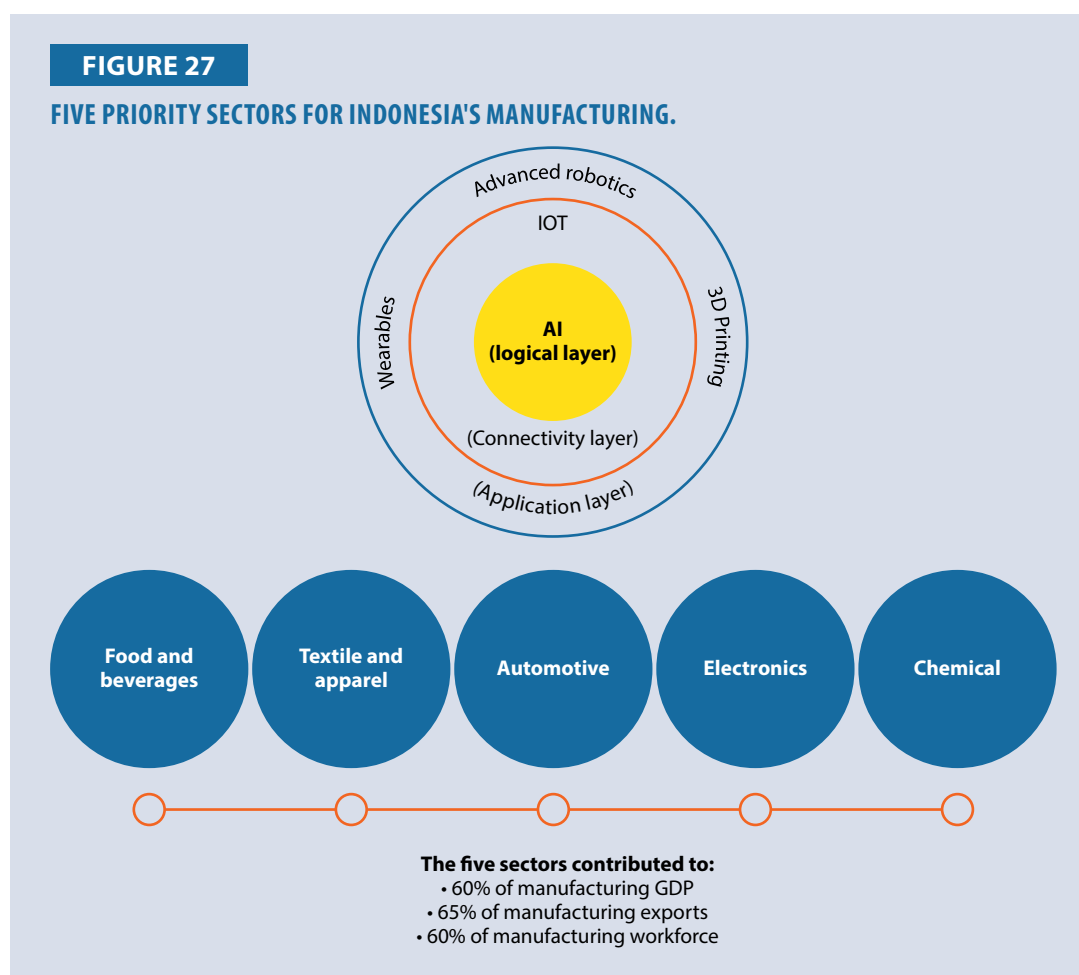
4IR=fourth industrial revolution; EV=electric-powered vehicle; R&D=research and development; SME=small and medium enterprise.

Source: Ministry of Industry, Government of Indonesia.

The government is optimistic that the ‘Making Indonesia 4.0’ program will improve the annual real GDP growth by 1% to 2% between 2018 and 2030. It is assumed that the real GDP growth will increase from the current 5.5% to 6–7% per year between 2018 and 2030, as stated by the Ministry of Industry from the World Bank, Badan Pusat Statistik, the Ministry of Industry, and A.T. Kearney.

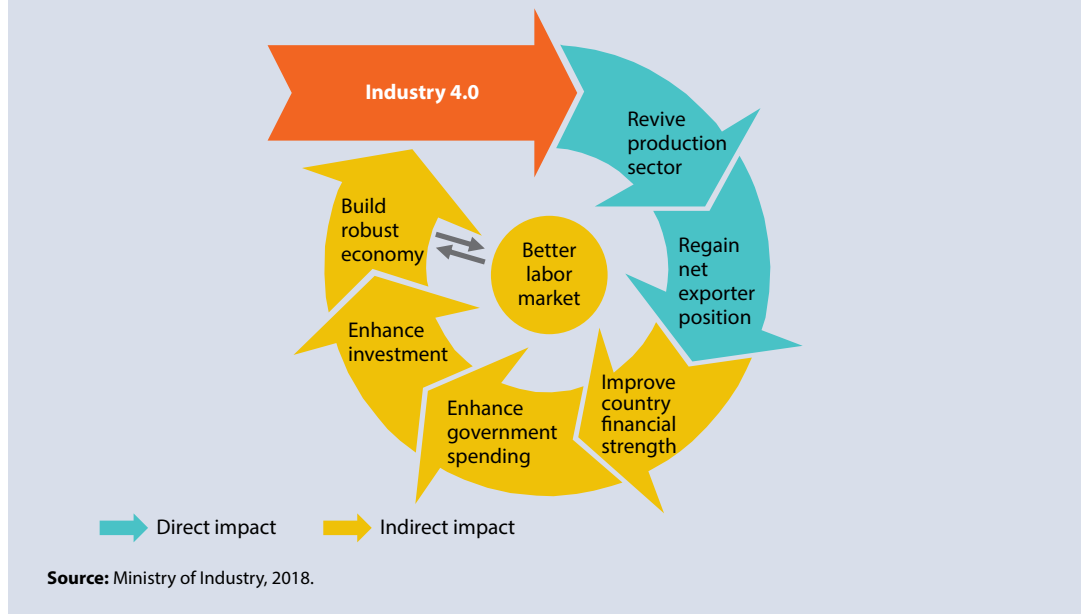
In the ‘Making Indonesia 4.0’ roadmap, five sectors are named as priority sectors. These priority sectors (food and beverage, automotive, textile, electronics, and chemicals) need focused resource allocations with corresponding development plans to enable migration using feasible technology roadmaps. They also need to upgrade their workforces as an important step on the way to Industry 4.0 (see Tables 15 and 16).

The five priority sectors are key to Indonesian manufacturing. They have been selected based on economic implementation and feasibility criteria, including GDP size, trade size, potential impact on other industries and speed of market penetration. Figure 27 illustrates the five priority sectors.



The implementation of industry 4.0 in Indonesia is potentially geared towards realizing direct and indirect positive impacts (see Figure 28). The direct impact is to revive the production sector and regain the position of a net exporter. The indirect impacts, according to the Ministry of Industry, would be increased financial strength, government expenditure, investment, and building of a strong economy.

**FIGURE 28**  
**DIRECT AND INDIRECT IMPACT OF INDUSTRY 4.0.**



There are several characteristics of Industry 4.0 according to the Ministry of Industry, including

- using a cyber-physical system;
- making activities more effective and efficient;
- real-time data gathering and analyses;
- improving productivity;
- relevance of internet of things;
- product customization; and
- accommodating sustainability plans.

Industry 4.0 is required to accommodate sustainability standards. Indonesia views the challenges of sustainability as an opportunity to build national industrial capacity based on clean technology, electricity, biochemistry, and renewable energy. Automotive-related industries contribute about 28% to the manufacturing GDP. Related automotive industries and supply chains (about 28%) account for 6% of the total GDP.

Making Indonesia 4.0 aims to deliver a significant increase in GDP growth, with creation of new jobs and increased contribution of manufacturing GDP. The policy, however, needs to be well coordinated and integrated with several stakeholders and other policies. An active collaboration between government, industry, and education is needed. Technology incentives, investor roadshows, vocational schools, and support for small and micro businesses is required as well.

The government has prepared Industry 4.0 Readiness Index (INDI 4.0), a reference index for industry and government in measuring the level of readiness of the industry to transform towards Industry 4.0. Workshop Self-Assessment INDI 4.0 was held in March 2019 in Jakarta to measure the readiness in conducting transformation towards industry 4.0. This event aimed to provide an understanding for measuring the readiness toward Industry 4.0. The participants of this event comprised 50 participants from the food and beverage industry and another 50 participants from the electronics industry. In addition, the event also provided an award for those who had already achieved a certain level in applying Industry 4.0 concepts in their firms.

Moreover, since SMEs make up 70–90% of manufacturing companies, as per ASEAN Statistical Yearbook 2016–17, the government tries harder to support the SMEs by facilitating training, business assistance, and providing grants. According to statistics, the growth of SMEs in Indonesia is increasing with time. SMEs are critical to Indonesia's economy. Considering their contribution to 97% of operational businesses and they being large providers of employment, it is important that more effort is exerted by the government to provide a sustainable environment for them [3a]. Therefore, it is crucial to pay more attention in implementing the smart manufacturing concept in SMEs.

The government has put in more efforts to raise awareness among SMEs and to prepare them for the future through increased understanding of the technological disruption. With 'Making Indonesia 4.0,' the government expects to improve the labor productivity and achieve higher market value added (MVA) in priority industries. Indonesia and some other ASEAN countries are facing similar challenges in approaching Industry 4.0, as the industrial infrastructures may not be ready for direct migration.

Since the launch of Making Indonesia 4.0 by President Joko Widodo in April 2019, the Ministry of Industry has produced a number of strategic policies to implement the program. Furthermore, an e-Smart SMEs program was initiated for promoting SME products through an e-commerce platform. The government also continues to encourage R&D activities and facilitate the development of the 4.0 industry innovation center.

Indonesia is one of those countries in ASEAN who tried to reduce the logistic costs in order to improve competitiveness. An efficient logistics and connectivity of supply chains can help reduce trade costs. However, most of the SMEs in Indonesia are not ready to apply the concept of smart factory as well as Industry 4.0 in their business settings. Merely 25% of total SMEs in Indonesia have adopted supply chain management software to manage logistics and distribution, according to A.T. Kearney.

During this time, the five priority sectors were able to contribute 60% of the GDP and 65% of total exports. Also, of the total industrial workforce, 60% was in the five priority sectors, according to the Ministry of Industry. Moreover, in supporting the implementation of Industry 4.0 in Indonesia, the Ministry of Industry continues to develop ecosystems that support the growth of innovations in the manufacturing sector. For example, the Ministry of Industry has built three units of the Industry 4.0 mini showcase, namely Mocaf 4.0 at the Bogor Agro Industrial Center (BBIA), Vision 4.0 at the Bandung Metal and Machining Center (BBLM), and Cacao 4.0 at the Indonesian Plantation Industries Center (BBIHP) Makassar.

The three mini showcases will conduct continuous improvements so that the public can directly see the simulation of industry 4.0 implementation. This facility is also expected to stimulate the growth of innovations believed to be able to accelerate the mastery of Industry 4.0 technologies in Indonesia while increasing the capacity of national innovators or researchers.

The Agency of Industrial Research and Development has held the Bandung Research Expo (Bandrex) 2019 as the media for the dissemination of information on the results of R&D services conducted by the Ministry of Industry. Through this Bandrex 2019 activity, it is expected to produce constructive ideas and innovations that can provide maximum benefits in increasing the competitiveness of national industries. In fact, it can strengthen the fabric of good cooperation between R&D institutions and other stakeholders, as well as the community.

In addition, the other program being run by the Ministry of Industry in the industrial sector is Digital Capability Center (DCC). By establishing this digital capability center, it is expected to encourage the development of technology. This program is designed as part of increasing productivity and competitiveness of the manufacturing sector in the industrial era. The plan is being conceptualized, and in the next two years, the government will have the DCC in collaboration with multinational management consulting firm, McKinsey. This facility needs to be built, along with the efforts to develop the industry towards 4.0, because domestic devices, networks, and applications (DNA) should be developed.

The construction of DCC would also see collaboration with a technology R&D institution in the ROC called the Industrial Technology Research Institute (ITRI). The model might be similar to the DCC that already exists in Singapore. The DCC development is expected to be utilized by industry players who have not implemented digitalization, especially the SMEs.

## Philippines

The fundamental goal of the Philippine industrial strategy is to build a strong globally competitive industry with domestic and global linkages [52]. About 95% of industries in the Philippines are micro, small and medium enterprises (MSMEs). Except for some local large factories, many medium and large factories that belongs to multinational companies are located in Philippine Economic Zone Authority (PEZA) special economic zones. The multinational companies that mainly export their finished products are the major contributors to the country's dollar income. In order to create higher-quality jobs and attain sustainable and inclusive growth in Philippine industry, Department of Trade and Industry (DTI) conducts the Comprehensive National Industrial Strategy (CNIS) by upgrading manufacturing and integrating it with the agriculture and services sectors. There are five main sectors that are viewed as priority industries. These are manufacturing, agribusiness, IT-BPM, tourism, and infrastructure and logistics [19, 47] (Figure 29).





Since Industry 4.0 poses new challenges and opportunities, it is critical for the government to build an innovative ecosystem. Based on CNIS, the government upgraded the framework and released the Inclusive, Innovation-led Industrial Strategy (i3S) in 2017 (see Figure 29). Similar to CNIS, the upgraded industrial strategy also focuses on competition, innovation, and productivity but lays more emphasis on innovation [52]. The i3S framework has the following five pillars: (1) build new industries, clusters, and agglomeration; (2) build and develop capacity and human resources; (3) focus on MSME growth and development; (4) innovation and entrepreneurship; and (5) create a better and easier environment for business and investment.

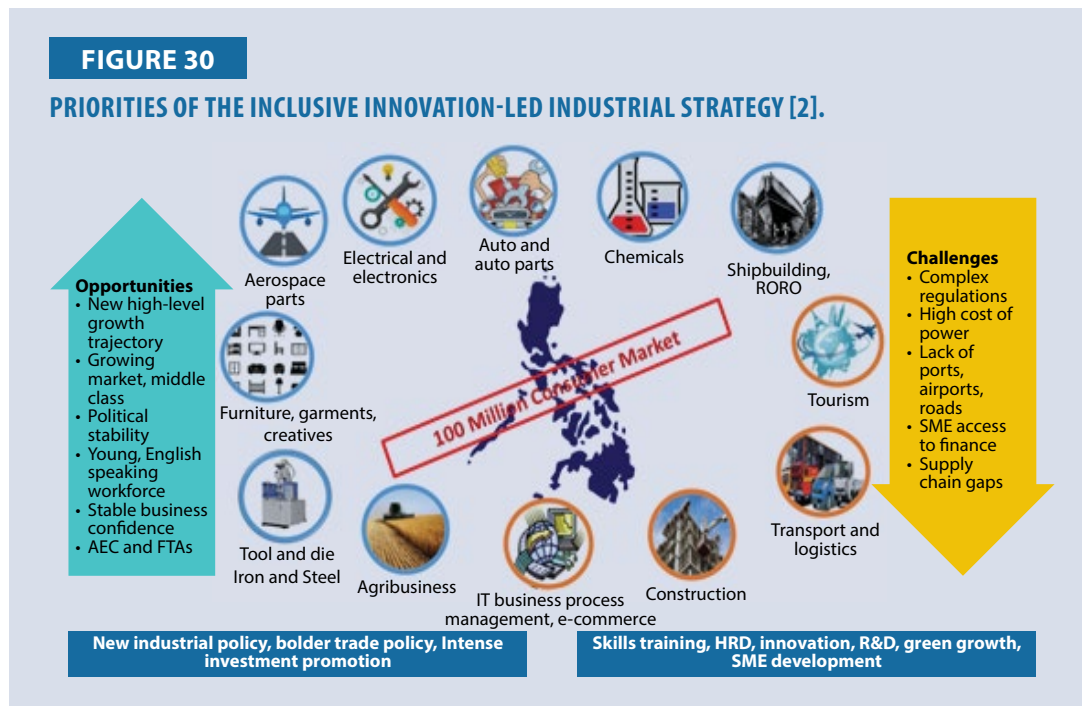
To improve productivity, the government also emphasizes the importance of higher education of human capital in the fields of science, technology, engineering, and mathematics, and of employing innovation-led technologies. In addition, entrepreneurship is added to the framework since it is envisioned and expected that the innovation ecosystem will produce a breed of Filipino entrepreneurs. DTI states that this will espouse ‘idea-based, demand-oriented, and research-driven innovation.’

Meanwhile, updating the progress of CNIS to i3S also involved updating the top-priority sectors. Table 17 and Figure 30 provide the updated list of priority sectors for industry development.

**TABLE 17**  
**THE PRIORITY SECTORS FOR INDUSTRY DEVELOPMENT [19].**

Industry	Priority sectors
Automation	Auto electronics, CARS Program, Public Utility Vehicle Modernization
Electronic manufacturing service	Auto electronics, medical devices, telecommunications equipment, Power storage, civil aviation/aerospace
Semiconductor manufacturing service	Integrated circuit (IC) design
Aerospace	Aircraft maintenance, repair, and overhaul
Chemicals	Petrochemicals, acyclic alcohols and derivatives, metallic salts and peroxy salts of inorganic acids, cyclic hydrocarbons, and oleo chemicals
Shipbuilding and ship-repair	Roll-on roll-off (RORO) as well as small- and mid-sized vessels
Furniture, garments, creative industries manufacturing and design	—
Iron and steel, tool, and die	—
Agribusiness	Rubber, coconut, mangoes, coffee, banana, and other high-value crops
Construction	Roads, railways, bridges, ports, airports, and low-cost housing
IT-BPM and e-commerce	Higher-earning more complex non-voice services BPO, knowledge process outsourcing in medical, financial, and legal services; game development; engineering services outsourcing (ESO), software development, and shared services
Transport and logistics	Land, air, and water transport; warehousing; and support facilities for transport
Tourism	—





According to Rosellon and Medalla [52], Board of Investments (BOI), the country's lead agency tasked with investment promotion, identifies preferred activities in its Investment Priorities Plan (IPP), to support the industries which mainly focus on MSME development. The program is obvious in the inclusion of knowledge-based services, creative industry, inclusive business models, and commercialization of new and emerging service technologies among the incentivized activities. These incentives enable the Philippine government to reach out to a broader segment of the population and also help address issues such as inequality of growth and jobs gap. Furthermore, in 2018, Department of Finance (DOF) submitted a new proposal on reconstructing the corporate income tax and modernizing its fiscal incentives as the second package of the Comprehensive Tax Reform Program. Specifically, to avail tax incentives, "use of modern technology" and "R&D expenditure" are listed as conditions.

## Thailand

### Electrical and Electronics Industry

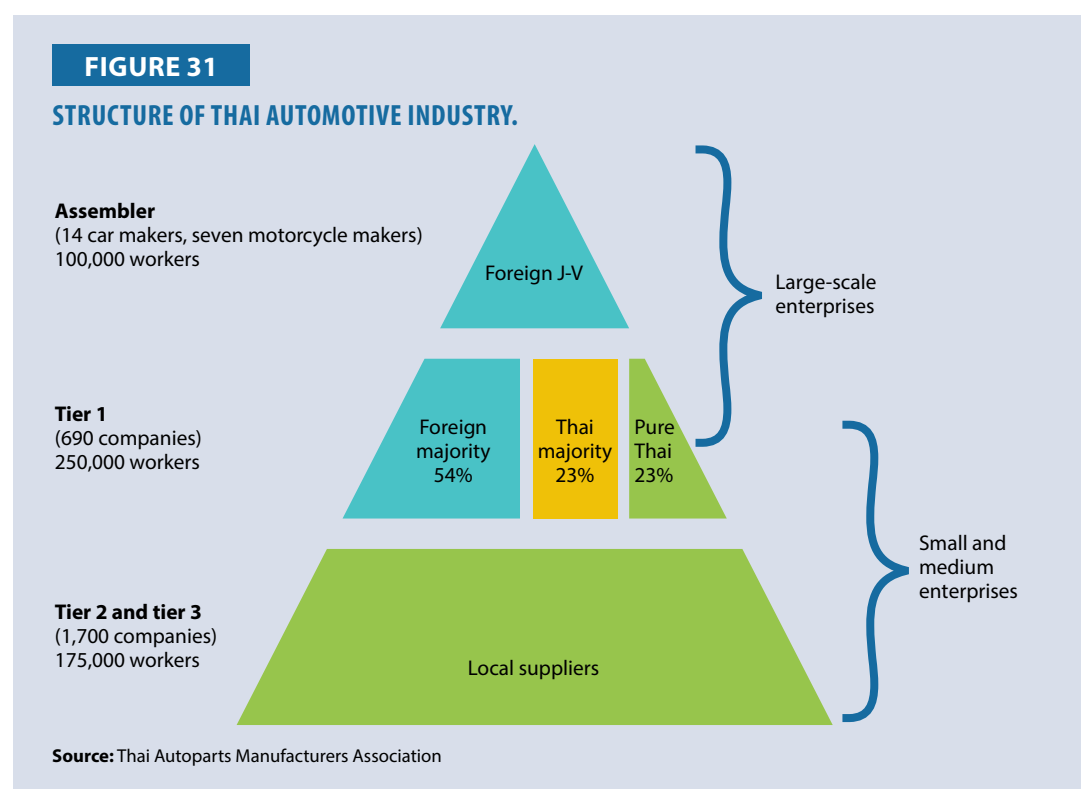
The largest export sector in Thailand is electrical and electronics (E&E) industry, accounting for around 15% of total exports from the country. In 2018, Thailand's E&E exports were around USD62.1 billion, which marked an increase of 2.16% over 2017. In 2019, Thai export shipments were projected to grow by 3.26% to USD64.1 billion. The manufacturing production in the E&E industry was forecasted to rise in value by 2.97% in 2019. In particular, the electrical appliances were to increase by 3.38% while electronics were to increase by 2.56%. More than 780,000 workers were employed by the sector in 2015, representing around 12% of the total employment in manufacturing.

Some of the biggest producers of hard disk drives have manufacturing bases in the Thailand, e.g., Western Digital, Seagate Technology, etc. This makes Thailand the world's second biggest manufacturer of HDDs after PR China, but in recent years, this sector has encountered many problems. In January 2015, the manufacturing number dropped for 22 consecutive months, with

production of television and radios decreasing by 38%. In order to take advantages and reduce costs, the location of factories is likely to be in a country with low labor expenses. For instance, LG Electronics factory shifted to Vietnam because the labor expenses per day are USD6.35 and USD9.14 in Vietnam and Thailand, respectively. Samsung Electronics also invested in two large smartphone factories in Vietnam. Given the E&E industry's situation, Thailand must reposition itself from a labor-intensive country to value/innovation-based destination.

### Automotive Industry

The automotive industry is a very crucial sector for Thailand's economy, being the second-largest export industry. The automotive industry has a long history in Thailand. It has evolved into an industry with foreign original equipment manufacturer (OEM) competition and an extensive network of supporting industries. The structure of Thai automotive industry consists of assemblers or carmakers and motorcycle makers, followed by tier 1 auto part makers, and tier 2 and 3 makers, as shown in Figure 31. The car and motorcycle makers are large international companies such as Toyota Motors, Isuzu, Honda Automobile, Nissan Motors, General Motors, Mitsubishi Motors, Suzuki Motors, BMW Manufacturing, Tata Motors, Ford Motor, and Mazda. The tier 1 auto part suppliers are approximately 690 in number, while tier 2 and 3 companies are around 1,700. Of the top 100 auto parts manufacturers in the world, 50% have factories in Thailand. The country's manufacturing base is strong enough to supply all the necessary components, from engine parts to interiors and body parts. This makes the industry competitive in the region.



Thailand is the regional leader in automotive production and sales. The sector employs around 417,000 workers, which account for 6.5% of total labor force in manufacturing sectors. Thus, Thailand is seen as a leader in automotive production and sales in southeast Asia. In 2019, Thailand produced 2,013,710 units of vehicles, with 1,007,552 units produced for domestic sale and the remaining for export. The data for the period 2011–18 is given in Tables 18 and 19.

TABLE 18

## CARS, MOTORCYCLE, PARTS, AND COMPONENTS EXPORT OF THAILAND.

Year	Value (THB billion)	As % of GDP
2011	566.355	5.37%
2012	751.132	6.08%
2013	812.085	6.29%
2014	832.750	6.31%
2015	892.623	6.53%
2016	944.434	6.58%
2017	881.380	5.90%
2018	882.083	n/a

TABLE 19

## CAR PRODUCTION IN THAILAND.

Year		Units	Production for		Export value (THB billion)	Export value as % of GDP
			Domestic market	Export		
2011	▼	1,457,795	723,845	733,950	343.383	3.26%
2012	▲	2,453,717	1,432,052	1,021,665	490.134	3.97%
2013	▲	2,457,086	1,335,783	1,121,303	512.186	3.97%
2014	▼	1,880,007	757,853	1,122,154	527.423	3.99%
2015	▲	1,913,002	712,028	1,200,974	592.550	4.33%
2016	▲	1,944,417	776,843	1,167,574	631.845	4.40%
2017	▲	1,988,823	862,391	1,126,432	603.037	4.04%
2018	▲	2,167,694	1,024,961	1,142,733	594.809	n/a

Source: Federation of Thai Industries.

## Vietnam

### Survey and Preliminary Assessment of the Current Situation

New standards, tools, and technologies will make smart manufacturing an important tool to improve business efficiency and boost business growth in the context of Industry 4.0 [38]. A survey was conducted to make a preliminary assessment of the current situation and the need to apply smart manufacturing to Vietnamese enterprises [24]. The survey had 25 questions for enterprises, focusing on the following five key issues:

1. **Business management activities:** The questions were focused on market needs for the manufacturing and business planning process of the enterprise; the level of regular implementation of research, design, and implementation of new products or product diversification; the importance of data (production, market, products, etc. in storage and exploitation for manufacturing and business activities); and the application of management tools (Kaizen, 5S, 7QC, 4M, Lean, Six Sigma, TPM, TQM, TQC, SPC, MSA, FMEA, PPAP, APQP, and ERP) in manufacturing and business.
2. **Technology application activities in manufacturing and business:** The questions probed the interest and awareness on the role of technology as an important tool in determining the success of enterprises; the application of quality control and assurance programs in

enterprises; the degree of automation and the ability to integrate machines and equipment in manufacturing with information technology software for remote control; the ability to respond and integrate with information technology solutions for production lines; and the availability of human resources in the enterprise for the adoption of new technologies.

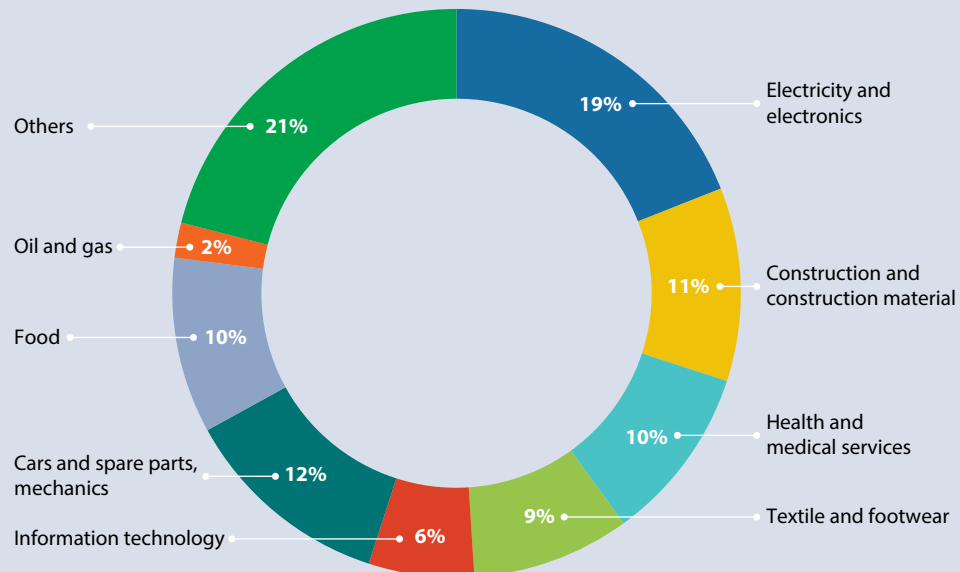
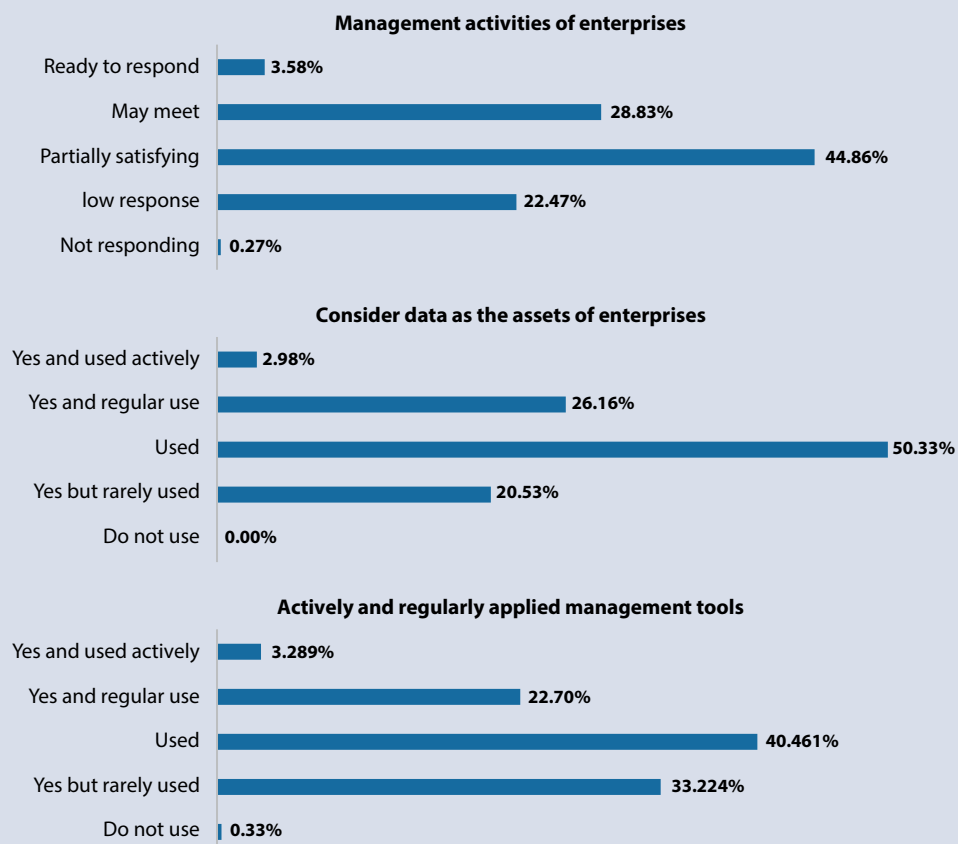
3. **Business workforce development activities:** In this section, the questions focused on employee awareness on the importance of data and data analysis for the success of the enterprise; the participation in training programs to improve the capacity and qualifications of employees; the sharing and exchange of knowledge (group activity) among employees; investing resources (machinery, equipment, training, and finance) to support self-improvement needs of enterprises' labor force; contact, coordinate the implementation of training activities for enterprises' employees with local training facilities and centers.
4. **The ability to build the manufacturing platform for access to smart manufacturing:** The questions focused on awareness of enterprises about interventions, amendment of production, and business data of enterprises; enterprises arranging for officials or specialized sections to apply and support information technology solutions in their production and business activities; enterprises collecting information and data on production and business markets; application of information technology in protecting assets on production and business data; and flexible production capabilities of enterprises to meet market and customer requirements.
5. **Needs of enterprises for participating in programs and projects to promote smart manufacturing:** The questions pertained to needs and wants of enterprises on smart manufacturing in future (5–10 years); the readiness of enterprises to participate in smart manufacturing; the readiness of top management to access and participate in programs and projects to promote smart manufacturing; the desire of businesses to increase competitiveness, revenue, and profits through application of smart manufacturing; the expectation of receiving support from the government or international organizations for participating in pilot deployments and models of smart manufacturing in the next five years.

The author conducted a preliminary survey of 302 enterprises. Based on the summary of the survey questionnaire, the authors grouped the enterprises participating in the survey into nine areas of activity, namely, electricity and electronics; construction and construction materials; health and medical services; textile and footwear; information technology; cars and spare parts, and mechanics; food; oil and gas; and others (banking, printing, packaging, services, trade, logistics, helmets, etc.).

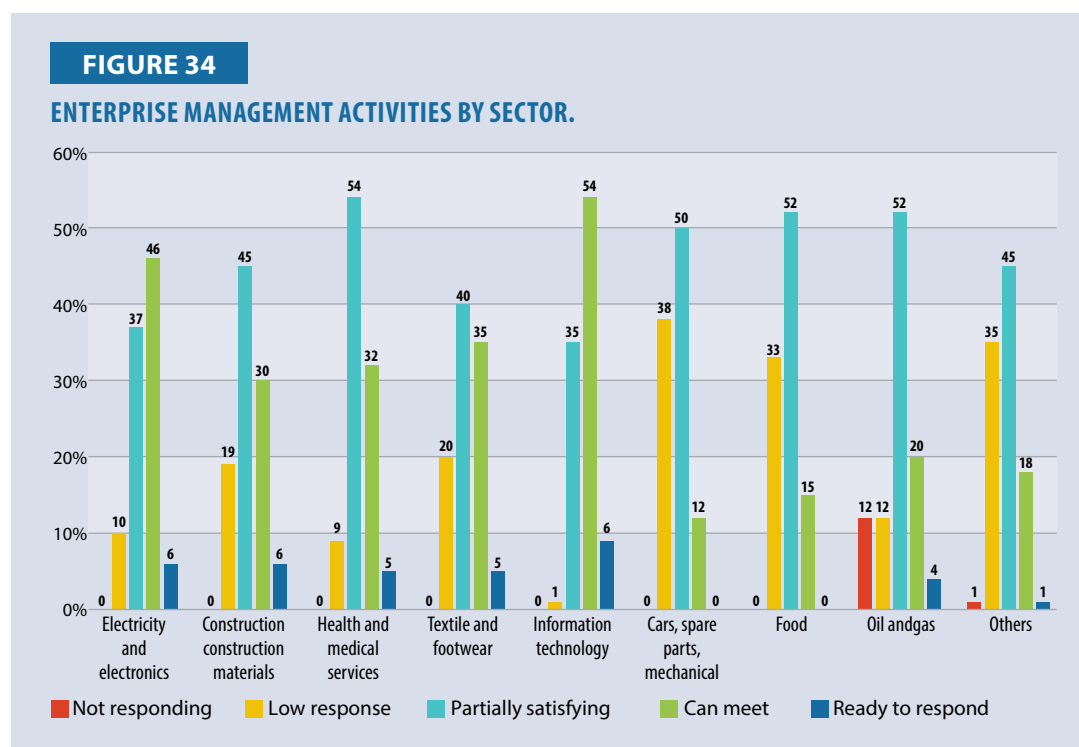
### Sector-wise Distribution of Respondents

As shown in Figure 32, the largest number of enterprises participating in the survey were from the field of electricity and electronics (19%), followed by the automobiles and spare parts, and mechanics (12%), construction and construction materials (11%).

From Figure 33, it can be seen that out of the total surveyed enterprises, about 32.41% have the potential to meet the management activities of enterprises for smart manufacturing access (3.58% of the respondents are ready to meet, while 28.83% can reach). Besides, 2.98% of the surveyed enterprises considered data as assets for enterprises and actively use the data for direct production and business, while another 26.16% regularly used these data assets. Further, the 25.99% of surveyed enterprises actively or regularly applied management tools in production and business, of which 2.98% of enterprises actively applied these tools (see Figure 33).

**FIGURE 32****SECTOR-WISE SHARES OF SURVEYED ENTERPRISES.****FIGURE 33****MANAGEMENT ACTIVITIES OF ENTERPRISES.**

The preliminary analysis of the existing status of enterprise management activities for specific production sectors is shown in Figure 34.

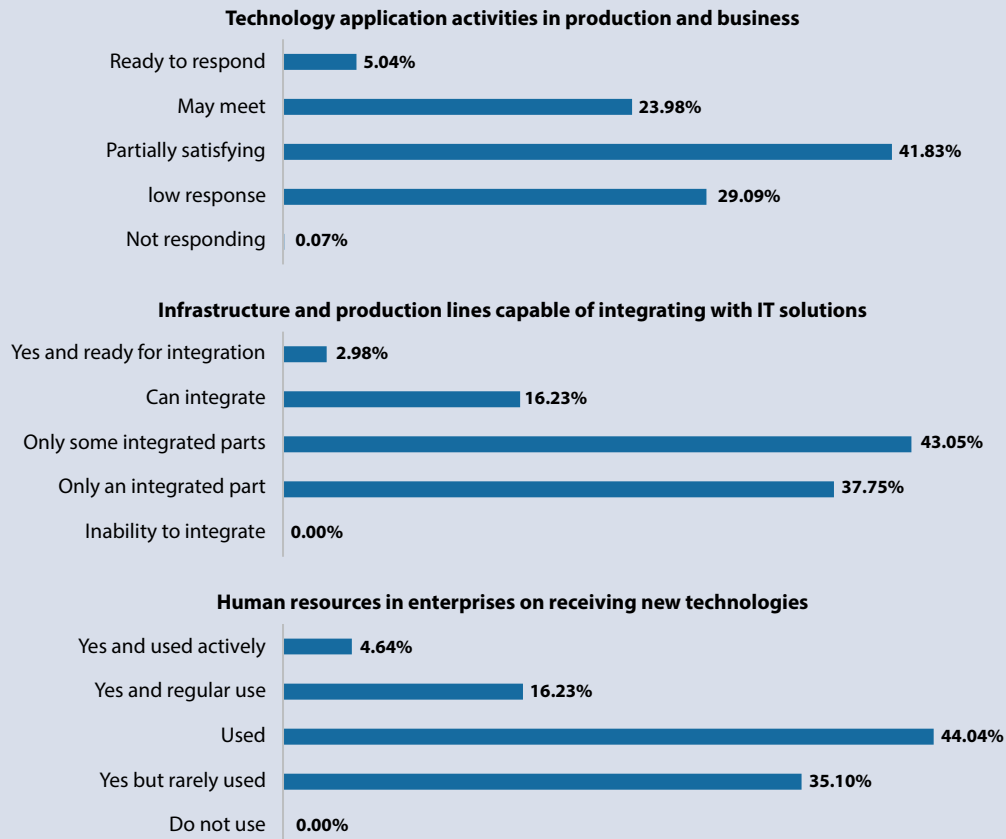
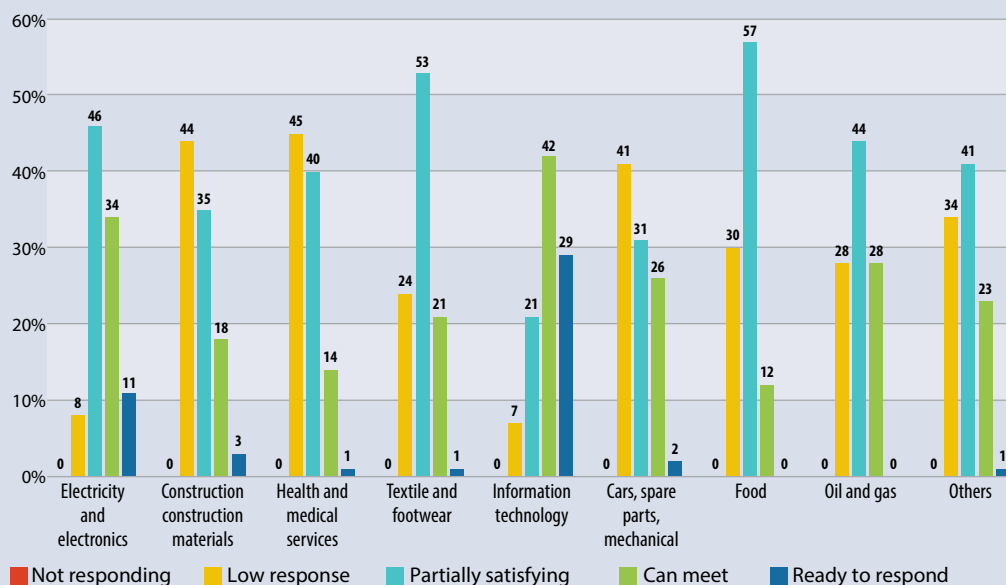


Regarding technology application activities in production and business, out of total surveyed enterprises, 29.02% were ready to meet and could meet technological application activities, which is an important approach to smart manufacturing. Moreover, 5.04% of surveyed enterprises were ready to meet technological application activities. Next, 19.21% of surveyed enterprises have infrastructure and production lines capable of integrating with information technology solutions; of which, 2.98% were ready to respond to this integration process, while 16.23% confirmed that they could confiscate enterprise infrastructure with information technology solutions. The readiness of human resources in enterprises on receiving new technologies accounted for a total of 20.87% of surveyed enterprises, of which, the number of enterprises with high human resources was only 4.64% (see Figure 35).

Preliminary analysis data on the status of technology application in production and business activities for specific production sectors is shown in Figure 36.

Regarding the development of labor force of enterprises, in general, 56.46% of surveyed enterprises were quite interested in developing labor force. Of this, about 3.98% of surveyed enterprises had the amount of labor available to meet the requirement, 16.5 confirmed that their workforce could meet the requirement, and 35.98% thought that their workforce could meet part of the access to smart manufacturing. Further, 16.77% of enterprises were surveyed continuously or periodically to organize employees to participate in training programs to improve the capacity and level of production and business.

Of the surveyed enterprises, 63.81% invested resources (machinery, equipment, training, and finance) to support self-improvement of their labor force. Those actively invested made up 4.93%, while others already invested accounted for 18.09% and those interested in implementing this activity accounted for 40.79% (see Figure 37).

**FIGURE 35****TECHNOLOGY APPLICATION ACTIVITIES IN PRODUCTION AND BUSINESS.****FIGURE 36****TECHNOLOGY APPLICATION ACTIVITIES IN PRODUCTION AND BUSINESS BY SECTOR.**

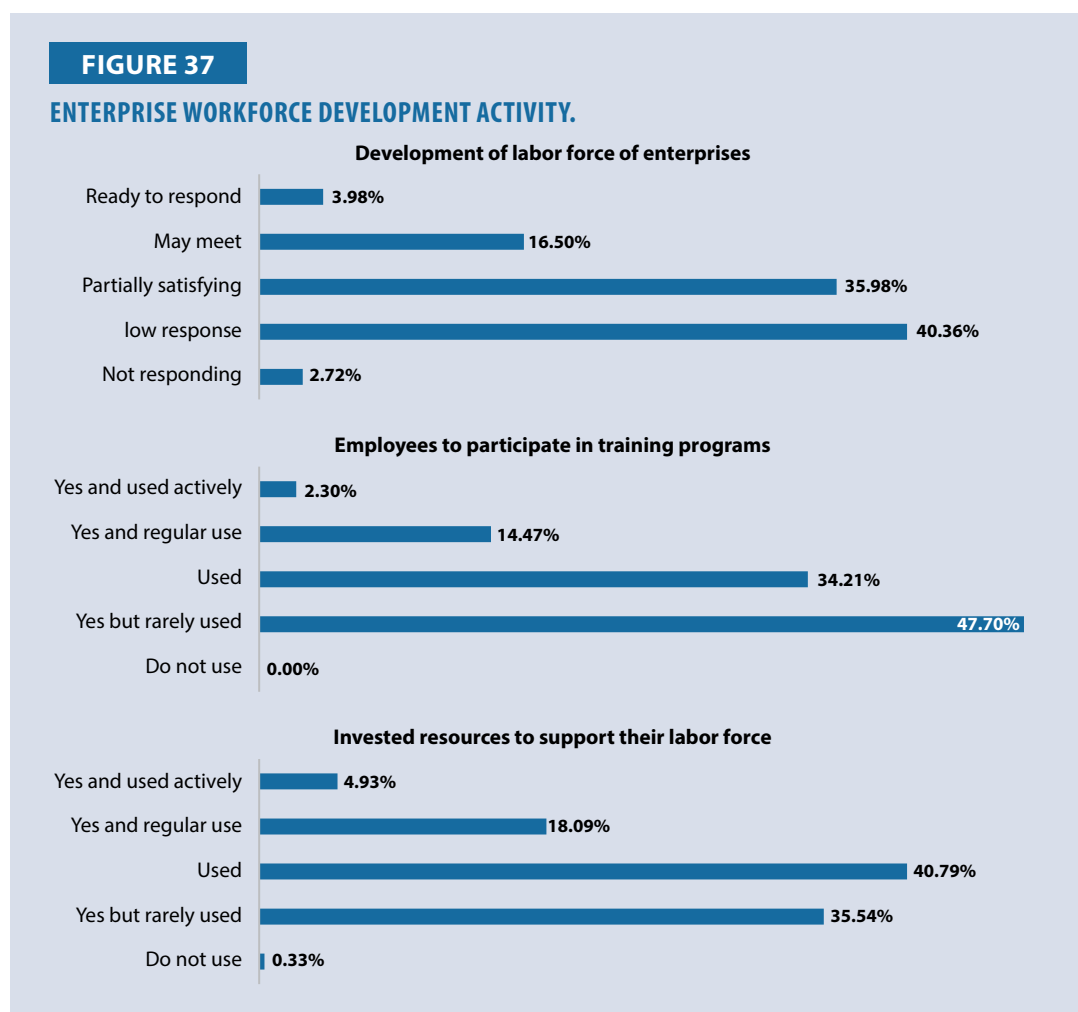


Figure 38 shows the preliminary analysis data on the status of enterprise labor force developments for specific production sectors.

Regarding the ability to build manufacturing platforms of enterprises for access to smart manufacturing, the survey data showed that 7.69% enterprises were ready to respond, while 26.91% might meet the requirement.

Next, the survey results showed that 28.95% of surveyed enterprises paid attention to, or arranged staff or specialized departments in application activities, supporting information technology solutions in production and business activities (2.96% of the respondents always give priority to this activity, 10.2% hired outside organizations to meet the requirement, while 58.22% used part-time staff for the purpose).

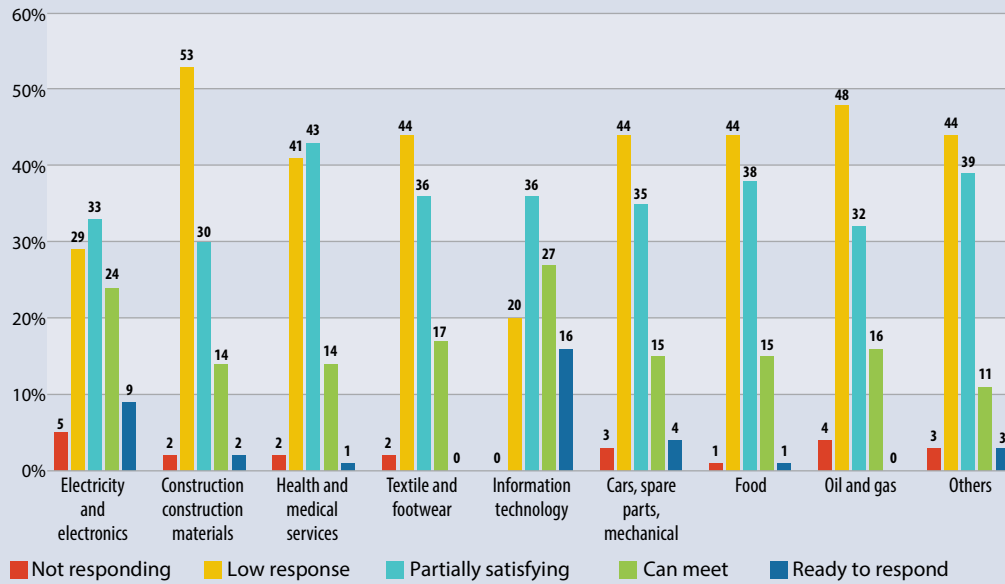
Regarding the flexible production capacity of enterprises to meet market and customer requirements, 5.26% of surveyed enterprises said they had the potential to meet flexible production requirements by maximizing the use of information technology, while 16.45% had the potential to meet flexible production requirements with partial support of information technology applications (Figure 39).

Figure 40 shows the preliminary analysis data on the enterprise's ability to build a production base for access to smart manufacturing for specific production sectors.



**FIGURE 38**

**LABOR FORCE DEVELOPMENT ACTIVITIES BY SECTOR.**



**FIGURE 39**

**ENTERPRISES' ABILITY TO BUILD PRODUCTION BASE.**

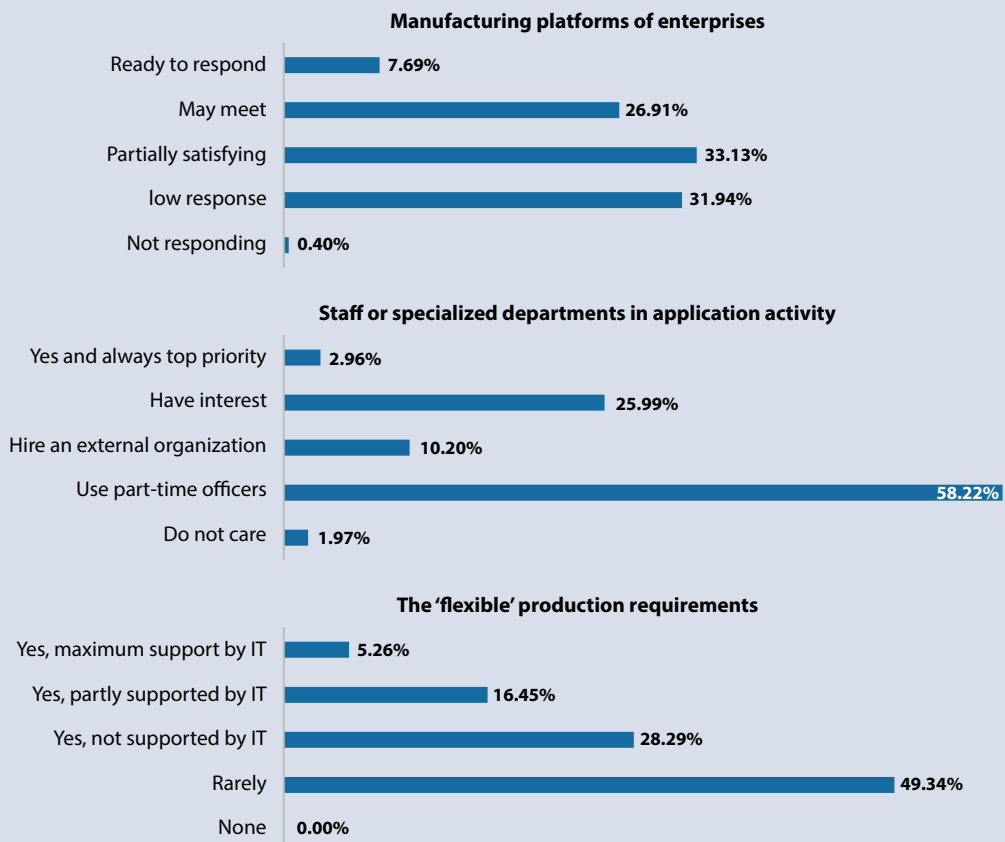
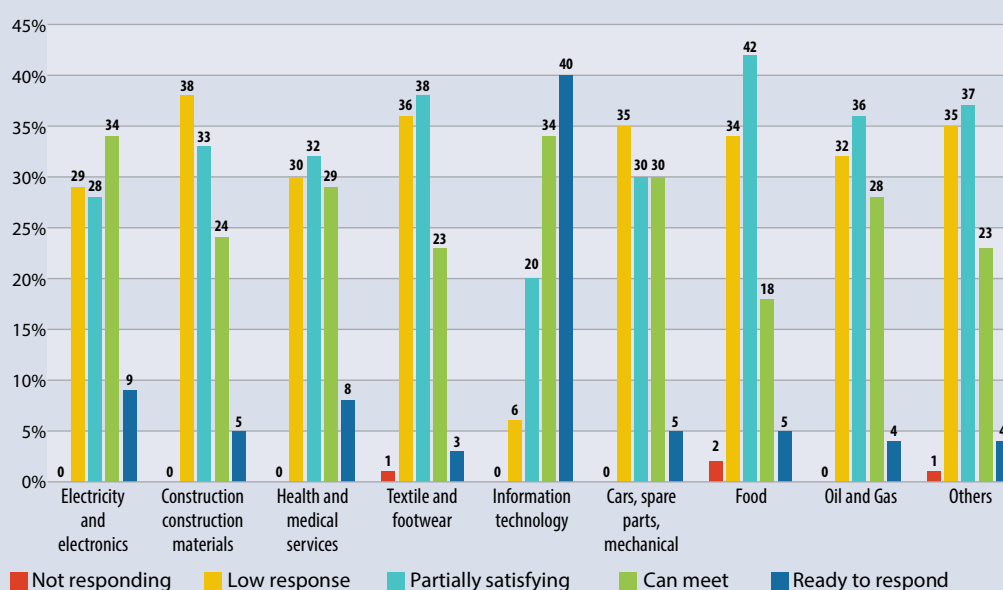


FIGURE 40

## SECTOR-WISE ABILITY OF ENTERPRISES TO BUILD PRODUCTION BASE.

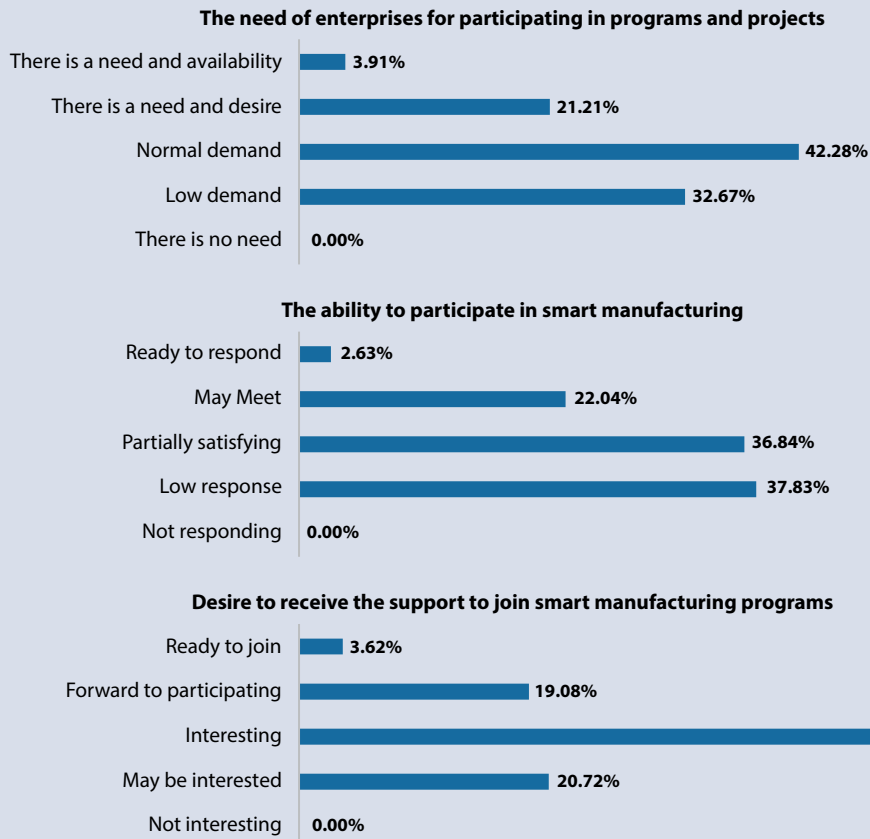
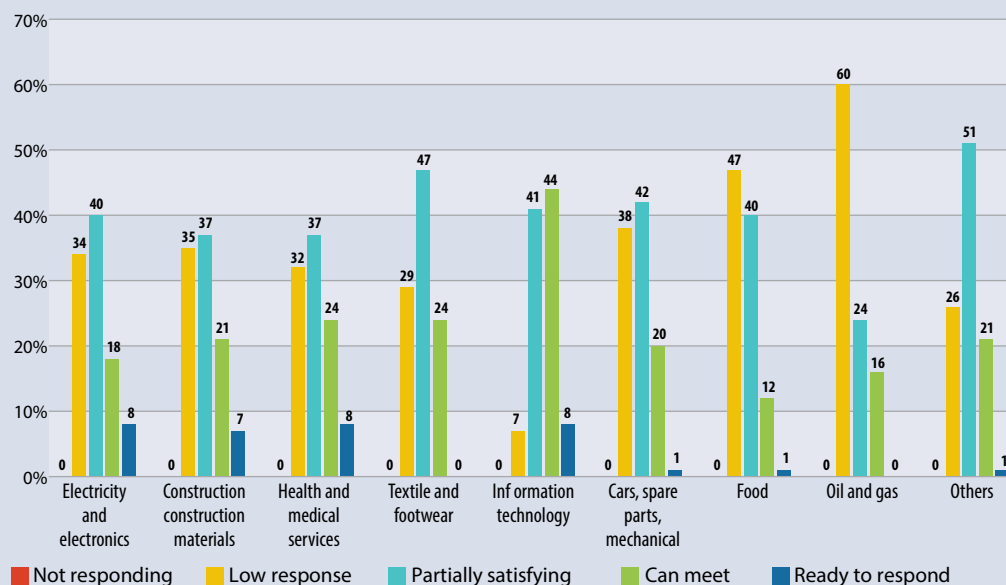


Regarding the needs of enterprises for participating in programs and projects to promote smart manufacturing, survey results show that 3.91% of surveyed enterprises had the need and were available to participate, while 21.21% had the need and a desire to participate. Regarding the readiness of enterprises to participate in smart manufacturing, 2.63% of surveyed enterprises were ready to respond to participate in smart manufacturing, 22.04% could meet the ability to participate, 36.84% only partially met the ability to participate, while 37.83% found it difficult to meet the ability to participate. Regarding the desire to receive the support of the government or international organizations for participating in a pilot deployment, the model of smart manufacturing in the next five years, a total of 78.62% of businesses were interested, while 20.72% said they might be interested the activity (Figure 41).

Figure 42 shows the preliminary analysis data on the needs of enterprises to participate in programs and projects to promote smart manufacturing for specific production sectors.

Based on the survey, the following recommendations are proposed to enable Vietnamese businesses to have access to smart manufacturing soon:

- **Early formation of ‘smart manufacturing thinking’:** The ideas and knowledge about smart manufacturing need to be propagated, disseminated, and practiced in enterprises, such that there is a commitment to promote participation in smart manufacturing from the top management of the business.
- **Need to build a ‘data culture’:** Data should be considered to be enterprise ‘assets.’ Enterprises not only use data to communicate and manage information about their organizations but also directly exploit data to connect and serve production and business functions. Enterprises should soon form and unify accurate data sources in their organizations.

**FIGURE 41****ENTERPRISES' DEMAND FOR PARTICIPATING IN PROGRAMS AND PROJECTS.****FIGURE 42****ENTERPRISES' DEMAND FOR PARTICIPATING IN PROGRAMS AND PROJECTS BY SECTOR.**

- **Early participation in the process of ‘digital transformation’:** Enterprises should accelerate the application of information technology in the production process associated with their business models, thus making the enterprise an important component of the digital economy.
- **Developing ‘human resources 4.0’:** Human resources in enterprises need to be regularly trained and fostered to raise their professional qualifications, especially the knowledge about smart manufacturing and Industry 4.0. Thus, workers will have enough skills and knowledge for participating and interacting with the CPS of smart manufacturing.
- **Develop and apply a framework of smart manufacturing standards:** Based on Vietnam’s standard framework for smart manufacturing, enterprises can consider, apply, or develop standards for product life cycle, production system life, and business life cycle.
- **Develop and apply smart manufacturing support tools:** Based on the results of assessing the current state of their production and business, enterprises should proactively identify a number of processes and stages. It is possible to apply smart manufacturing support tools, and proceed to apply them throughout the enterprise system.
- **Develop a roadmap for achieving ‘smart levels’:** To be certified as a smart manufacturing enterprise, organizations need to build and implement synchronous solutions, specific plans, and investments for each development stage and upgrade to the ‘smart levels.’

In the context that Vietnam is integrating deeply into the world economy with the completion of many largescale agreements such as the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) and free trade agreement (FTA) with the European Union (EU), approaching the achievements of Industry 4.0 to effectively participate in global value chains and promote industrialization and modernization are urgent needs. With the attention of the Party, the state, and the government, there is adequate knowledge, especially at management and policymaker levels. The awareness about the application and use of information technology and the high levels of international integration in science and technology, innovations, and trade and investment show that Vietnam has sufficient opportunities to approach smart manufacturing. We need to continue to build and strongly implement breakthrough mechanisms for policies and solutions to soon form smart manufacturing models in enterprises, successfully implement the transformation of digital economy, and take the country to higher levels step by step.

## Summary

Industry 4.0 is opening up many opportunities for APO member countries, while developing countries are facing the challenges to improve productivity and manufacturing intelligence to move up the industry value chain and thus shorten the gap with developed countries [32, 37, 58]. The experience sharing of experts and international exposure of lessons learned will improve production efficiency and add value for APO member countries. To achieve these goals, the following strategic action plans should be employed:

### 1. International collaborations

- The CoE reviews the industrial IoT-related infrastructures in a member country and evaluates the country’s proficiency and competency in integrating machinery technology and information technology to the extent needed for its industries. The CoE will conduct

a site visit to determine the country's needs and requirements for future development of automation and smart manufacturing, followed by identifying ways to add value to its output and building an integrated network of cross-disciplinary supply chains.

- The CoE will promote the formation of smart manufacturing industry clusters and attract all actors in the advanced smart manufacturing industry supply chain in APO member countries to visit these clusters to maximize the international industry cluster effect.

## 2. Technology

- In designing programs that introduce smart manufacturing technologies and expert assessments to APO member countries, the CoE will review the combination of an APO member's governmental policies, academic exchange platforms, and industry development strategies to ensure that programs are customized to meet the needs of the member country. Planning will be delivered throughout the entire lifecycle, albeit in stages; while advices will be given to guide the client through the integration and collaborative R&D processes.
- The CoE will facilitate the formation of consensus among APO member countries in relation with smart manufacturing, Industry 4.0, and key industrial technologies associated with smart machinery adoption in order to encourage learning by benchmarking and to help industries move up the value chain.
- Intelligent solutions, designed according to the specific needs relating to design, manufacturing, marketing, service, and other aspects of an industry serving its end users in APO member countries, will be implemented. The CoE can help APO member countries to identify the strategic directions and development plans to integrate related resources to support successful migration and transformation through joint efforts such as technology exchanges and international visits.

## 3. Promotion

- The CoE on SM can improve the innovation capabilities of APO member countries through an integrated knowledge network and by creating a forward-looking strategic planning framework to address fast-changing global market needs. It can enhance competitive advantages of APO member countries in the global value chains by helping their industries successfully migrate to Industry 4.0 and thus contribute to the economic and social development of each country.
- The CoE on SM will familiarize itself with the country-specific supply chain models operating in each APO member country, and promote, through international platforms and technology integration services that meet different policy needs. Demonstration projects that highlight different natures of various industries, including manufacturing, service and agriculture, will be launched to optimize general market conditions.
- Resources of all APO member countries will be combined to build a platform for smart machinery industry that can improve system integration and facilitate formation of smart manufacturing ecosystems for national development and value enhancement for priority industries.

# PRIORITY INDUSTRY BY GOVERNMENT AGENCY AND NATIONAL PRODUCTIVITY CENTER

In Industry 4.0, machines will be self-adaptive, self-configurable, and self-optimizable to take decentralized decisions through the application of CPS. Indeed, the concept of Industry 4.0 is the vision of the future factories. However, for most of the industries, it will take a long way to achieve these objectives. Thus, it is crucial to select priority industries to allocate more resources for pilot projects in APO member countries through joint efforts of government agencies and national productivity centers (NPOs).

Furthermore, international technical service teams should be formed to integrate related efforts and domain experts in various industries to deliver information sessions at member countries and address APO members' interests and needs in implementing smart manufacturing projects via customized solutions.

In particular, the CoE on SM of the APO should continue to strengthen its operation, promote its achievements from all aspects of various industries, share the experiences with other member countries, and engage in consensus-forming processes to continuously promote smart manufacturing for APO economies.

## Republic of China

### Introduction

For the Republic of China (ROC), China Productivity Center (CPC) is chosen for the case study. CPC was established on 11 November 1955 to assist the government in achieving goals of economic growth and industrial progress. Since its founding, CPC has been the largest management consulting organization in the ROC for supporting enterprises to increase their productivity. From the 1950s to the 1970s, the main purpose of CPC was to help enterprises increase their productivity. In the 1980s, as enterprises focused on quality issues, CPC aimed to achieve total quality improvement. In the 1990s, the goal of CPC was expended to increase overall competitiveness for enterprises. In the twenty-first century, due to the rising importance of knowledge, CPC has been dedicated to assisting enterprises to pursue innovation, create higher value, enhance knowledge power, and adopt the green production operating model.

CPC includes service teams for the following areas: agriculture, smart manufacturing, chain and franchise, e-integration, and innovation. These are dedicated to seven diverse services, namely

1. smart manufacturing and services (management knowledge/smart system integration);
2. international exchange (Center of Excellence on Smart Manufacturing);
3. innovative agricultural management (agribusiness upgrade and transformation advisory);

4. tech infusion for the food-and-drink industry;
5. R&D power boost;
6. business value-added innovation (management of big data analysis); and
7. CPC Business Innovation System® Framework.

In particular, for the smart manufacturing and services, manufacturing Execution System Plus (MES+) was developed by CPC on 6 July 2018. It provides a comprehensive roadmap including system development planning, business management consultation, and professional talent cultivation. MES+ is divided into four modules: on-site diagnosis, improvement advisory, device networking, and talent cultivation.

On-site diagnosis provides status analysis and improvement suggestions, such as organizational strategy, smart manufacturing, smartification, and innovative value. Improvement advisory supports businesses to streamline, rationalize, standardize, systematize, informationize, visualize, and monitorize. Device networking introduces the advanced technologies to drive productivity, including visualization of machine performance (smart machine box), scheduling accuracy optimization (smart order picking box), remote warning control, networked communication integration, and dynamic system monitoring. Talent cultivation tries to develop talent pool from diverse domains related to smart manufacturing such as smart tooling machines, sensors, controllers, identification system, cloud database, network big data analysis, and dynamic decision-making. Center of Excellence on Smart Manufacturing (CoE on SM) supports businesses to achieve the real-time assessment of information, immediate improvement, and accurate decision making.

As a competitive strategy, Industry 4.0 was proposed to enhance manufacturing capability and flexibility. However, the deployment of Industry 4.0 cannot be achieved overnight since the production systems may not be ready for the migration, especially in emerging economies in Asia-Pacific. Countries in Asia-Pacific need to combine regional resources to solidify strongholds, as a high-mix, low-volume production strategy can push the boundaries to uttermost limits. Consequently, mass personalization can be achieved and thus partial implementation of flexible decision-making can be enabled, as envisioned in Industry 4.0 [14, 33]. Hence, the ROC is committed to the CoE on SM to provide the leadership in facilitating industry development in the Asia-Pacific region. For the next section, Policy Modeling Canvas is applied as the framework of assessment including factors of governance, input, issues, goals, activities, output, beneficiary, and outcomes. Each part will be described individually.

### Policy Modeling Canvas

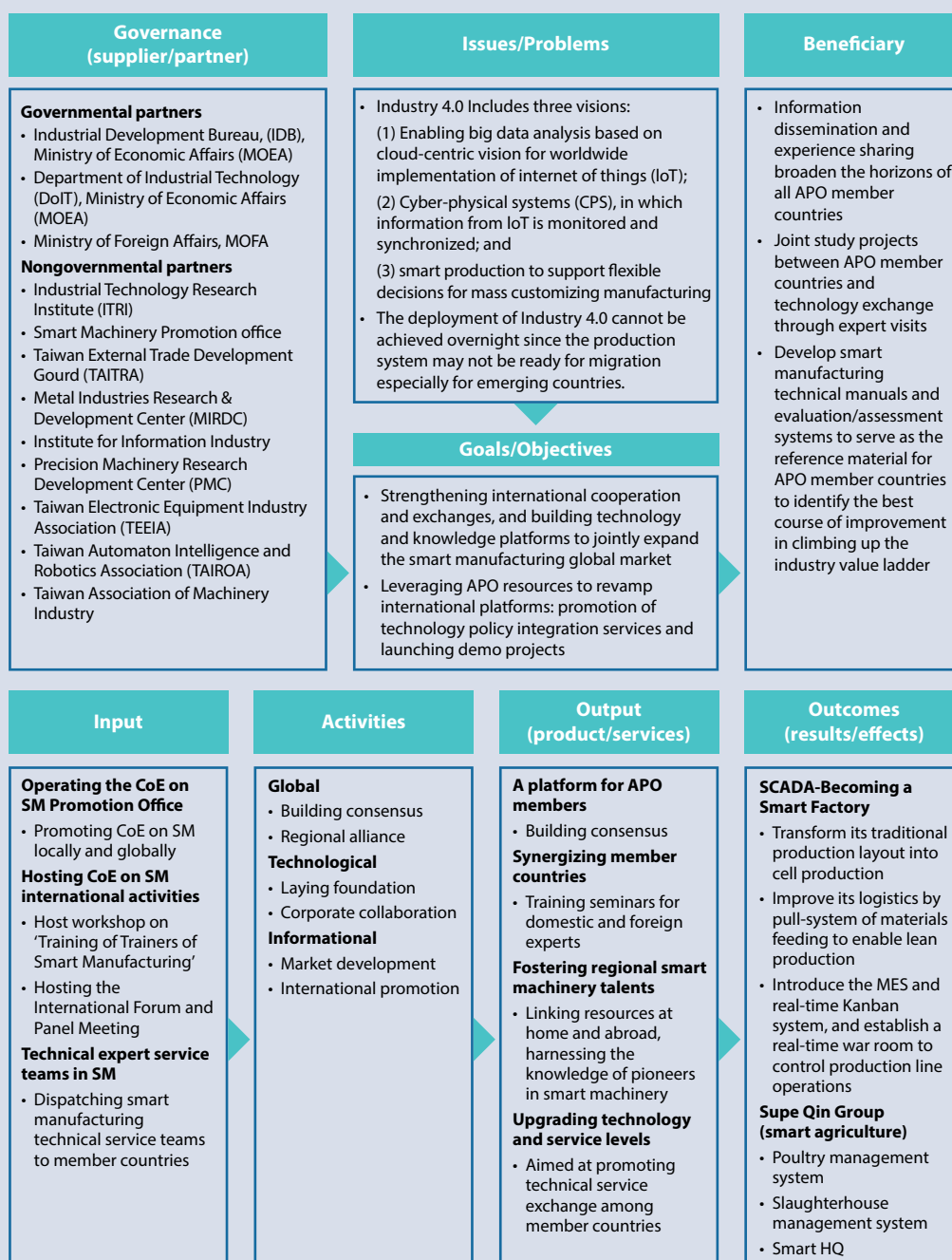
Figure 43 illustrates the overall framework of Policy Modeling Canvas.

#### Governance (Supplier/Partnership)

The governmental partners, nongovernmental partners, and CPC's internal partners are listed in Table 20. Among governmental partners, two are from Ministry of Economic Affairs (MOEA), namely, Industrial Development Bureau (IDB) and Department of Industrial Technology (DoIT), for assisting and guiding regional economic integration and development of key industries. In addition, Ministry of Foreign Affairs (MOFA) also takes parts in supporting communication mechanisms and cooperative relationships between the ROC and other target countries. Furthermore,

FIGURE 43

POLICY MODELING CANVAS.



there are nongovernmental partners that dedicate to corporate research and technology transfer services across various domains. These include Metal Industries Research & Development Center (MIRDC) for metal industry; Smart Machinery Promotion Office, Precision Machinery Research Development Center (PMC), Taiwan Automation Intelligence and Robotics Association (TAIROA), and Taiwan Association of Machinery Industry for machinery industry; Taiwan Electronic Equipment Industry Association (TEEIA) for electronic equipment industry; and Institute for Information Industry for information industry.



**TABLE 20**  
**GOVERNANCE (SUPPLIER/PARTNERSHIP).**

Attribute	Partnership
Governmental partners	<ul style="list-style-type: none"> <li>Industrial Development Bureau (IDB), Ministry of Economic Affairs (MOEA)</li> <li>Department of Industrial Technology (DoIT), Ministry of Economic Affairs (MOEA)</li> <li>Ministry of Foreign Affairs (MOFA)</li> </ul>
Nongovernmental partners	<ul style="list-style-type: none"> <li>Industrial Technology Research Institute (ITRI)</li> <li>Smart Machinery Promotion Office</li> <li>Taiwan External Trade Development Council (TAITRA)</li> <li>Metal Industries Research &amp; Development Center (MIRDC)</li> <li>Institute for Information Industry</li> <li>Precision Machinery Research Development Center (PMC)</li> <li>Taiwan Electronic Equipment Industry Association (TEEIA)</li> <li>Taiwan Automation Intelligence and Robotics Association (TAIROA)</li> <li>Taiwan Association of Machinery Industry</li> </ul>

#### Input

CPC organized an international advisor committee to provide domestic and international expertise opinions for improving the CoE on SM with support from the APO Secretariat. The APO subsidizes or reimburses the experts' expenses, local event costs, and other expenses. Besides, CPC also obtains support from government (including IDB, DoIT, and MOFA) for the operating cost.

The CoE on SM Promotion Office has been established to 1) handle administrative needs; 2) draft plans for coordination and communication with corresponding parties; 3) play the contact role between the APO and related countries; and 4) coordinate and communicate with domestic government bodies and private sectors such as the APO Secretariat (see Figure 44).

To support the above plans, the budgets for 2019 and 2020 are summarized in Tables 21 and 22. The budgets are mainly for establishing and operating the CoE on SM Promotion Office, fully supported by IDB, DoIT, and MOFA. The APO subsidizes the budget planned for hosting international activities including the International Forum and Panel Meeting. Most of the expenditure is related to technical service teams for dispatching smart manufacturing technical experts to member countries.

**FIGURE 44**

#### ORGANIZATION OF THE COE ON SM PROMOTION OFFICE.

Governing Body: Industrial Development Bureau, MOEA

1. The promotion office handles all administrative needs
2. The office will draft plans coordinate and communicate with related parties
3. The office will serve as the contact role between the APO Secretariat and the member countries that participate in project of CoE on SM
4. The office will coordinate and communicate with domestic government bodies and private sectors vis-à-vis APO Secretariat

**TABLE 21****ESTIMATED BUDGET FOR COE ON SM PROMOTION OFFICE, 2019.**

Project	Details	Budget (USD)
Establishing the CoE on SM Promotion Office	Establishing and operating the CoE on SM Promotion Office	65,402
	Marketing/promoting CoE on SM locally and globally	49,052
Hosting CoE on SM international activities	Hosting International Forum and Panel Meeting	83,245
	Hosting CoE on SM Initiation Ceremony	49,084
Technical expert service teams on smart manufacturing	Dispatching smart manufacturing technical expert services teams to member countries	81,806

**TABLE 22****ESTIMATED BUDGET FOR COE ON SM PROMOTION OFFICE, 2020.**

Project	Details	Budget estimation (USD)
Operating the CoE on SM Promotion Office	Operating the CoE on SM Promotion Office	49,052
	Marketing/promoting CoE on SM locally and globally	26,160
Hosting CoE on SM international activities	Hosting workshop on 'Training of Trainers of Smart Manufacturing'	52,356
	Hosting International Forum and Panel Meeting	52,356
Technical expert service teams on smart manufacturing	Dispatching smart manufacturing technical service teams to member countries	147,251

**Issues/Problems**

Industry 4.0 includes three visions [31] of

1. enabling big data analysis based on cloud-centric vision for worldwide implementation of internet of things (IoT);
2. cyber-physical systems (CPS), in which information from IoT is monitored and synchronized between the physical factory floor and the cyber computational space [39, 49]; and
3. smart production to support flexible decisions for mass-customizing manufacturing [21].

Since the deployment of Industry 4.0 cannot be achieved overnight, CPC leads the CoE on SM to help APO members to migrate the industry value chain and determine the best smart technology and automation adoption methods. This is enabled via the consultant using the expert's experience and heightened international exposure. The process revolves around the IoT, mobility, and data, which are the three major elements in smart manufacturing; and covers the entire product life cycle from development, design, production, and marketing to service. It culminates in smart factory, smart manufacturing, smart logistics, and smart services.

### Goals/Objectives

The ROC government aims to create new economic development models to improve industries' international competitiveness. Therefore, programs are launched to facilitate industrial transformation. In order to guarantee that enterprises are capable of retaining their competitive advantages in the global value chain while confronting the fast-changing global market conditions, the fundamental goals of CoE on SM are to strengthen international cooperation via building technology and knowledge platforms and thus jointly expand the smart manufacturing global market. In addition, CPC also leverages APO resources to revamp international platforms for the promotion of technology policy integration services and launching demo projects. Through the integrated knowledge network, CPC is able to provide an overall strategic and forward-looking planning framework.

### Activities

The concept of integrated service platforms is promoted by CPC to ROC industries. CPC promotes the idea of 'Productivity Again,' which aims to revolutionize the existing paradigm. This replaces the traditional focus on capital investment with the attention to management of innovations and values.

CPC releases a performance assessment system called iBench, which evaluates an organization's readiness for smart manufacturing. iBench is the first step in building a smart manufacturing service platform for enterprises. It provides online self-assessment, status check, and improvement analysis to enterprises by benchmarking other similar industries that help enterprises become lean and thus improve. The system also offers the feature for mapping enterprises developing short-, medium-, and long-term plans for the purpose of effective and successful transition to smart manufacturing and digitalization. In addition, CPC also develops the MES+ manufacturing execution system to enhance data connectivity for industry users. CPC reports the performance of the provided system and its application in Industry 4.0 international conferences and system assessment workshops hosted by APO.

CPC has also founded the following: 1) Smart Manufacturing Experience Training Site; 2) Smart Manufacturing Human Resource Development and Academic Exchange Platform; and 3) Smart Manufacturing Equipment and System Development Integrated Service Platform at CPC's Central Regional Office in Taichung. These will serve as hubs to converge government resources and domain expertise to facilitate and accelerate the industrial transition.

### Output (Product/Services)

CPC contributes to the CoE on SM by creating 1) a platform for APO members; 2) synergizing member countries; 3) fostering regional smart machinery talents; and 4) upgrading technology and service levels. 'Industry Upgrading Solutions' is another plan that CPC aims to conduct in 2020 as part of promoting smart manufacturing. The selected industry will be evaluated in terms of availability of domestic and foreign resources in software and hardware applications. Based on the varying levels and characteristics of industrial development, CPC will dispatch experts as consultants and advisors to facilitate the adoption of business management systems and whole-plant technical support services. A standardized assessment system will thus be introduced to the currently operating assessment system for industry transition in the ROC, thereby creating high-value-added industries. The evaluation standard for each program will be based on the results of effectiveness that will be incorporated with industry assessment standards. The allocated experts in those projects will be dispatched between industries, modifying the core development strategies for smart machinery and plan demonstration sites as appropriate.

### Beneficiary

The ROC has the strengths of its long-standing history in industrial development, manufacturing advantages, and professional consulting experience. CPC aims to exploit these strengths via the CoE on SM. With the support of various programs, the ROC's manufacturing sector is then able to reengineer the industry value chain using its strengths in service, digital technologies, and integration. The adaptable industries are expected to help improve production efficiency, reduce the total cost of ownership (TCO), increase profits, and break out of the existing markets and clienteles.

### Outcomes (Result/Effects)

In order to maintain coordination and communication among members, CPC invites international and domestic experts and holds annual member meetings and international forums for discussion on the current progress and plans for the CoE on SM. Through the web portal, CPC provides a smart manufacturing experts database enabling access to industrial and academic experts to meet the policy goal of providing technology integration services.

For instance, to help SMEs in the ROC with enhanced technical development, system integration, and automation-related competency adoption, CPC has provided the evaluation system as a service. In this program, CPC evaluated the progress of the development of industries and addressed the weaknesses by appointing consultants for technical assistance. By investigating and identifying the requirements of these industries, research delegations from CPC could better develop customized production-and-business models for smart manufacturing. In addition, regional technical seminars and international conferences will be held and corresponding plans will be translated into actions. Integrated industrial park planning services will be organized, based on the understanding of the advantages in the border areas. This is expected to further expand the horizons of domestic industries and opportunities in the international supply chain.

### Suggestions, Discussions, and Future Issues

The major countries in the world are actively looking for ways to enhance the value chain of the industry in order to better respond to the rapidly changing business environment. These countries are committed to strengthening the core competitiveness related to smart manufacturing, which is crucial for the development of the smart machinery industry. The ROC is recognized for her long history of industrial development, technical advantages, and professional consulting experience, and aims to develop the intelligent manufacturing value chain in the Asia-Pacific region. The CPC will establish a communication platform for sharing experience and knowledge, and customize plans to better meet the specific requirements of the manufacturing, services, and agricultural sectors in APO member countries, thereby promoting the overall development of the Asia-Pacific region.

In close cooperation with APO member countries, the CoE on SM relies on comprehensive support of company leaders and private nonprofit organizations for collecting, compiling, and providing information related to smart machines, which will certainly have an impact on the development of SMEs. In addition, the CoE on SM will combine domestic and foreign resources that are conducive to the development of Industry 4.0, and help in the knowledge transfer process of APO member countries using intelligent manufacturing and related management models. In view of the rising market demand for high-quality products produced in a more flexible way using 'small-volume large-variety production,' the adoption of this process is a response to changing global trends and market conditions.

In addition, the CoE on SM supports international exchange. It strengthens international cooperation, and builds ‘technology and knowledge platforms’ to jointly expand the smart manufacturing global market. The goal is to leverage APO resources to revamp international platforms by promoting technology policy, service integration, and demo project implementation. The platform for APO members can synergize member countries, foster regional smart machinery talents, and upgrade the technology and service levels. For international cooperation and engagements, the CoE builds consensus and regional alliances by providing policy exchanges, surveys and need assessments, and conference-related affairs to APO member countries. For innovative applications and knowledge enablement, the CoE lays the foundation and enables business collaboration by organizing technical seminars/training courses and establishing an exchange platform for annual meetings among member countries. For benchmark learning and building reputation, the CoE supports market development and international promotion by arranging bilateral exchange delegations between member countries and by organizing international forums.

With the era of intelligent manufacturing, the government of the ROC and the CPC are watching the development of Industry 4.0 with great interest. The new wave of technological revolution has brought a variety of problems and challenges. CPC is committed to promoting concepts and technologies related to smart manufacturing and sharing experiences with APO member countries. The CoE is a place for continuous learning and exchange of expert experiences to achieve the ultimate goal of improving the competitiveness of industries in the Asia-Pacific region.

## India

In Industry 4.0, machines will be self-adaptive, self-configurable, and self-optimizable to take decentralized decisions through the application of CPS. Indeed, the concept of Industry 4.0 is the vision of the future factories. However, for most of the industries, it will take a long way to achieve these objectives. Thus, it is crucial to select priority industries to allocate more resources for pilot projects in APO member countries through joint efforts of government agencies and national productivity centers (NPOs).

Furthermore, international technical service teams should be formed to integrate related efforts and domain experts in various industries to deliver information sessions at member countries and address APO members’ interests and needs in implementing smart manufacturing projects via customized solutions.

In particular, the CoE on SM of the APO should continue to strengthen its operation, promote its achievements from all aspects of various industries, share the experiences with other member countries, and engage in consensus-forming processes to continuously promote smart manufacturing for APO economies.

## Introduction

Today, the global manufacturing sector is undergoing a structural transformation. A new paradigm that is in tune with the digital twenty-first century is fast emerging, driven by Industry 4.0 (I4.0). There is a need for smart factories that will be characterized in terms of flexible systems and machines using digital technologies. In this new scenario, the flow of information becomes the common thread, providing cross-functional visibility across the enterprise from the shop floor to top management. The industrial sector, especially the SMEs in developing countries can leapfrog with Industry 4.0, which is characterized by an increasing digitization and interconnection of

products, value chains, and business models. While many large companies are already attempting to anticipate the potential risks of digitization for their business models, and have introduced innovative processes, SMEs have now started realizing the potential benefits of I4.0 implementation for overall productivity improvement.

Economist Nicholas Kaldor theorized manufacturing as the engine of growth and stipulated that there exists a close relationship between the growth of manufacturing output and the GDP of a country. Although India banks heavily on its services sector for growth, the manufacturing sector too plays a significant role in its economy. The MSME sector plays a pivotal role in the Indian economy and provides the largest share of employment after agriculture.

To transform India into a global design and manufacturing hub, Government of India has launched the landmark 'Make in India' aimed at increasing the share of manufacturing in the country's GDP from 16% at the time of writing this report to 25% by 2022 and creating 100 million additional jobs by 2022.

Digital connectivity forms the backbone for adoption of Industry 4.0 technologies. With increasing penetration of the internet in India and emergence of e-commerce, the presence of enterprises on the internet has become inevitable. Ensuring comprehensive broadband connectivity in industrial clusters, Government of India has launched the Digital India program with a vision to transform India into a digitally empowered society and knowledge economy.

As with any disruptive technology, Industry 4.0 will have a transformational impact on employment and skills. The shift in employment caused by adoption of Industry 4.0 is imminent and profound. Existing jobs will require to be transformed with the aid of virtual reality and augmented reality. The existing workforce will require largescale reskilling to adjust to the new reality at speed. The education system will need to provide industry-based training, aligned with global standards, combined on-job learning and supported by public policy leaders and civil society.

As the government aims for a USD5 trillion economy by 2025, of which manufacturing would be USD1 trillion, the convergence of flagship programs such as 'Make in India,' 'Skill India,' and 'Digital India' would be key to achieve this goal.

If India wants to be the next manufacturing hub of the world and improve its exports share in global trade, it has to move up the global value chain and close the quality gap with its peers, while ensuring environmental sustainability. This will require manufacturers to leapfrog to newer technologies and transition to a new and exacting definition of competition, both of which will have implications on job creation, especially for the unskilled.

#### **CoE on IT for Industry 4.0**

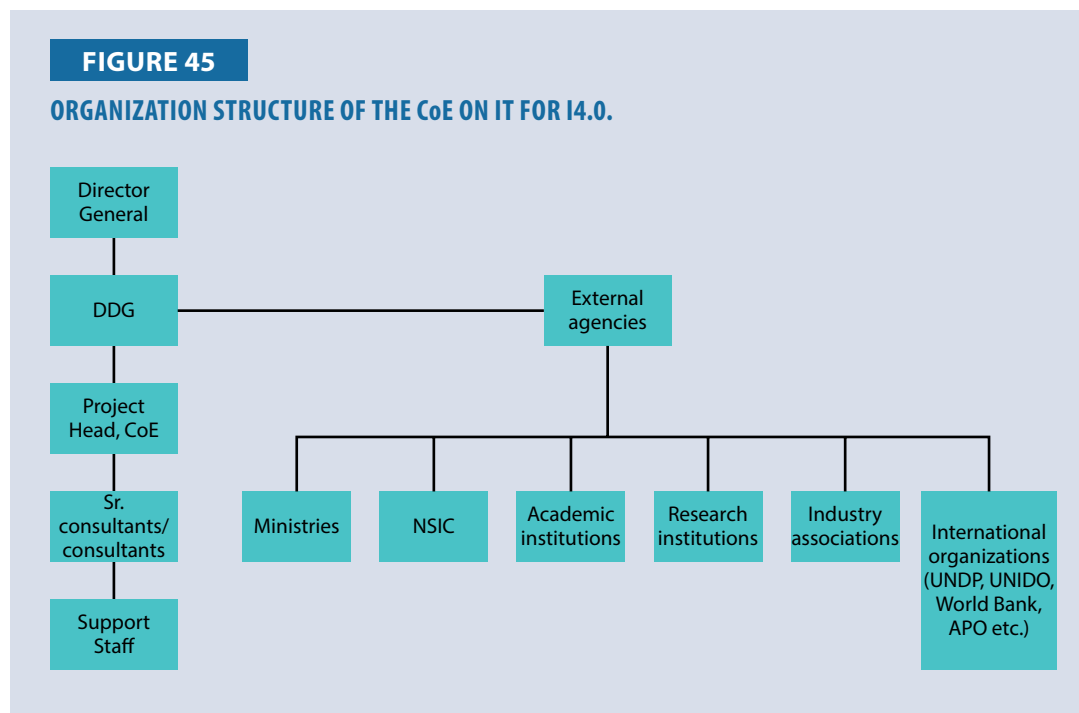
National Productivity Council (NPC) is the national-level organization to promote productivity culture in India. Established by the Ministry of Industry, Government of India in 1958, it is an autonomous, multipartite, nonprofit organization with equal representation from the organizations of employers and workers and the government, apart from technical and professional institutions and other interest groups. The NPC is a constituent of the Tokyo-based APO, an intergovernmental body, of which India is a founding member.

The NPC is poised to play a pivotal role of the torchbearer enabling industries to successfully embrace Industry 4.0 technologies. In this regard, the NPC has established a CoE on IT for Industry

4.0 (CoE on IT for I4.0), in collaboration with the APO. It has a mandate to function as a channel for enhancing competitiveness of the manufacturing sector by inculcating I4.0 features to make the industry/SMEs future-ready and digitally productive. The approach in support of Industry 4.0 is to integrate SMEs with global value chains and develop their manufacturing capability for realizing the productivity and competitiveness gains.

### Organization Structure

The CoE team consists of dedicated staff and draws experts from other organizations within India and across the APO to assist in specific initiatives. The CoE will engage external experts as needed, both in the current startup phase and in the upcoming implementation phase. In addition, the CoE will utilize staff in the NPC's network of regional offices. The organizational structure is given in Figure 45.



As the organizational chart illustrates, the CoE will utilize the strong network that the NPC has established with various stakeholders comprising consultants and other organizations, government agencies, industry associations, and international organizations, including the UNDP, UNIDO, and The World Bank. It is also supported by the APO's technical advisors. In addition, the CoE will be establishing a hub-spoke delivery structure linked with the NPC's network of 13 regional offices across India.

### CoE's Focus

The NPC India has outlined the directions for the CoE to

1. bring a paradigm shift in manufacturing strategies (purpose);
2. be the knowledge center in India and to provide support to Asia-Pacific on I4.0, showcasing the success stories of digital transformation for improving manufacturing competitiveness (vision); and
3. help in transforming manufacturing processes of SMEs with I4.0 technologies (mission).

The broad objectives of the CoE are to

1. create awareness and develop knowledge base on I4.0;
2. showcase connected industries using I4.0 technologies; and
3. disseminate knowledge to various stakeholders.

**Functions:** The NPC has identified the following functions as the practical roles that the CoE could initiate to meet those objectives and deliver on the CoE's mission:

1. Function as a knowledge center for entrepreneurs and startups regarding concepts of information technology and its application in Industry 4.0.
2. Build a database of technical and domain experts to assist APO member countries with Industry 4.0 programs.
3. Facilitate display of latest technologies/demonstration projects for helping MSMEs, startups, etc.
4. Establish industry-academia linkages to resolve productivity-related issues of SMEs in particular and the economy in general.

**Key CoE objectives:** At the outset, the APO has identified some key objectives for the CoE:

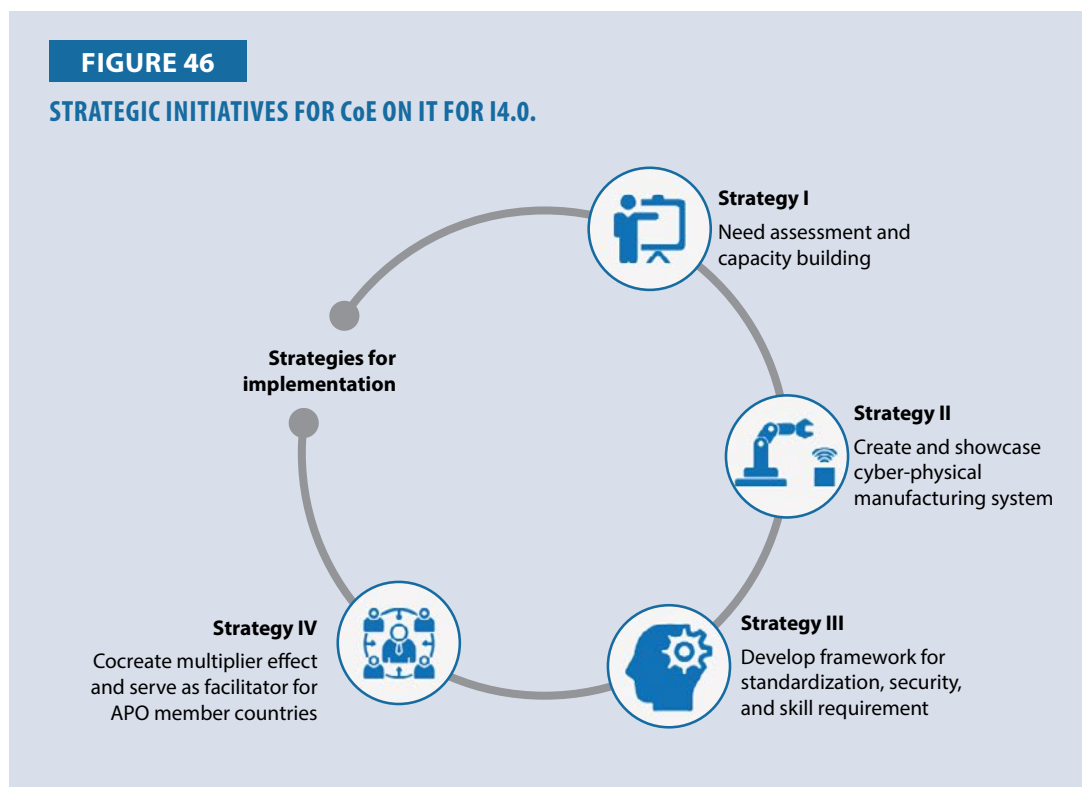
1. Facilitate awareness, training, learning, and sharing of knowledge and best practices through customized training modules in the fields of Industry 4.0, lean manufacturing, and continuous improvement.
2. Identify and disseminate innovations and best practices in Industry 4.0 and lean manufacturing among other NPOs.
3. Provide international training-of-trainers courses for APO members.
4. Develop training materials and modules to support its activities.
5. Build a database of technical and domain experts to assist APO member countries with their Industry 4.0 and lean manufacturing programs.
6. Develop a certification program for Industry 4.0 and lean manufacturing based on IT through national courses.
7. Undertake research in the field of Industry 4.0 and lean manufacturing to develop IT app-based dissemination tools for greater scalability.
8. Undertake meta-analysis and benchmarking research leading to sectoral action plans for productivity enhancement.



9. Establish industry–academia linkages with institutions like IIT, Gandhinagar, to resolve productivity-related issues of SMEs in particular and the economy as a whole in the Industry 4.0 scenario, through use of IT.
10. Develop strategic engagements with leading international organizations/bodies, including institutions like Fraunhofer and Bosch in Germany and others in APO member countries, to maximize the benefits of Industry 4.0 in Asia-Pacific for different sectors.

The above are broad mandates for the CoE. In line with these, the NPC has identified four strategic implementation initiatives (see Figure 46) that it should undertake in a stepped approach over its first three years of operation. These are

1. conducting needs assessment and capacity building (2019);
2. creating and showcasing a cyber-physical manufacturing system (2019–20);
3. developing framework for standardization, security, and skill requirement (2020); and
4. cocreating multiplier effect and providing the facilitator’s role to APO member countries (1920–21).



**Resources (finances):** The CoE reported a projected budget for the initial five years on an approximately 50/50 cost-sharing basis between the CoE and the APO. However, the forecast predicated some fluctuation over the period (see Table 23). The CoE has an aggressive strategy to ensure the financial sustainability of the CoE as the program delivery ramps up.

TABLE 23

## BUDGET PROJECTIONS AND SHARING BETWEEN APO AND COE, 2017–21.

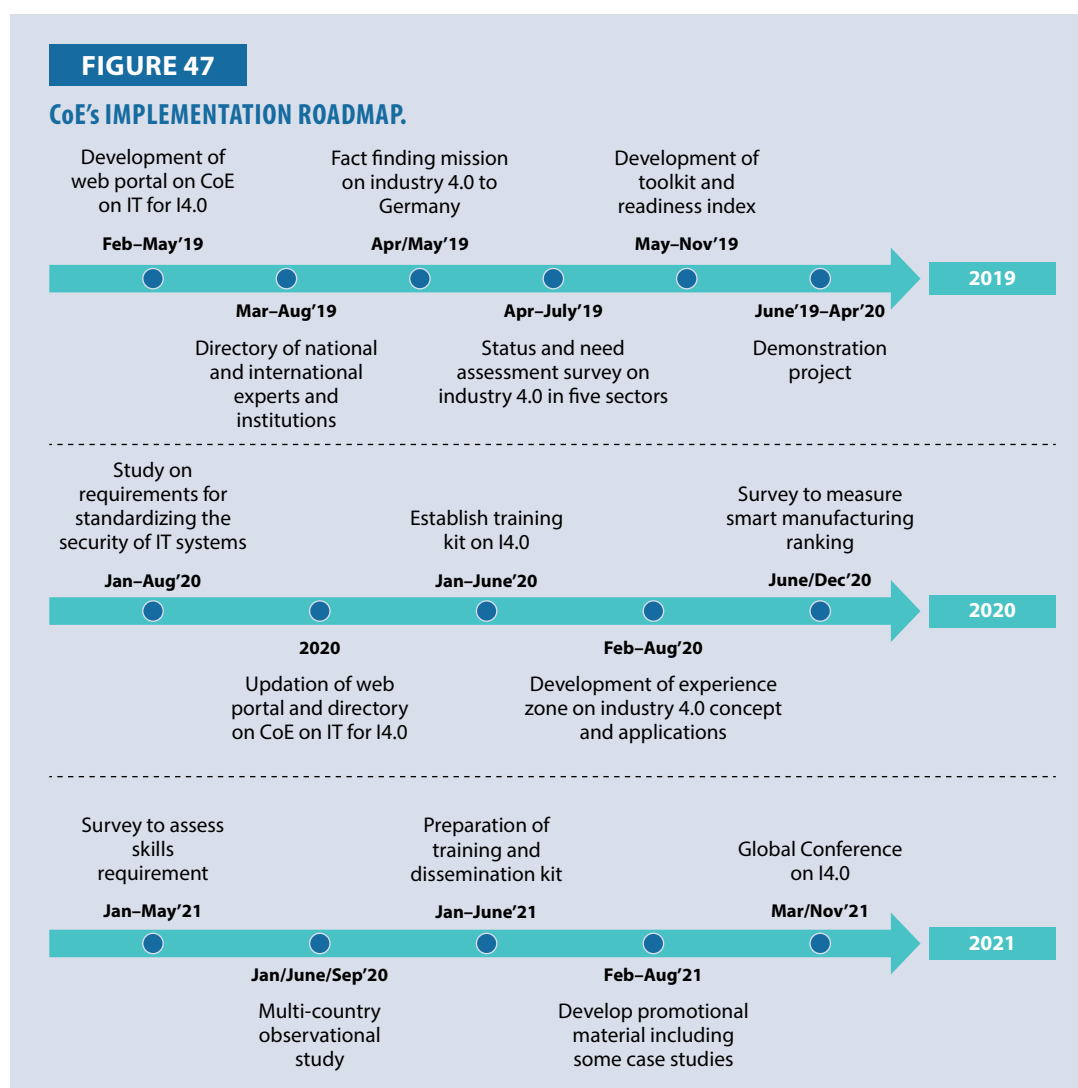
Agency	2017–19	2020 (Projected)	2021 (Projected)
APO	USD208,340	USD57,000	USD125,000
CoE	INR8,825,000 (USD119,257)	INR15,000,000 (USD202,703)	INR18,700,000 (USD252,703)
Total	USD327,597	USD259,703	USD377,703
APO%	63.5%	22%	33.09%

## Marketing and Communications

The CoE has established a web portal, <https://coeindustry4.in>. Here, all activities related to CoE on IT for I4.0, e.g., Demonstration Project on Industry 4.0, outcome videos and reports, reports of activities of CoE, etc. are being uploaded on regular basis.

## Planning and Implementation

Figure 47 illustrates the CoE's roadmap for three years (2019–21), which is aligned with achieving its objectives.



The CoE is striving to create the digital ecosystem for augmenting the capabilities and capacities of manufacturing SMEs and startups at an enterprise/unit level. The CoE aims to create and highlight cyber-physical manufacturing systems through creation of experience zones in key industrial sectors, and by undertaking a demonstration project that will provide information about complete cycle of implementation of Industry 4.0 technologies besides productivity improvement. Some of the major activities completed, planned, or ongoing are discussed next.

In order to highlight the real-time benefits through application of smart technologies, the CoE has undertaken a demonstration project in association with the APO on 'Application of Smart Technologies' at Vibgyor Automotive Ltd, Chennai and an auto component manufacturer. The smart transformation of value chain in business process, use of smart technology and smart solutions, and empowerment of workers has shown very positive results with quality improvements, enhanced overall equipment effectiveness (OEE) monitoring, and improved inventory turnover ratio (ITR) that amounted to total savings of INR5 million per year.

Further, the CoE is also leading the implementation of the Demonstration Project on IT for Industry 4.0 in five SME companies in the Delhi–NCR region in association with the APO. These demonstration companies will serve as lighthouses and training centers for further propagation of Industry 4.0 among SMEs and other companies.

A research study spanning five sectors (automotive, food processing, agriculture machinery, pharmaceutical and healthcare, and textiles and garments) is underway to assess the current level of digitization and the readiness for Industry 4.0 in these sectors. The outcome of the research study will form the basis for further policy interventions required to bridge the gap in adoption of Industry 4.0 on a wider scale in the manufacturing sector.

A directory of national and international expert and institutions to create a robust pool of technology pioneers working on the latest concepts and technologies related to Industry 4.0 is currently under development. This will serve as a basis for reaching out to a wider gamut of experts to make them part of the knowledge chain for sharing, learning, collaboration, and cocreation for mutual benefits.

As per the roadmap, the CoE is also developing an experience zone at the NPC's headquarter in Delhi in the form of a studio for digital display of storyboards with cases, etc. on the walls. It will also incorporate virtual reality (VR) displays of use cases in the forms of films and other multimedia to create a virtual manufacturing environment.

An I4.0 assessment model is being developed to assess the current level of digitization and readiness for Industry 4.0 among the manufacturing industries/SMEs. It will also be able to identify gaps and critical requirements and strategies for the industries, including SMEs, to transform and rise to the next level of 'connected industry.'

The CoE's strategy, as noted above, is to propagate the concepts and applications of I4.0, and develop the analytical tools and information materials. To educate and demonstrate the potential and impact of I4.0, the CoE is creating experience zones at its headquarters. The CoE is also working with best-practice Industry 4.0 implementers to recognize some existing I4.0-enabled highly productive organizations as demonstration sites. Once these are established, the CoE will encourage industries/SMEs in India and other APO member countries to visit these sites to learn

more about Industry 4.0. As other NPOs indicate their interests, the CoE will work with them to undertake in-country needs assessments on a sector-to-sector basis.

#### Framework for Industry 4.0 Implementation

In order to upgrade the activities of the CoE on a wider scale, it has taken up a new initiative and developed a framework for developing academic-industry linkages comprising the following components:

**Empanelment of academic institutions and consulting companies:** Five academic Institutions and six consulting companies are the implementation partners of the CoE.

**Outreach CoEs (OCoE) as E-Grow centers:** The overall objective of this initiative is to transform OCoEs established at the empaneled universities into E-Grow centers to support industries, enterprises and academia through project implementations and helping the SMEs to grow. At the OCoEs, three verticals will be set up under the overall umbrella of CoE on IT for I4.0. These three verticals will be augmented by the 3M concept, encompassing “Man (Enterprise 4.0), Machine (Industry 4.0), and Market (Marketing 4.0).”

Marketing 4.0 adapts to the wave of the new industrial revolution, which in turn adapts to the new consumer behavior by introducing intelligent production systems. These systems allow to know in advance the tastes and needs of users and to overcome the limitations of the traditional mass-market approach in delivering personalized consumer experiences. Industry 4.0 enables technological interventions through IoT, data analytics, 3D printing, AI, etc. Enterprise 4.0 focuses on the human empowerment (new skills) required to manage highly skilled business operations.

The CoE, NPC will oversee the transformational processes of the OCoEs to align with the above model through detailed studies of existing human skills, infrastructure, and industrial ecosystems in their vicinity and will chart out development roadmaps for each OCoE.

**Functions of Outreach CoEs:** These OCoEs at universities will act as partners of the CoE and coordinate for conducting the following activities:

- Industry awareness programs under the banner of CoE Cell, NPC: The aim is to enlighten the industry, including SMEs on latest concepts on I4.0, innovation, and growth model for generating interest and selection for project implementations in those SMEs.
- Implementing Industry 4.0 projects at SMEs: The CoE Cell, NPC, and the empaneled academic institutions and consulting companies will combine to form a triparty wherein CoE Cell, NPC will function as the hub, while the academic institutions and consulting companies will work as spokes. A designated team termed I4.0 Taskforce, consisting of professors and students/research associates will be formed and attached to a chief consultant from the consulting company empaneled with the CoE Cell, NPC to form an I4.0 Implementation Group. This group will take the Industry 4.0 projects to manufacturing industries/SMEs present in and around the regions of each OCoE. The CoE Cell, NPC will be the focal point for coordinating the overall implementation of the I4.0 projects, apart from carrying out the initial assessment to check the readiness of SMEs for Industry 4.0, along with the I4.0 Implementation Group.
- Development of entrepreneurship: This will be done through the Real Time Entrepreneurship Program under Enterprise 4.0 and Marketing 4.0.

- Development of two credit systems per year at empaneled universities: The development of both faculty and students will be undertaken through participation in real-time projects on Industry 4.0, Enterprise 4.0, and Marketing 4.0.

As a pilot, a workshop on ‘Innovative Business Transformation Tools’ was organized at Sharda University in Greater Noida on 13 March 2020, where SME owners from the Noida and Greater Noida region participated. A needs assessment survey was also conducted during the workshop. The industries appreciated the impact and recognized the need for implementation of innovation in their businesses through Industry 4.0, Enterprise 4.0, and Marketing 4.0. Most of them have shown willingness for NPC-led detailed assessments at their respective plants to ascertain the major pain areas and chart out implementation roadmaps for their industries.

## Indonesia

In the ‘Making Indonesia 4.0’ roadmap, five priority sectors are selected by considering their industrial sizes or values in terms of contribution, the net export potential, and feasibility in terms of adoption of disruptive technologies.

### Food and Beverage

This sector accounted for 29% of Indonesia manufacturing GDP in 2016. Indonesia has great growth potential in comparison with other countries in Asia. Productivity can be improved by adopting technologies such as automated monitoring systems and drones. It is also expected that the food and beverage sector can create a powerhouse in the ASEAN region.

Smart packaging is a term that is used to define a packaging material that contains an intelligent element to maintain the food quality and safety standards. However, regulations should be enforced to support smart packaging. It is expected that a supportive regulation can encourage smart packaging manufacturers to scale up their production and provide an effective means to smart manufacturing implementation in Indonesia (see Figure 48).

### Textile and Apparel

This sector is the second-largest contributor to Indonesia’s manufacturing exports. Its position weakened as global manufacturers shifted their production facilities to lower-cost countries, but the local sector can lift up its competitiveness by adopting key processing technologies. Indonesia can commit to becoming a leading functional clothing manufacturer by effectively and efficiently adopting the smart manufacturing concept (see Figure 49).

### Automotive

Indonesia is already the second-largest automotive exporter in the region. However, it can further improve its competitiveness by increasing local production of raw materials and components. Moreover, Indonesia can commit to become a leading player in electric vehicles (EVs) and internal combustion engine (ICE) exports (see Figure 50).

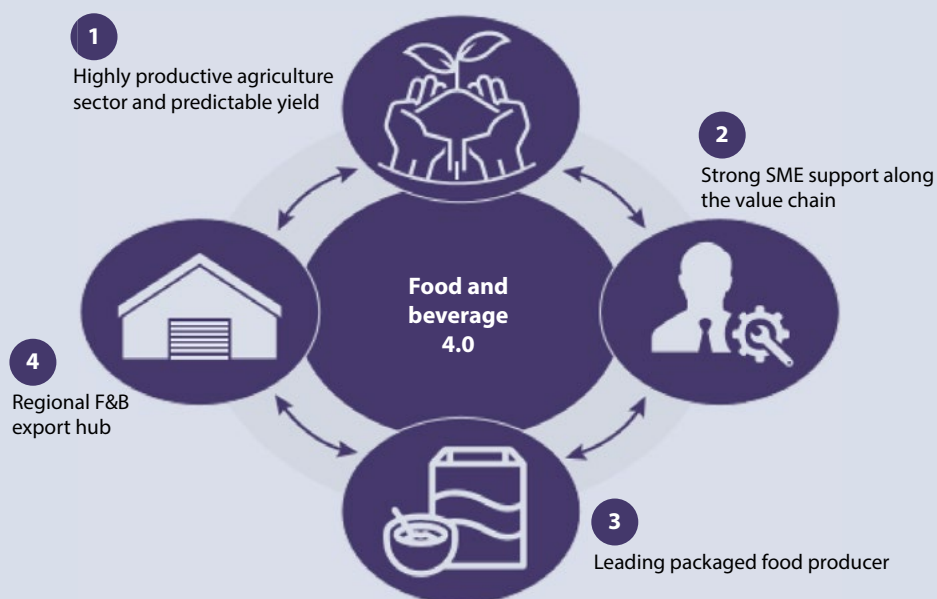
### Chemicals

Strengthening this sector is imperative to building a globally competitive manufacturing industry. Indonesia has abundant agricultural, oil, and gas resources, which gives its chemicals sector a competitive advantage. It can improve its capabilities by adopting fourth industrial revolution technologies and accelerating R&D. In addition, positioning Indonesia as a leading player in the biochemicals industry can be the main target in this priority sector (see Figure 51).

**FIGURE 48**

**FOOD AND BEVERAGE SECTOR'S POTENTIAL FOR INDONESIA.**

**Towards 2030**

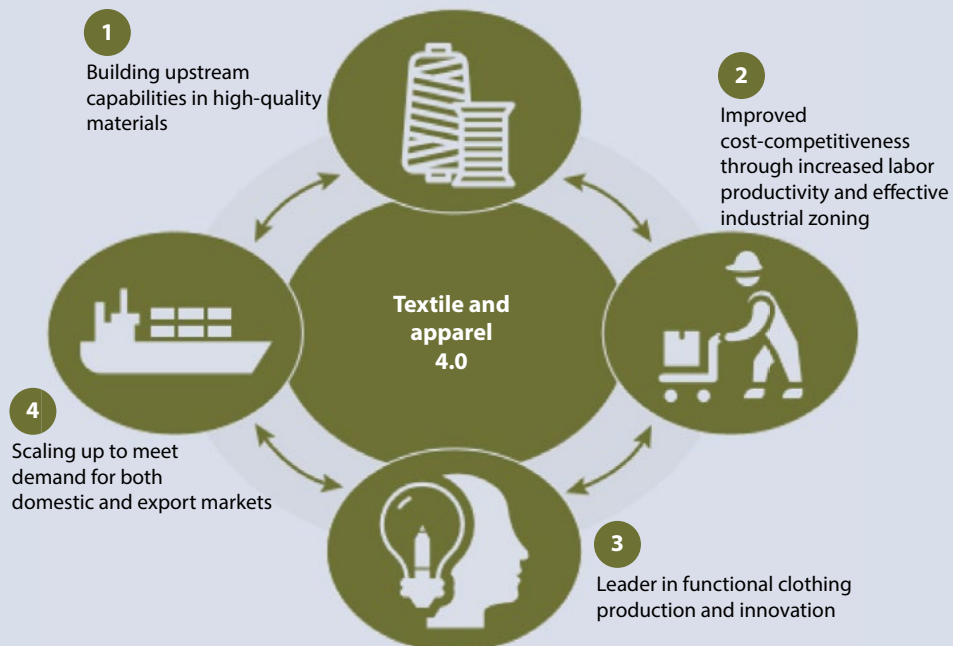


Source: Ministry of Industry.

**FIGURE 49**

**INCREASING THE COMPETITIVENESS OF INDONESIA'S TEXTILE AND APPAREL SECTOR.**

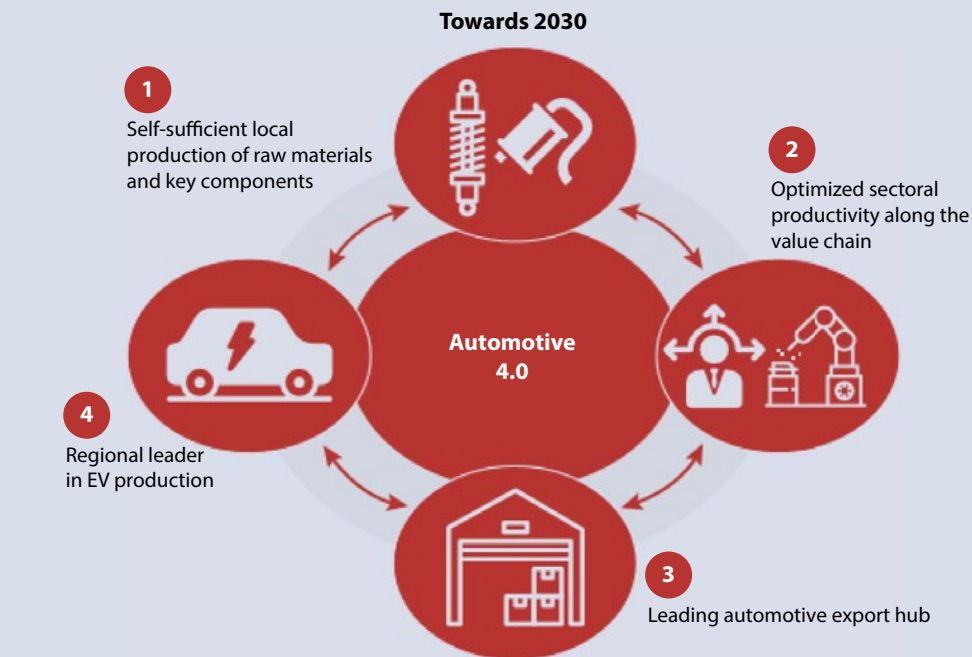
**Towards 2030**



Source: Ministry of Industry.

**FIGURE 50**

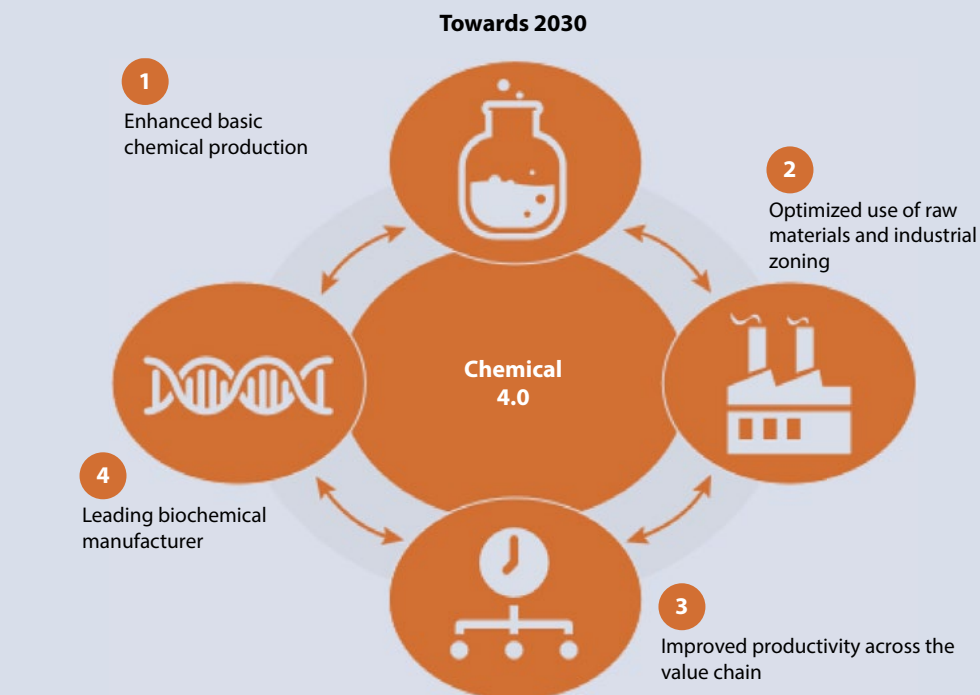
**RECHARGING INDONESIA'S AUTOMOTIVE SECTOR.**



Source: Ministry of Industry.

**FIGURE 51**

**INCREASING COMPETITIVENESS OF INDONESIA'S CHEMICALS SECTOR.**

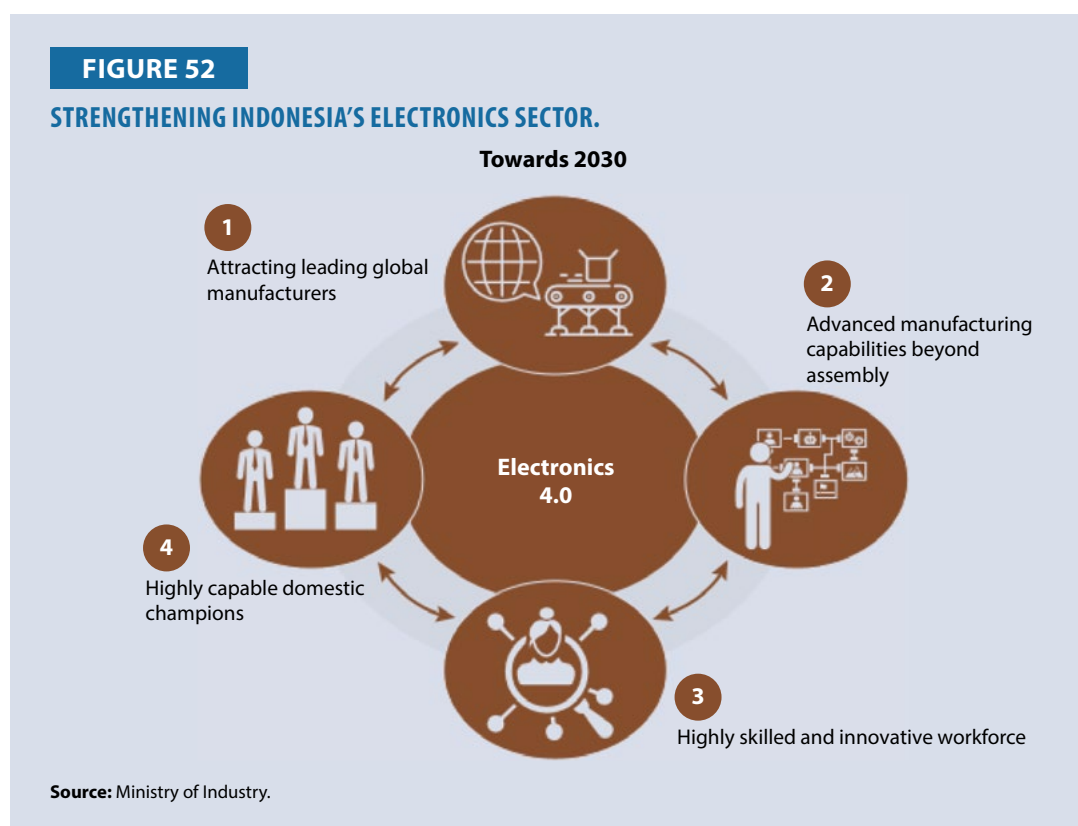


Source: Ministry of Industry.



## Electronics

Attracting investment from top global players and upskilling local engineers will be important in developing the nation's emerging electronics industry. In this sector, the government aims to develop the ability of domestic industry players (see Figure 52).



By focusing on these five sectors, the implementation of smart manufacturing can raise the country's economic growth. The Ministry of Industry has announced the companies that received the INDI 4.0 awards across these five sectors. They are PT Indolakto (food and beverage sector); PT Pupuk Kaltim (chemicals sector); PT Pan Brothers, Tbk (textiles sector); PT Toyota Motor Manufacturing Indonesia (automotive sector); and PT Hartono Istana Teknologi (electronics sector). These several companies have become models in the implementation of Industry 4.0. The application of the digital economy will create new opportunities. Based on the studies of McKinsey and PwC, digital economics has the potential to increase the national GDP by USD150 billion in 2025.

In fact, in 2025, Indonesia will also need as many as 17 million new technology-literate workers. Therefore, they need new skills, including talents that are different from what they have now. In the manufacturing sector, it is estimated that there will be an increase of 4.5 million workers, while another 12.5 million workers will be needed for the support services sector. Reskilling, retraining, vocational, and polytechnic programs are therefore the government's priorities. For this reason, preparing quality human resources is a priority of President Joko Widodo in his second term.

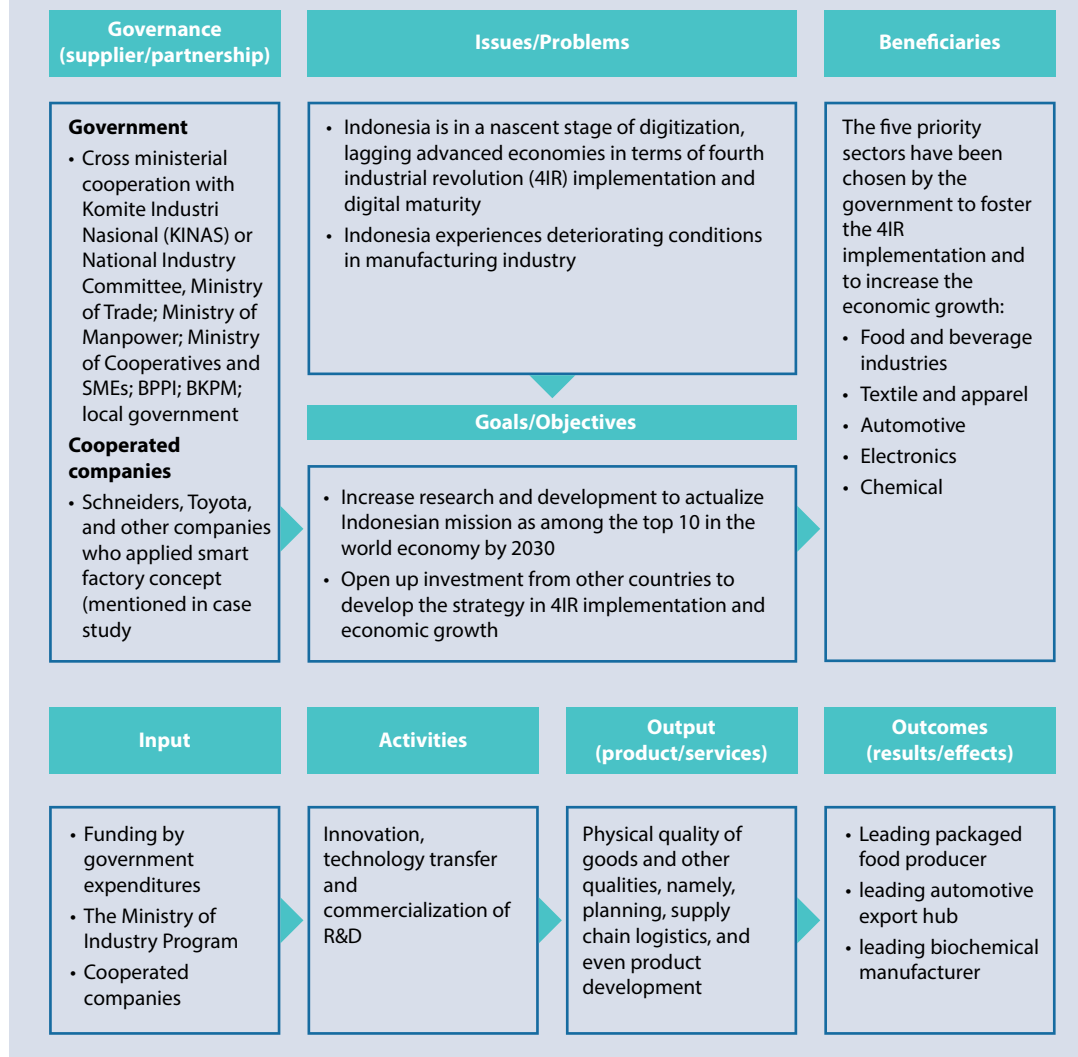
## Industry 4.0 Readiness Index (INDI 4.0)

The implementation of Industry 4.0 is set to encourage an increase in the industrial sector's productivity more efficiently. This is because connectivity will be empowered via digital technologies such as IoT and AI.



FIGURE 53

## POLICY MODELING CANVAS FOR INDONESIA.



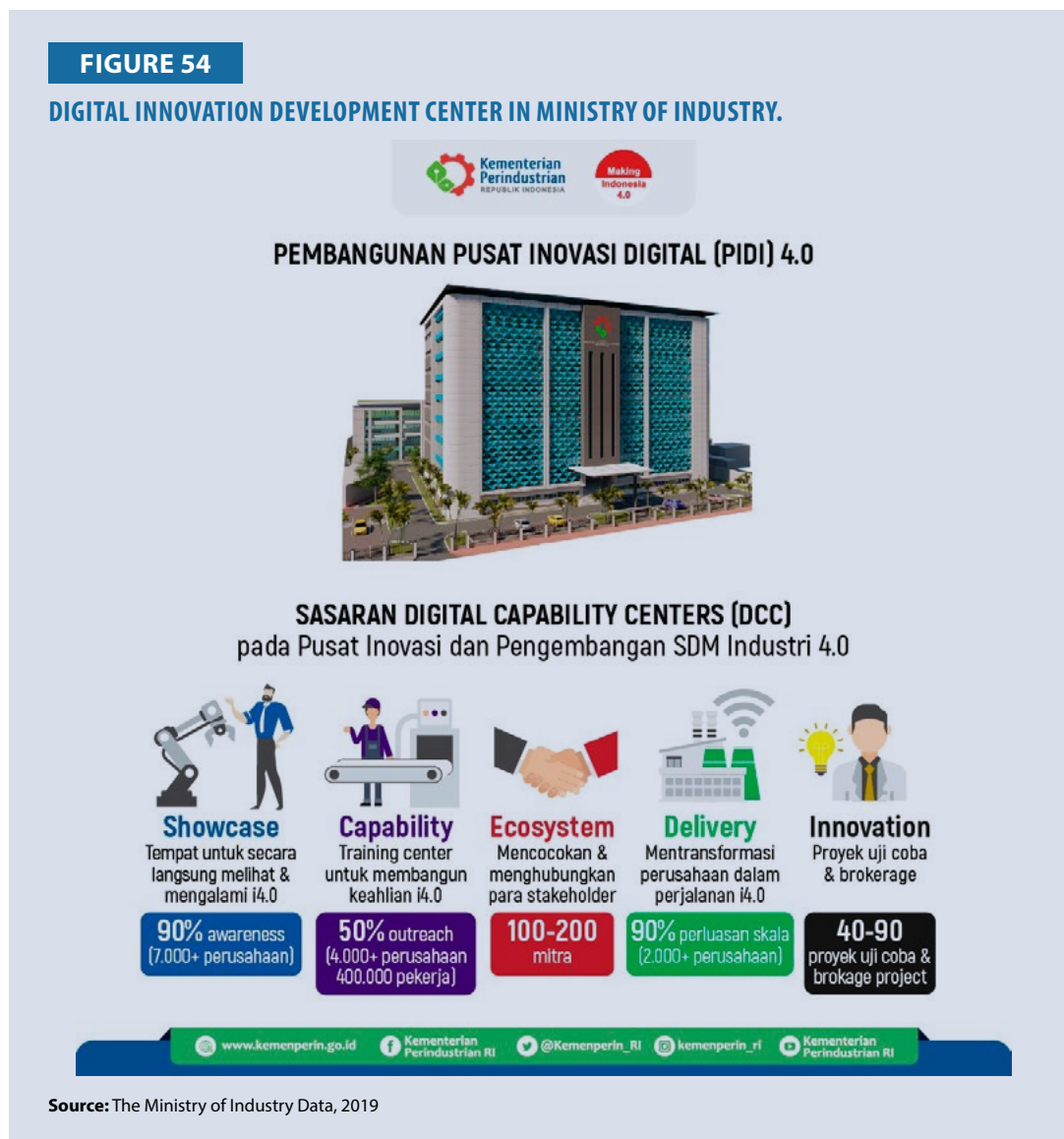
The use of human intelligence and human resources fully in the process of adopting modern manufacturing and computer technology (Yuejin, 2000). In fact, Industry 4.0 will be able to bring up many new jobs, such as technicians to repair robots and experts to process data. Moreover, many applications have been developed to support the production process. The Ministry of Industry has assisted the inaugural implementation of Industry 4.0 to 10 national manufacturing companies. This strategic effort is to spur global competitiveness and support the readiness for transformation in the digital age. These companies are expected to serve as pilots in Indonesia. They represent the five manufacturing sectors that receive development priorities according to the 'Making Indonesia 4.0' roadmap. The ten companies are PT Belindo International Carpet, PT Biggy Cemerlang, PT Paragon Technology and Innovation, PT Dharma Precision Tools, PT Sanken, Nutrifood, PT Nirmas Utama, PT Globalindo, Suzuki Indomobil, and PT Sunindo Adipersada.

As a follow up, the Ministry of Industry conducted an INDI 4.0 assessment of 326 industrial companies. As a result, 166 industrial companies (50.92%) received scores in the range of 1–2, which indicates the initial readiness of Industry 4.0 implementation. Next, 116 industrial companies

(35.58%) achieved scores in the range of 2–3, which indicates moderate readiness. Further, 22 industrial companies (6.75%) earned score in the range of 3–4, which shows that they have implemented Industry 4.0.

The assessment provides industrial positioning in Indonesia for readiness in transforming to Industry 4.0, which provides a basis for the government to make appropriate policies and programs for Industry 4.0. Moreover, it is important to develop the industrial ecosystem 4.0. There are five points regarding the benefits of the ecosystem. First, in principle, it needs to be formed for the acceleration of industrial transformation 4.0. Second, some parties can collaborate more with each other to accelerate the industry transformation process 4.0. Third, regarding the demand and supply between parties can be better achieved through the ecosystem. Fourth, it can increase the availability of local experts to accelerate the process of industrial transformation so that it is more effective and efficient in terms of both time and cost. The fifth point is that the government initiated the formation of industrial ecosystem 4.0 from things that are easy and can be collaborated between parties in the process of acceleration of industrial transformation 4.0. Reflecting on the results of the formulation, the government initiated to form the Indonesian Ecosystem 4.0 called SINDI 4.0 (see Figure 54).

**FIGURE 54**  
**DIGITAL INNOVATION DEVELOPMENT CENTER IN MINISTRY OF INDUSTRY.**



In this series of events, the Ministry of Industry appointed PT. Batam Electric Manufacturing Schneider (PT. SEMB) as Lighthouse Industry 4.0 in Indonesia. This appointment is based on the Batam Digital Transformation Journey Program that began in 2017, covering four pillars, namely cyber security, people and leadership, product life cycle and data management, and data analytics. The key to the success of PT. SEMB in conducting digital transformation is carried out through several stages including 1) defining commitments from top management to the lowest level and clearly formulating company targets; 2) development of digital competencies and changing mindset, work culture and organization towards digital attitude; and 3) Scaling up through capacity development and adoption of new and efficient operational models to be applied in the company. Schneider as a lighthouse can be a lesson for other industries in transforming to Industry 4.0. The government hopes more and more lighthouses will be scattered throughout Indonesia in future.

In 2018, the Ministry of Industry, TUV Rheinland, PT. Festo Indonesia, and PT. Schneider Electric Indonesia held technical guidance at PT. SEMB for 65 participants (4.0 industry transformation managers). The transformation manager is a leader for transformation to Industry 4.0 in his or her company. Based on the INDI 4.0 assessment, the Ministry of Industry provides technical guidance on industrial transformation 4.0 to both managers and industrial company engineers.

The government, through the Ministry of Industry, is targeting 500 industrial company managers and engineers to follow the technical guidance of industry transformation 4.0 so that more companies will transform to Industry 4.0. In order to campaign for ‘Making Indonesia 4.0’ and show the achievements of Industry 4.0 implementations in Indonesia as a result of the INDI 4.0 assessment and assistance that has been carried out, the Ministry of Industry held its first INDI 4.0 Roadshow in Surabaya, on 17–18 September 2019. Surabaya became the first city for the roadshow, which will later be held in several other cities. The goal is to demonstrate the ability of the industrial sector in Indonesia in implementing Industry 4.0. This event is also a venue for meeting of stakeholders.

In 2018, the tax realization from the industrial sector reached Rp363.60 trillion or 30% of the total tax revenue of Rp1,316 trillion. The industrial deposits increased by 11.12% compared to 2017. In addition, the industry was able to contribute excise tax revenue of Rp159.7 trillion. During January to June 2019, shipments of national manufactured products were able to reach up to USD60.16 billion. This value accounted for 74.88% of the national exports that reached USD80.32 billion in the first half of the year, as per the Ministry of Industry.

## Philippines

### Background

Automation, mechatronics, and robotics are the technologies that provide the foundation for the latest advancement of manufacturing system that best characterizes the Fourth Industrial Revolution, also known as Industry 4.0. The merging of these technologies, which led to the spawning of cyber-physical systems (CPS), internet of things (IoT), and cloud computing, paved the way for the phenomenal growth and usage of data exchange and machine-to-machine interactions. Industry 4.0 works on the principle that connected machines, work pieces, and systems create intelligent networks that can control each other autonomously. For businesses, the advent of these cutting-edge capabilities translate into processes improvements along the value chain, thereby reducing costs and enhancing productivity.

According to Abdula [1], the Philippines' economic growth has been highly unstable since the 1980s. The country is still primarily a consumption-led economy. In terms of manufacturing, production chains are largely labor-intensive and import-dependent. Moreover, the country's workforce lags behind other Asian countries in areas of advanced technology, particularly mechatronics and robotics, due to the unavailability of R&D facilities and lack of qualified training personnel. A study conducted by Singapore Management University in partnership with J.P. Morgan also revealed that the local workforce lacks science, technology, engineering, and mathematical skillsets, making its profile generally suited only for low-skill manufacturing.

The Philippines has to make proactive moves in order to take advantage of Industry 4.0 (I4.0) opportunities. To be able to jumpstart the Philippines' efforts towards I4.0, there is a need to strengthen the automation, mechatronics, and robotics skills and competencies of the Filipino workforce in the manufacturing industry. In doing so, the Philippines will also be able to achieve sustainable economic growth, overcome the problem of shortage of skilled employees and workers, and address the demands of globalization adaptation, among others.

Robotics and mechatronics are definitely the areas to exploit. Some of the major initiatives for training in robotics and mechatronics are spearheaded by the Technical Education and Skills Development Authority (TESDA) through the Mechatronics Technologies Corporation (MTC), and the various activities implemented by the Mechatronics and Robotics Society of the Philippines (MRSP).

Recognizing the crucial role of manufacturing technology advancements, Metals Industry Research and Development Center (MIRDC) proposes to establish the Advanced Mechatronics, Robotics, and Industrial Automation Laboratory (AMERIAL) as a complementary facility to further support manufacturing resurgence that will make the enabling technology-based processes available to more industries. AMERIAL is envisioned to create a pool of skilled and highly qualified workforce, and to become an accredited training and development facility in industrial automation. Its service offerings include conduction of training programs, development of automation applications, and promotion of research collaborations (see Table 24).

## Policy Modeling Canvas

### Issues/Problems

1. Unavailability of R&D facility for advanced robotics and mechatronic and Smart Factory applications (There are three key issues. First, only basic mechatronic courses are offered locally. Second, MS and PhD students conduct their research abroad. Third, local manufacturing companies heavily depend on imported products and services.)
2. Lack of qualified training personnel for advanced robotics, mechatronics, and smart factory
3. R&D in the Philippines not active as compared with other developed ASEAN countries

### Goals/Objectives

1. **General objective:** Establish AMERIAL to support the technological advancement, workforce improvement, and competitiveness of the metals and engineering (M&E) industries.
2. **Specific objectives:** There are two specific objectives. First, to acquire advanced mechatronics, robotics, and smart manufacturing technologies, and establish the industrial

laboratory to serve as common service facility for the local M&E industries. Second, to provide trainings in specialized techniques and procedures on the relevant technologies.

#### Governance (Supplier/Partnership)

These include Department of Science and Technology (DOST), MIRDC, and MRSP.

#### Beneficiaries

The key beneficiaries are academia, automotive industry, agricultural industry, metal and engineering industry, and semiconductor industry.

#### Inputs

1. **Funding:** DOST, MIRDC, and MRSP.
2. **Human resources:** DOST-PCIEERD, MIRDC, and MRSP.

#### Activities

1. Renovation and upgradation of existing facilities;
  - Layout metal workshop II of MIRDC as per the requirements
  - Design and construction of offices, laboratories, and seminar rooms
2. Acquisition of advanced technologies;
  - Preparation of equipment description, specification, terms of reference, and other required documents prior to purchasing
  - Pre-bidding and bidding of advance equipment
3. Advanced technologies training;
  - Identification of appropriate advanced technology training programs for MIRDC key personnel
  - Identification of key personnel, who will be trained, qualified, and certified for specific trainings and NC levels
4. Promotion and marketing of training programs and services offered; and
  - Promotion of training programs by the Mechatronics and Robotics Society of the Philippines (MRSP) to members (individuals, companies, organizations) and other entities from M&E industries
  - Participation in exhibitions conducted by MIRDC, MRSP, and TESDA as well as SUC's related activities
5. Conduct R&D activities:
  - Sign MOAs with identified R&D facilities and SUC's partner

- Conduct at least two in-house R&D projects related to mechatronics and robotics
- Conduct at least one R&D project with the MRS.
- Conduct at least three automation projects for SETUP adapters in the regions in cooperation with local SUCs
- Conduct one IoT project with DOST-ASTI

### Output

The outputs were

1. established the AMERIAL office and smart factory, and acquired the other equipment;
2. trained and certified key MIRDC personnel, industry, and academia partners;
3. prepared and submitted one scientific paper;
4. presented three papers;
5. submitted and presented two scientific paper in conferences, both locally and abroad; and
6. applied one IP for the developed equipment.

### Outcomes

The outcome details are provided in Table 24.

**TABLE 24**  
**OUTCOMES OF AMERIAL.**

Outcomes	Number
Publications	6
Patents	4
<b>Products and technical services</b>	
R&D Project implementations	350
New services offered	6
Technical services rendered	25
Training programs implementation	9
<b>People services</b>	
MIRDC personnel trained	15
Industry/academia personnel trained	60
New startup companies	3
<b>Places and partnerships</b>	
Facility established	1
Partnership forged/established	15
<b>Policies</b>	
New training curriculum developed	4
Facility sharing scheme	1

## Conclusion

The AMERIAL project directly addresses the apprehension and anticipation for the coming smart manufacturing era. Preparation through establishment of an Industry 4.0 center for learning, training, and R&D will be one of the best investments the government can make as proven through the experiences of many developed countries. Therefore, replicating this project in several locations across the country will accelerate a successful achievement of the goals and objectives of the project.

## Thailand

### Thailand 4.0 and Smart Manufacturing

The economic development of Thailand consists of three stages. The first stage was Thailand 1.0 that relied on an agriculture-based economy. In the second stage, Thailand 2.0, economic growth depended on light industry. The third stage Thailand 3.0 depended on heavy industry as the engine of growth. At the end of the first decade of the twenty-first century, Thailand recognized that it was caught in a developmental trap on account of (1) being a middle-income country; (2) income inequality; and (3) socioeconomic imbalance. In response, Thailand came up with ‘Thailand 4.0’ development policy.

‘Thailand 4.0’ is an economic model based on Industry 4.0 that aims to free the country of several economic challenges resulting from past economic development models. Thailand 4.0 aims at achieving economic prosperity, social wellbeing, human values, and environmental protection. These goals will be achieved through raising competitiveness in four main sectors and areas.

First, in the agricultural sector, Thailand 4.0 would transform traditional farming into smart farming. Second, traditional SMEs and manufacturing would be transformed into smart SMEs and manufacturing. Third, Thailand 4.0 would be able to transform the services sector and focus on high-value services. Last but not the least, labor will be transformed into skilled labor. To achieve this, Thailand needs to implement technology, innovation, and creativity. Specifically, the country needs to commit 4% of the GDP to research and development, and raise the per capita earning to \$15,000 by 2032.

For many years, Thailand’s economy relied on the manufacturing sector. However, chances for manufacturing improvement are at risk due to competitive pressures from technology advancement and countries like Vietnam and PR China. The implementation of new manufacturing techniques and technologies varies significantly across the manufacturing sector. Although large manufacturing companies have been relatively quick to implement such technologies, many small and medium manufacturing companies are lagging behind. A research implemented by Federation of Thai Industries pointed out that 75% of Thai companies are still at a level below Industry 3.0. Thailand 4.0 will become a central tool to encourage Thai manufacturing firms to approach an advanced manufacturing future with the development of connectivity, automation, robotics, AI, and big data, among others.

### Policy Modeling Canvas

Figure 55 illustrates the overall framework of Policy Modeling Canvas for Thailand.

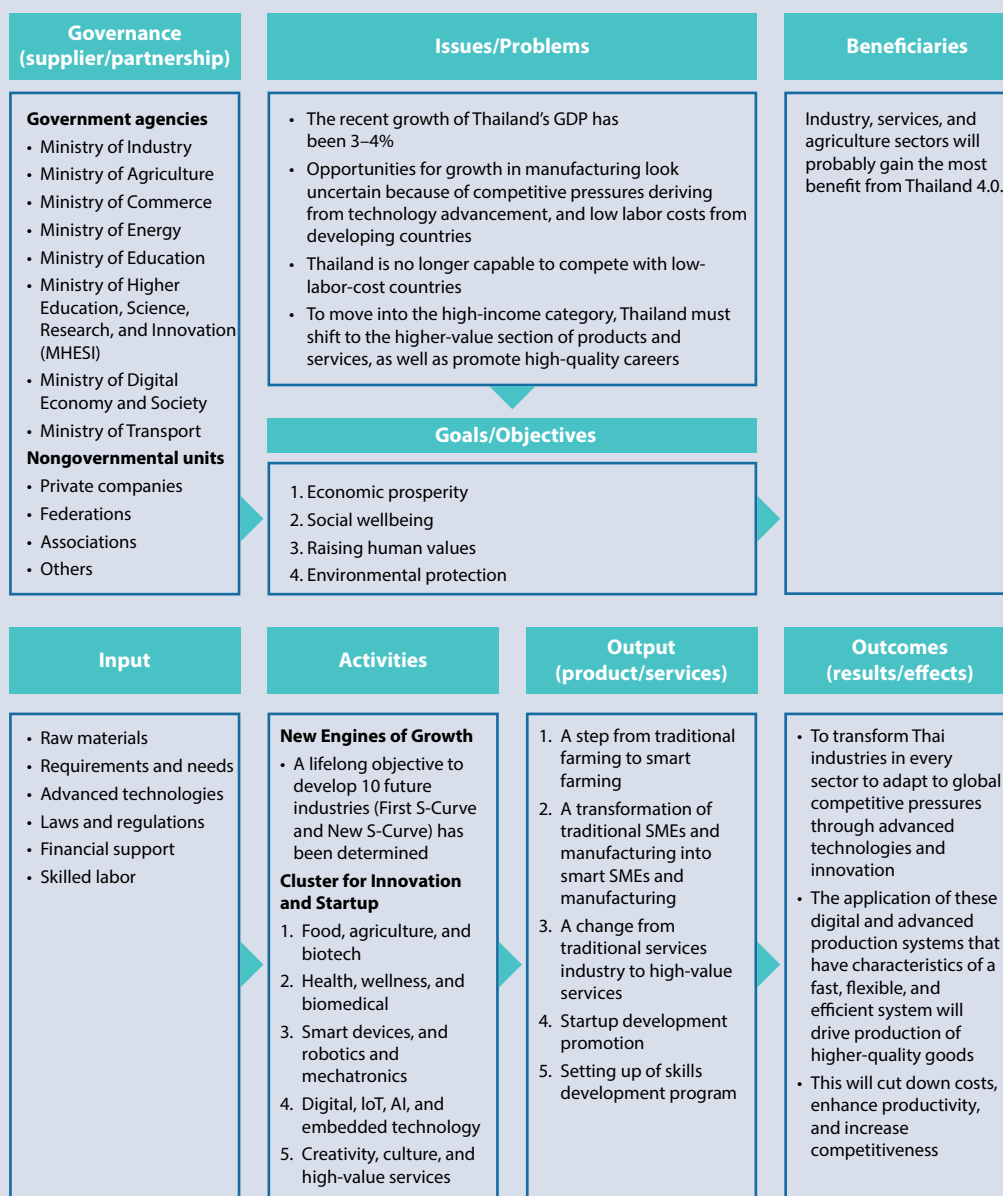
#### Governance (Suppliers/Partners)

Thai government agencies play important roles in transforming Thailand. These government agencies include Ministry of Industry, Ministry of Agriculture, Ministry of Commerce, Ministry of



FIGURE 55

POLICY MODELING CANVAS FOR THAILAND 4.0.



Energy, Ministry of Education, Ministry of Higher Education, Science, Research, and Innovation (MHESI), Ministry of Digital Economy and Society, and Ministry of Transport. In addition, private companies, associations and foundations, such as Federation of Thai Industry, and Thai Automotive Industry Association, are also an integral part of Thailand 4.0. They have different roles in supporting Thailand 4.0. As for smart manufacturing, Ministry of Industry has an extremely important role in supporting the country to accomplish Thailand 4.0.

### Inputs

Various inputs are required to drive the Thai Economy to achieve Thailand 4.0. Inputs can be categorized into raw materials, requirements and needs, advanced technologies, laws and



regulations, financial support, and skilled labor. Suppliers/partners identified above provide different inputs for elevating to Thailand 4.0. Government agencies provide the roadmap, financial support, and incentives, and also ease the laws and regulations to facilitate private companies in doing business. Ministry of Education and MHESI must prepare the skilled labor needed for Thailand 4.0. Advanced technologies usually are from large private companies.

#### Issues/Problems

The average GDP growth for Thailand, between 1952 and 2005, was 6.3%. This growth put Thailand in the upper-middle-income group of nations in 2011. This was largely due to the manufacturing sector, which rapidly expanded the export of goods. Thus, manufacturing has been a driving force for Thailand's economy for so many years. However, the recent growth of GDP has been 3–4%. Opportunities for growth in manufacturing look uncertain because of competitive pressures on due to technology advancement and low labor costs in countries like Vietnam and PR China. Thailand is no longer able to compete with low-labor-cost countries. To make the matter worse, the country does not possess enough skills, research, and innovation to compete with advanced countries that have strong bases in high-value markets. To move into the high-income group of countries, Thailand must focus on the higher-value section of products and services and also create more high-quality careers.

The Thai government therefore came up with an initiative called Thailand 4.0 to enhance the country's competitiveness against other advanced and developing countries. This program encourages manufacturing companies to make use of advanced concepts and technologies such as innovation, connectivity, automation, robotics, AI, and big data. Among these components, the promotion of advanced manufacturing for high-value manufactures, enabled by innovations in connectivity, data, and automation is a central aspect of Thailand 4.0. The integration of sensors, machines, and IT systems is significantly necessary in the entire supply chain. The benefits of applying advanced digital production systems in manufacture of high-quality products are speed, flexibility, and efficiency. IT helps decrease production costs, improve productivity, and enhance competitiveness. The Thai government needs to increase research and development funding to 1.5% of the GDP, raise GDP growth to annual rates of more than 5% within five years, and raises the national income per capita from USD5,470 in 2014 to USD15,000 by 2032.

#### Goals/Objectives

Thailand 4.0 has four main objectives as shown below.

1. **Economic prosperity:** A value-based economy that is driven by innovation, technology and creativity must be developed. Research-and-development spending must be increased to 4% of the GDP, the economic growth rate must be at least 5-6% within five years, and the national income per capita must be raised from USD5,470 in 2014 to USD15,000 by 2032.
2. **Social wellbeing:** Social disparity must be reduced from 0.465 in 2013 to 0.360 by 2034. Social welfare system must be transformed within 20 years, and 20,000 households should be developed into smart farming units within five years.
3. **Raising human values:** The third objective is to transform Thai people into “competent human beings in the 21st century” and develop “Thais 4.0 as the first-world citizens.” Thailand's HDI must be raised from 0.722 to 0.800, i.e. it should be among the top 50

countries within 10 years. At least five Thai universities must be ranked among the world's top 100 universities within 20 years.

4. **Environmental protection:** The last objective is to create a livable, low-carbon society in which the economic system is capable of coping with climate change. At least 10 cities in Thailand must be developed into the world's most livable cities.

#### Activities

**New engine of growth:** The Thai government has initiated a lifelong target to create 10 future industries (the First S-Curve and the New S-Curve). This program helps the country to move from comparative advantages to competitive advantages by leveraging technology, knowledge, and innovation. The First S-Curve consisting of five industries, namely, next-generation automotive, smart electronics, affluent medical and wellness tourism, agricultural and biotechnology, and food for the future must be enhanced innovatively as well as with more value through research and development activities in order to stay competitive globally. In addition, automation and robotics, aviation and logistics, biofuels and biochemical, digital economy, and medical hub industries must be developed to reinforce Thailand's competitiveness as part of the New S-Curve project.

**Cluster for innovation and startup:** Thailand 4.0 has focused on science, knowledge, technology, research, creativity, and innovation, so that these are considered as tools to push new economic growth. Five groups of technology industries are key to building comparative advantages for Thailand:

1. Food, agriculture, and biotech: Based on biodiversity and environmentally friendly biotechnology, the country must become a key center for premium agricultural products and food. Moreover, it can be an exporter of high-end technologies in seeds, agriculture, and vaccine in the region.
2. Health, wellness, and biomedical: The country needs to build medical infrastructure to become a medical hub in the ASEAN region by 2025.
3. Smart devices, and robotics and mechatronics: It is certainly important to drive Thailand as a leader in industrial robotics and automation in southeast Asia.
4. Digital, internet of things (IoT), artificial intelligence (AI), and embedded technology: There should be a utilization of digital devices and IoT in all industries, especially in agriculture, industrial, service, and education sectors as platforms to improve quality and efficiency.
5. Creativity, culture, and high-value services: The ambition to become a creative hub in the ASEAN region within 10 years requires Thailand to take some necessary actions as well as aggregate cultural assets, innovation, and technology for creation of commercial value.

#### Output

The five technology groups and newly emerging industries are great opportunities for entrepreneurs and networks of innovation that drive companies through the following initiatives:

1. A shift from traditional farmers to smart farmers: Thai government has to pay attention to management and technology as well as necessary capacities to enable the country with a

modernized agricultural business model in Asian area. Moreover, career-and-study supporting funds, education and training, databases, information systems, and agricultural development are of paramount importance to establish the needed ecosystem for smart farmers.

2. A transformation of traditional SMEs and manufacturing into smart SMEs and manufacturing: With the application of Thailand 4.0, the contribution of SMEs to total GDP is predicted to increase from 37% to 50% within 10 years. The lack of financial sources for SMEs can be solved through government's support. The government must also develop knowledge and management skills, promote big data, boost digital transformation, and improve open innovation for SMEs.
3. A switch from traditional services to high-value services: Investment promotions, global collaboration, establishment of 'food Innopolis' and market networks are some measures to reinforce competitiveness of services industries in Thailand. There are six service businesses in Thailand that are internationally recognized. These are (1) digital content services comprising animation, advertising, gaming, movies, and software; (2) education services; (3) hospitality services including hotel management, event organizations, tourism services, and reception services; (4) logistics services including IT logistics, logistics, postal services, and distribution centers; (5) professional services comprising doctors, dentists, designers, accountants, consultants, lawyers, and developers; and (6) wellness and medical services consisting of medical services, spa and beauty services, and elderly care services.
4. Startup development promotion: 'Center of Connectivity and Destination for Startup Investment in ASEAN' is a final target, and Thailand 4.0 has established a policy to support startups. Throughout this program, startups companies may have many pros such as (1) providing clarify and robust incentives to investors; (2) establishing environment for stock exchanges for startups to increase their equity as well as connect with other interested investors; (3) implementing regulations to support incubation and expansion of startups; and (4) enhancing competition for business ideas.
5. Skills development program: It is predicted that routine jobs will be replaced by robotics and automation in Industry 4.0. Thus, the development of new skills through nonroutine, task specific, nonrepetitive, or project-based jobs is considered a helpful solution of unemployment. Thai people are encouraged to participate in training, education, and occupation development to adapt with changes as well as let to them shape their future careers. Furthermore, the demands of industrial sectors are increasing, thus leading to alternatives for development of academics and training systems, occupation development, and development of necessary skills.

#### Beneficiary

The objective of Thailand 4.0 is to raise the income per capita for all Thai people. Industry, service and agriculture sectors will probably gain the most. Hopefully, all of the goals, i.e., economic prosperity, social wellbeing, raising human values, and environmental protection, set in Thailand 4.0 would be realized and benefit all people in Thailand.

#### Outcomes

One of the crucial goals of Thailand 4.0 is to transform Thailand in every sector such as industry, agriculture, and services, to adapt to global competitive pressures generated by advanced technologies

and innovation. Thai manufacturing firms, for instance, will make use of future advanced manufacturing, combined with data, connectivity, and automation. As a consequence, the production of higher-quality goods by applying these digital and advanced production systems will empower efficient, fast, flexible, and productive characteristics. Furthermore, this system will also be able to reduce expenses, promote productivity, and improve competitiveness. The agricultural sector will reconfigure its advantage, which is no longer the cost. It will need to adopt innovation and technology into the processes with the support of biotechnology and agriculture technology, also called smart farming.

#### Suggestions, Discussions, and Future Issues

Thailand 4.0 is an inspired initiative. It is a development blueprint for Thailand with a 20-year horizon to achieve its targets. The objective of Thailand 4.0 is to achieve economic prosperity, social wellbeing, human values, and environmental protection. The ultimate goal of Thailand 4.0 is for Thailand to achieve the status of a first-world economy. However, it is extremely difficult to achieve this due to many questions without answers yet. One worthy point of the initiative is the improvement of skilled and high-quality labor, e.g., engineers, technicians, skilled workers, teachers, and researchers, to develop smart farmers and SME digital entrepreneurs. In addition, the share of investment in research and development has been 0.2–0.3% of the GDP in the past ten years, and this number is quite low when compared with other developed countries. Not only does Thailand invest modestly in research, it also buys technologies, instead of creating or developing its own technologies. Investment in research and development as well as innovation will play an important role for Thailand 4.0. Thus, research, innovation, and education, especially higher education, will be the key drivers for transforming Thailand.

## Vietnam

#### Smart Manufacturing Standards in Vietnam

In the current Vietnam system of standards, Tiêu chuẩn Việt Nam (TCVN), there are about 500 standards related to smart manufacturing, focusing on the areas of

- information technology (information technology infrastructure, metadata exchange, IoT, etc.), with over 200 TCVNs;
- information security, network security (system security management, information quality, network safety, security architecture, system risk management, etc.), with 35 TCVNs;
- automation (industrial automation systems, integrated models of automation, etc.), with 16 TCVNs;
- robots, with five TCVNs;
- smart city (concepts and terminology of smart city, standard urban smart framework, smart city assessment index, etc.), with nine TCVNs;
- intelligent traffic (ITS system), with five TCVNs;
- waste control and environmental pollution control, with over 74 TCVNs;
- traceability, with 67 TCVNs.

- services (supply chain security management system, supplier capacity assessment, financial services, health services, credit institution identification code, payment cards, etc.), with 70 TCVNs;
- advanced management systems, with over 30 TCVNs; and
- management and development of human resources, with five TCVNs.

Most of these TCVN are built on the basis of accepting international standards such as ISO, IEC, and ITU.

### Building a Framework for Smart Manufacturing Standards

Based on the references of various models of smart manufacturing in other countries, and taking into account the actual situation and industrial level of domestic production, it can be noticed that standardization is an effective tool to promote access to Industry 4.0 and gradually transform Vietnamese enterprises through a smart manufacturing model. Some orientations are proposed for smart manufacturing, which should prioritize the following main groups of standard objects:

- **Product standard:** product life cycle, in the context of smart manufacturing ecosystem, includes six stages: design, process, production techniques, production, use and service, end of product, and return to life cycle. Current standards, especially in the areas of computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided technology (CAT), often lead to improved efficiency in the product design and manufacturing processes. In addition, these standards increase the accuracy of the model, reduce product innovation cycles, and contribute directly to the flexibility of the production system, thus leading to better product quality. Advances in this area have led to a new product development model called Technology-based Model.
- **Production system standard:** A production system is a collection of machines, equipment, and auxiliary systems organized to create products and services from many different resources. As one of the most complex components of smart manufacturing, the production system has many distinct standards. Production systems usually have a longer life cycle than the life cycle of the products at a traditional system produces. The standards for the above system often refer to the fields of automation, control, operation, and maintenance of the system.
- **Supply chain standards:** Standards for interaction and connectivity between manufacturers, suppliers, customers, partners, and even competitors include business modeling standards, production modeling standards, and corresponding interaction protocols. These standards are the key to improve supply-chain efficiency and production flexibility. The focus is on three sets of manufacturing integration standards, namely SCOR, OAGIS, and B2MML. Standards for advanced management system include ISO 9001, ISO 22301, ISO 22800, and IEC 62443.
- **System management and human resource development standards:** Standards for ensuring quality of resources, controlling aspects of labor productivity and efficiency, supervising/ensuring information security, and labor control/anticorruption include ISO 9001, ISO 22301, ISO 22313, ISO 30414, ISO 31000, ISO 37001, and ISO 45001.

### Summary

For specific production areas, priority should be given to the development of the following groups of standards:

- **Industrial sector:** Focus on information electronics industry (supporting the development of 4G and 5G networks); transportation industry; equipment industry, food industry and textile industry; on the basis of automation, integrated into the CPS, to create smart and predictable future products, or preventive maintenance and production other added value; integrating electronics/digitization/smart technology with rational development, efficient use of resources and human factor-intelligent engineering machine through business partners and business processes, create appropriated products and outsourcing.
- **Service sector:** The standard framework should prioritize, promote service quality improvement models, and support global trade services, such as retail/commercial distribution systems, supply chain management, automate business, smart hotel/hospital services, combine big data technology/universal network/cloud computing, develop traceability applications (MSMV, QR Code , etc.) in service business.
- **Agricultural sector:** Focusing on developing standards to develop practical systems that link industries and services, marketing, design, development and production; integrating retail channels, automatic logistics, serving consumers conveniently, safely, continuously and in accordance with consumers' experiences, boosting the overall business service industry in economy scale; promoting production with advanced technology, high quality, increase marketing, enhancing consumer confidence with the safety of agricultural products, and restructure agriculture in the direction of applying high technologies. Prioritizing the development of standards on the management of quality systems in animal husbandry, smart cultivation, improving the efficiency of agricultural production; geographic information systems, big data analysis for farming; traceability system, promoting backup food safety and serving clean agricultural products.

### COVID-19 Response Solutions for SMEs in Vietnam

On 4 March 2020, the Prime Minister issued Directive No. 11/CT-TTg on urgent tasks and solutions to remove difficulties in production and business and ensuring social security in response to COVID-19. In particular, the government has shown that the COVID-19 epidemic will continue to be complicated, unpredictable, increasingly widespread, and at risk of outbreaks in many countries and regions around the world. This will have continued impacts on the global economy and many countries, including major partners of Vietnam.

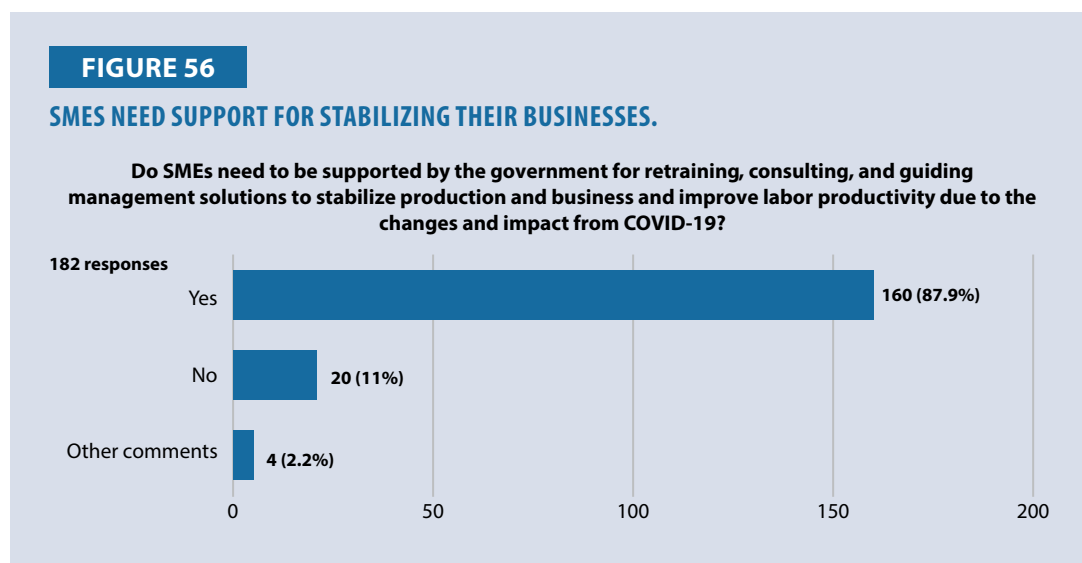
In Vietnam, the COVID-19 epidemic has been affecting many aspects of economic and social life. Activities of import, export, circulation, transport of goods and passengers, and many service sectors such as health, education, catering, accommodation, entertainment, and tourism in particular, are clearly affected. Some industries and production sectors were initially affected, with temporary labor shortages, and disruptions to supply chains of input materials, thus causing disruptions in production and business activities. Many businesses, especially SMEs in the epidemic areas, had to scale down their manufacturing or business activities or suspend operations.

With the current situation of COVID-19 pandemic in Vietnam and globally, Vietnam National Productivity Institute (VNPI) has proposed to the Ministry of Science and Technology a new project to support SMEs in recovering and increasing productivity during and after the COVID-19 epidemic. A quick survey of 182 enterprises conducted by VNPI in March 2020 shows the following:

- Manufacturing enterprises faced a lack of input materials. This is especially true for garment and textile enterprises, assembly of components enterprises, and agricultural enterprises. Manufacturing processes have stagnated due to lack of production materials, canceled orders, delayed deliveries, etc.
- Activities of commercial and services enterprises were stalled due to limited room for service requirements and reduced market demand.

The above difficulties led to a decrease in turnover, workers had to take a break from work, thus affecting the income of workers and resulting in reduced productivity. SMEs have started experimenting with online methods, but have difficulty in terms of infrastructure (hardware and software), workflow and work control, leadership skills, and management skills. SMEs also have difficulties in maintaining management systems and tools to improve quality of productivity, thereby significantly affecting their labor productivity.

The survey questions are given in Figures 56 through 60.



In order to support the recovery of manufacturing and productivity growth among SMEs, VNPI has proposed to the Ministry of Science and Technology a number of solutions to support SMEs during and after the COVID-19 pandemic as follows:

- Regarding training, all enterprises need to be supported by the government. During and after the COVID-19 epidemic, SMEs will face difficulties in personnel changes. Retraining personnel to maintain and operate the management system will help SMEs quickly stabilize their businesses to adapt to new requirements. Besides, SMEs are very interested in the content of digital transformation and smart manufacturing solutions being provided through VNPI's ecosystem.



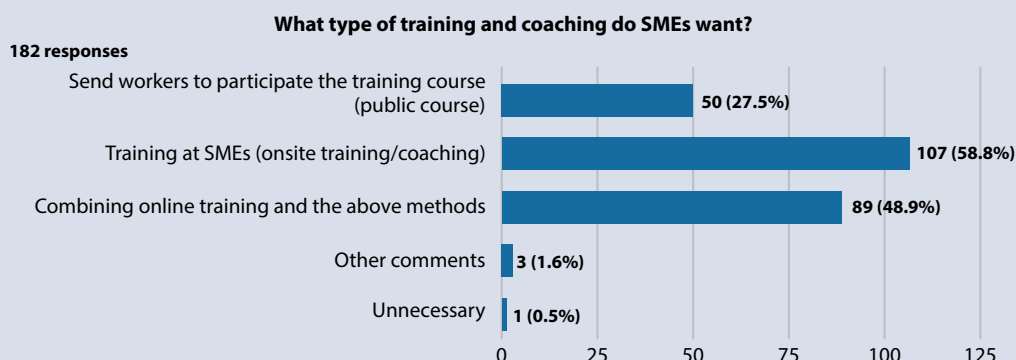
**FIGURE 57**

**SME PRIORITIES ON TRAINING ASPECTS.**



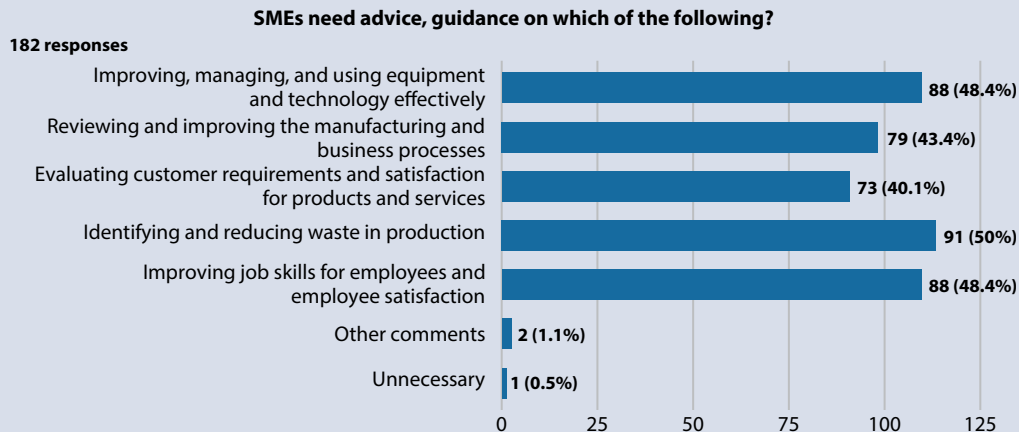
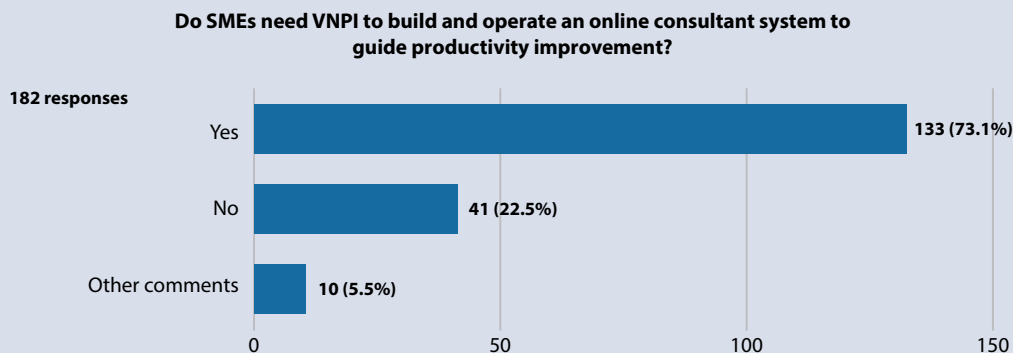
**FIGURE 58**

**SME PREFERENCES ON MODES OF TRAINING.**



- Regarding productivity improvement guidelines, SMEs wish to be supported by the government to optimize their operations, help them recover, and seize opportunities when the global economy recovers from the COVID-19 crisis. SMEs are interested in such issues as reviewing and improving the manufacturing and business processes; assessing customer requirements and satisfaction for products and services in a new context; and identifying and reducing waste in production or service provisioning. SMEs are very interested in transforming their management and working methods using an online platform, in which the content focuses on guiding the review of regulations, management process, working towards digitalization, and smart manufacturing.
- The majority of SMEs wish to be supported by the government for providing them information and direct guidance to restore their businesses and production through an online system of domestic and international productivity experts.



**FIGURE 59****AREAS IN WHICH SMEs NEED ADVICE AND GUIDANCE.****FIGURE 60****NEED FOR AN ONLINE CONSULTING PLATFORM FROM VNPI.**

Based on this analysis, VNPI has developed a new project to support SMEs in recovering and increasing productivity during and after the COVID-19 epidemic through a practical guidance training system based on a digital platform.

This project aims to support SMEs in following ways:

- Help them quickly recover and maintain business production during and after the COVID-19 outbreak.
- Provide coaching/hands-on training on solutions to improve productivity directly in the enterprise to ensure a working environment, reduce waste, and improve the production and business processes to achieve productivity growth.

Particularly, in the project, VNPI will build and operate a system of consultants using digital platforms to provide information and direct instructions to SMEs to quickly restore their business and production.

# CASE STUDIES OF COMPANIES FOR SMART MANUFACTURING

The supply chain of the industry is becoming more and more complex. In Industry 4.0, the entire supply chain will be connected as a network through the implementation of IoT, with big data being delivered automatically by the platform. With highly adaptive networks and intelligent solutions, decision-making for demand forecasting, capacity planning, or logistics will become easier. However, the development of such future supply chains remains a challenge. To maintain the competitiveness of the industry, strengthening of individual companies to reposition themselves in the future supply chain is crucial. Thus, a number of case studies of different companies across various industries in APO economies were conducted as illustrations.

Indeed, most of the companies in APO economies still focus on mass production and expert manufacturing to achieve economies of scale. The case studies aim to improve the production and quality performance of existing manufacturing environments with novel solutions. In particular, artificial intelligence, big data/analytics, and optimization can be applied to each level of operation, including operational strategy, supply chain management, shop-floor control, and quality control.

## Industrial Intelligentization in ROC

For intelligentization, we propose the autonomy of key parts and components in smart machinery:

- Develop the high-end domestic controller, high-precision servo feed driver, and high-power servo motor; and promote the autonomous robot controller, software, motor driver, and damper for building the supply chain system.
- Establish core technology and integrated application of industrial sensors. In particular, develop integration system including vibration, position, and 3D visual sensors.
- Speed up R&D through industry policy and international cooperation. In addition, promote domestic components and sensors by introducing the policy fund with respect to equipment R&D subsidy and promoting international technology and investment.

In the category of machine intelligentization, we focus on failure prediction, precision compensation, and automatic parameter adjustments:

- For failure prediction, install vibration, noise and temperature sensors inside the spindle equipment, and transfer the data to the cloud network for big data analysis and pre-alarm detection.
- For precision compensation, install the temperature sensor attached to the spindle inside the equipment to avoid a deformed tool caused by the thermal expansion and contraction. In addition, the real-time data collection from sensor can be transferred to cloud network

for precision analysis, and then the result can be passed on to the controller for precision compensation by adjusting feed rate.

- Finally, for automatic parameter adjustment, measure the sound frequency of the contact between the tool and the work piece by the audio sensor (microphone). We can automatically control the spindle speed to avoid the anomaly vibration of the machine and poor quality of the product.

In the category of line intelligentization, we focus on automatic scheduling, flexible production, and capacity adjustment. The automatic scheduling module is developed based on the order and product specification in the manufacturing execution system (MES), to optimize the capacity and fulfill demand by monitoring the utilization of the equipment and inventory level. Flexible production is used for small-volume and diverse-type products through equipment setup and changeover. In particular, mixed-line production is based on product-mix and software package, such as identification system in the workstation (e.g., RFID, QR code, laser marker, and barcode), to realize line intelligentization. The automatic capacity adjustment is one key method to ensure continuous and uninterrupted production by rescheduling and resetting the production status via the MES system. Production-condition monitoring and product-quality inspection are generally used to clarify production performance through the equipment network and process monitoring software, e.g., supervisory control and data acquisition (SCADA). In addition, the visualization tool is used to support the staff for shop-floor decision-making.

For factory intelligentization, the ERP system is designed to connect all the upstream and downstream vendors in the supply chain. We build a common standard networking interface and install this platform in the ERP system to connect all vendors. Real-time exchange of ERP system information of all manufacturers is integrated with customer relationship management (CRM) and supply chain management (SCM) systems, to optimize supply chain capacity. The remaining capacity status of all suppliers can be known through this ERP system, which benefits the evaluation of the build-to-order ability. We establish the machine-to-machine communication (M2M) standards with respect to machine tools, robots and other equipment and provide it to domestic and foreign industries, universities, and institutes. In addition, connecting the end-customer can enhance the ability for producing the customized products by collecting the customer's requirement at the retailer's end and passing the information to the whole supply chain. After realizing the factory intelligentization, the domestic equipment, automation, total solution, and the entire plant intelligent system can be exported to global markets.

Based on the Smart Machinery Promotion Program, the fund accelerates companies' shift toward smart machinery. In particular, smart manufacturing strategies are associated with 1) connected locally; 2) connected to the future; and 3) connected internationally.

For 'connected locally,' the policy aims to build a smart machinery office and integrate the industry-academia cooperation. For example, the Smart Machinery Industrial Park was built in Taichung in 2016 on 160 ha for 21,329 jobs. Local and foreign companies set up the demonstration site. We bridge the R&D of business and academia, and train talent by integrating academic and research sectors. More than 28 universities form the strategic alliance with smart machinery. Development centers, exhibition centers, and training centers are built. The international cooperation and the New Southbound Policy bring potential opportunities for business development.

For connected to the future, creating the turnkey total solution for niche industries (e.g., aerospace and advanced semiconductor industries) and providing trial field for the future development of inter-discipline or cross-domain capabilities is important. We introduce for small and medium-sized enterprises (SMEs) smart automation services such as manufacturing execution systems (MES) and enterprise resource planning (ERP). We also provide SMEs with intelligent sensors, network infrastructure, and prototypes of IoT. These smart automation and application services make many substantial contributions. For example, these services contribute to 75% saving in defect detection time and 50% reduction in defect detection rate in the printed circuit board (PCB) industry. The services increase product yield by 20%, initial color success rate by 5%, and energy savings by 15% in the textile industry. They reduce product delivery time by 30%, increase productivity by 10%, and reduce production costs by 10% in aerospace machine tool industry. They also increase total equipment efficiency by 80% in the smart machinery factories for flexible processing of cars and motorcycles.

For connected internationally, global cooperation and global market expansion are the key missions. It is important to drive global cooperation with Europe, America, and Japan. We can expand the global market (e.g., southeast Asia) and niche industry (e.g., aerospace) by exporting the system integration solutions, services, and devices. We form buyer alliance for strengthening promotion in worldwide countries. In particular, smart aerospace machinery alliance through memorandum of understanding (MoU) brings NTD68.6 billion business opportunity for advanced trainer aircraft. In addition, we establish Taipei International Machine Tool Show for promoting smart machinery devices and equipment with orders more than USD1.5 billion.

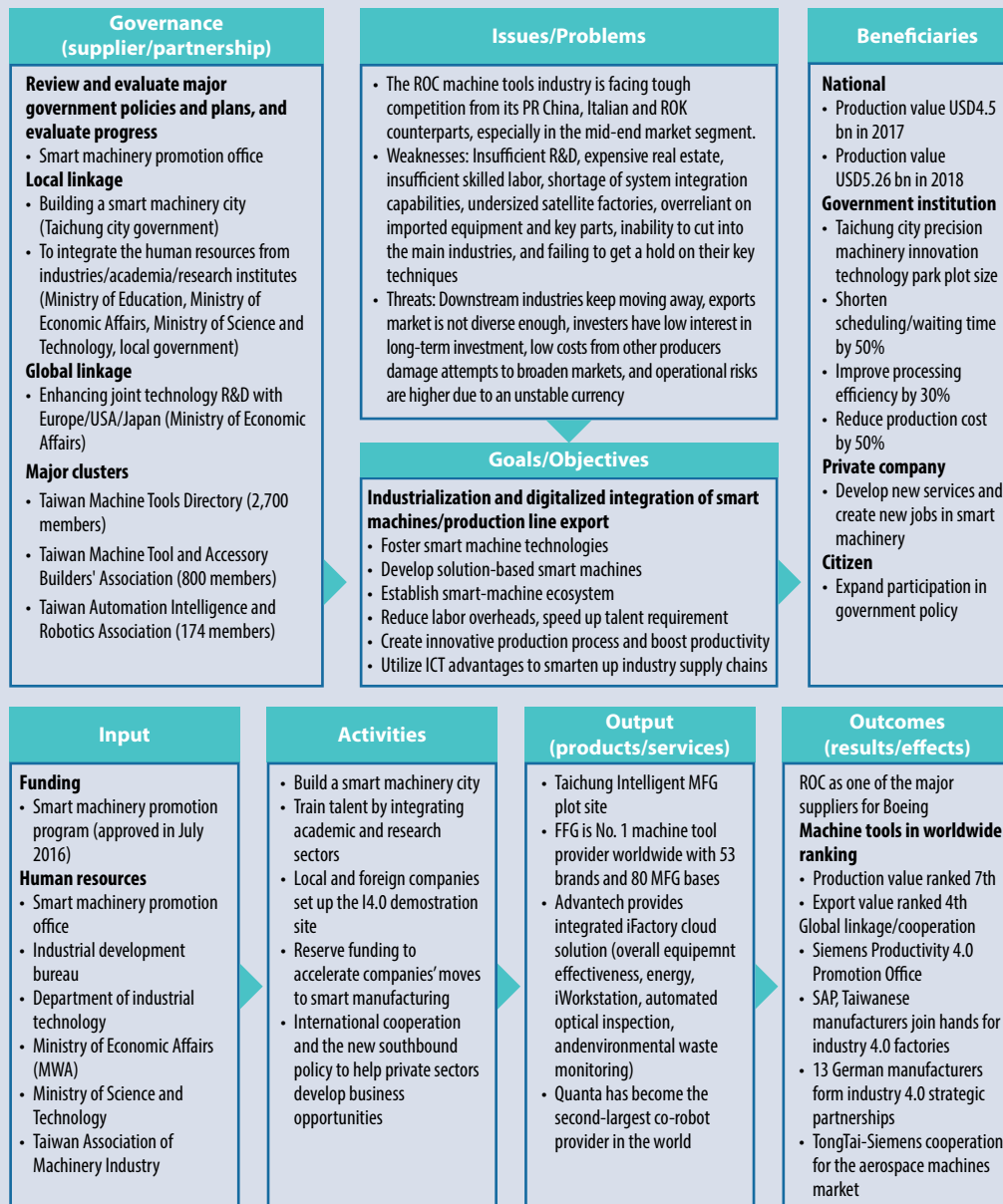
In this section, we summarize the related items mentioned above and build the Policy Model Canvas as illustrated in Figure 61. This canvas clarifies all the key components and their relationship to illustrate the industrial policy. Specifically, the talent pool is always critical and thus the industry-academia cooperation is promoted to develop a healthy environment and ecosystem for the smart machinery industry.

For the smart machinery policy in the ROC, several success factors can be investigated [20, 60]. First, the government, research sectors, and private sectors work closely. Also, the ROC has the most concentrated industry clusters (ranked No. 1 globally). In particular, the high-tech industry is located across three science parks. Second, the ROC's investment environment and close proximity with southeast Asia enable the country to tap into market demand efficiently (ranked No. 2 in Asia). Third, the ROC shows high levels of hardware/software integration capability for flexible production and rapid commercialization (ranked No. 2 in high-tech exports). Finally, the ROC shows skilled talent for ICT, electronic/electrical, and machinery industries.

Some managerial implications and insights related to smart manufacturing policy are as follows. First, forming an ecosystem is important for smart manufacturing industrialization, even though introducing AI and smart devices benefits industry intelligentization (i.e., industry adoption of smart machines). Second, environment construction and expansion play the roles for industry concentration and building clusters. On one hand, the government can fund the research center and university alliance, while on the other hand, it can also fund the technology and science parks for smart manufacturing. This benefits the industry-academia cooperation and supports the talent pool training and cultivation. Third, the policy supports the development of domestic base. Priorities in industrial categories include fastener, tools, aerospace machine tools, vehicle parts and components, and semiconductor equipment. Companies can build pilot lines and trial fields to accumulate

FIGURE 61

## POLICY MODELING CANVAS FOR SMART MACHINERY POLICY IN ROC.



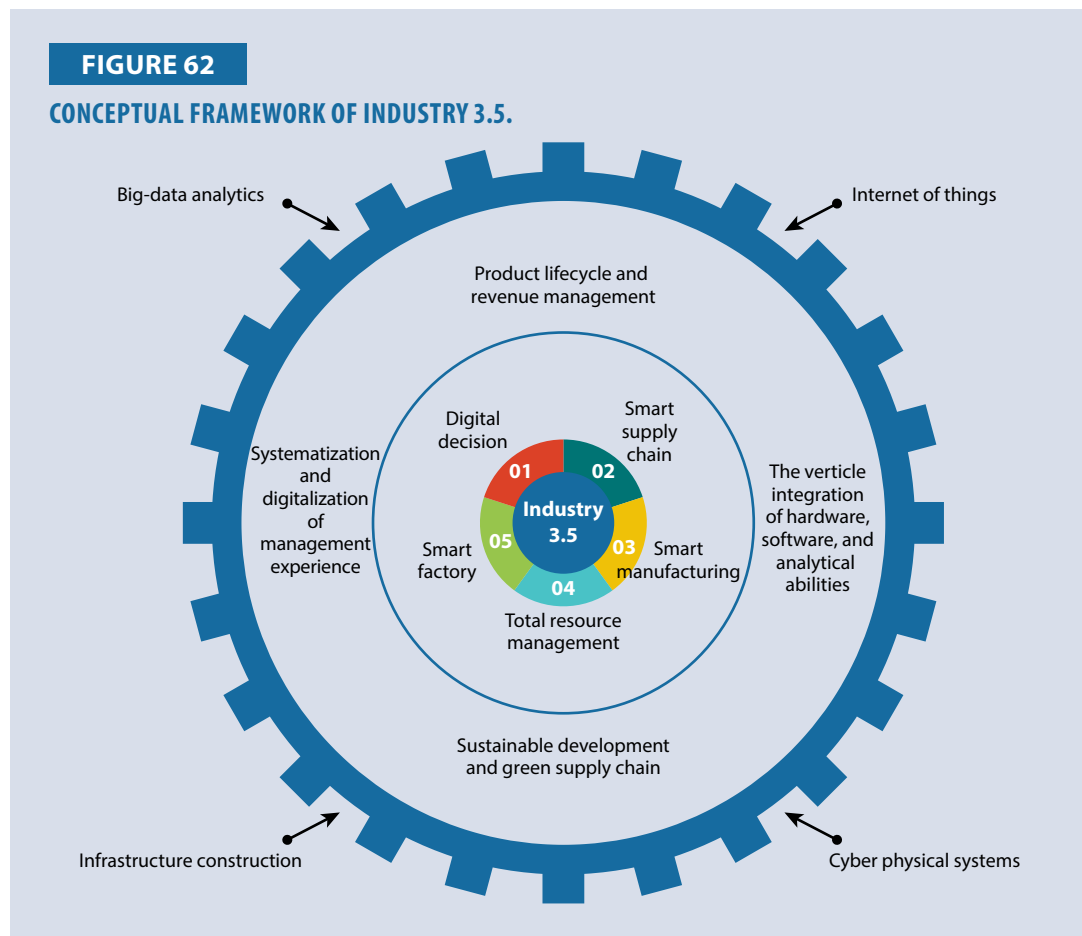
experience and knowledge of smart manufacturing. Building several international machine-tool shows and exhibition halls are good alternatives for industry and marketing promotion. Finally, exports can help in expanding the global markets. Intelligent equipment that have been tested and verified in the domestic market can be sold to global market as total solutions with respect to the promotion of single machine, whole line, or whole plant.

### Industry 3.5 for Smart Textile Manufacturing in ROC

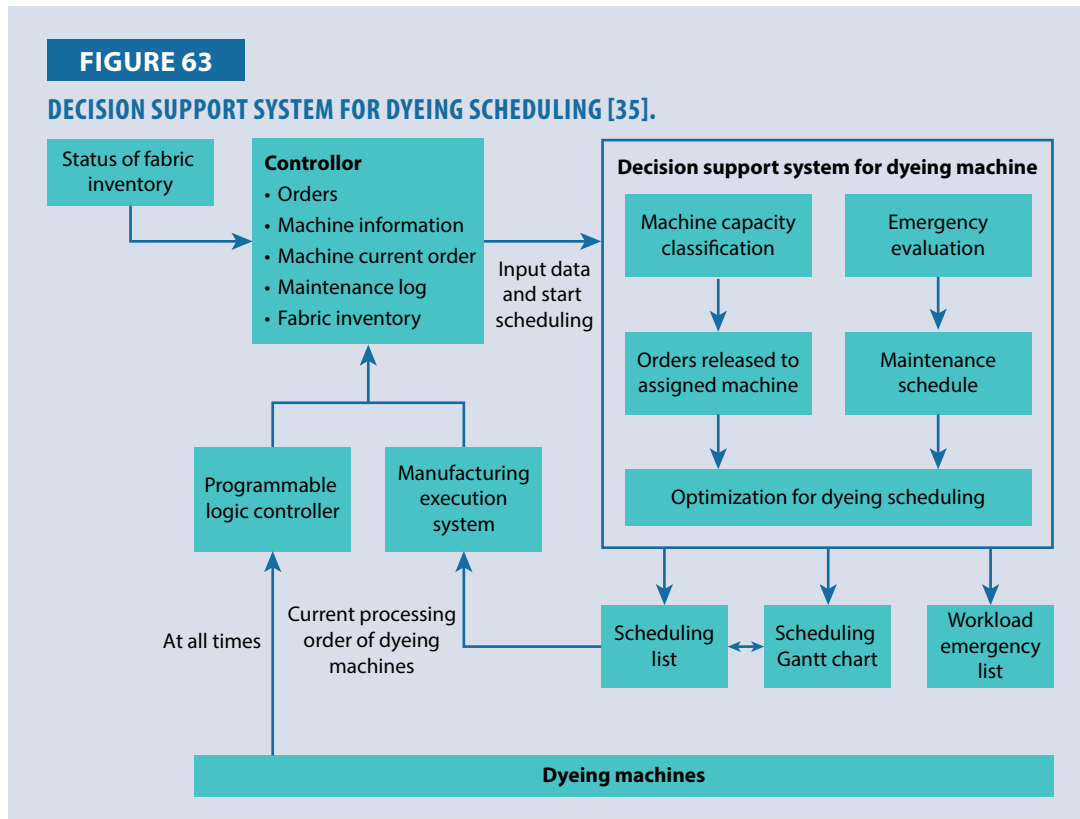
Industry 3.5 was proposed as a hybrid strategy between Industry 3.0 and Industry 4.0 to address the fundamental objectives of smart manufacturing while employing artificial intelligence, big data/ analytics, and resource optimization as disruptive technologies for developing smart manufacturing

solutions [10, 11, 12]. Industry 3.5 solutions are constructed using five pillars, namely, digital decision, smart supply chain, smart manufacturing, total resource management, and smart factory, as shown in Figure 62 [11, 12]. A number of case studies [10, 11, 13, 25, 30, 35] have been done to employ Industry 3.5 for smart manufacturing in various industries, including high-tech manufacturing, assembly, process industry, and textile industry, to address some of the visions for flexible decisions and smart production proposed in Industry 4.0.

The textile industry in APO economics is facing global competition for mass customization to address dynamic customer demands. To meet the challenges ranging from mass production to build-on-demand with small-lot sizes and diversified product mixes, a case study was conducted in a textile manufacturing company, which is a world-leading provider of various applications in function fabric such as waterproof fabrics with a number of factories in the ROC, Vietnam, and the USA.



To conquer obstacles of implementing Industry 3.5, the information silos between individual systems are removed for digital transformation and a decision support system for dyeing machine scheduling is developed to empower smart manufacturing as illustrated in Figure 63. The developed smart manufacturing system for dyeing machine scheduling is designed to integrate production information across individual systems and provide dyeing machine scheduling for maximizing utilization. In particular, setup time for textile dyeing operations is sequence-dependent, and products of different types and colors require setups for tank cleaning. The results have shown the practical viability of the proposed approach and Industry 3.5. Indeed, the developed solution has been implemented in a textile company in the ROC.



The flowchart for dispatching rules for dyeing machine scheduling is illustrated in Figure 64. The textile company previously scheduled the orders manually to fulfill its daily demand for low operations volatility. Based on the increasing order complexity and order variation, it is necessary to adopt digital transformation for smart manufacturing in textile dye scheduling.

Considering that data is inconsistently stored in several separated systems, and the MES cannot execute dyeing machine scheduling based on PLC's monitoring of order data, a decision support system is developed to overcome information silos and maximize the utilization of the dyeing machine. The system handles the collected control data from MES, PLC, and other systems that includes orders, machine information, machine current order, maintenance schedule, and fabric inventory.

Sorting and dispatching is done as per process priority, RGB distance, and material type. The status can be categorized as grey fabric inspection, work in progress (WIP), dyeing-await, dyeing, re-dyeing-await, re-dyeing, washing-await, washing, and processing. The priority number is changed according to the order status. RGB values of all orders in the dyeing machine are compared with the RGB value of current or last processing order by calculating Euclidean distance. The larger the sum of RGB value, the lighter the color it reflects. Because the value ranges of bright colors are too close to separate (e.g., the sum of RGB values for the red and blue groups) when descending, considering the color group as a parameter can prevent this problem. Further, each dyeing machine may be assigned orders with material of nylon or polyether at the same time, with the classifying criteria being based on the current or last processing order. If fabric material of the orders that are identical to the processing order is identified as the major material, others will be minor. The output result will be displayed as a scheduling list and Gantt chart, and feedback to the MES will be updated accordingly.

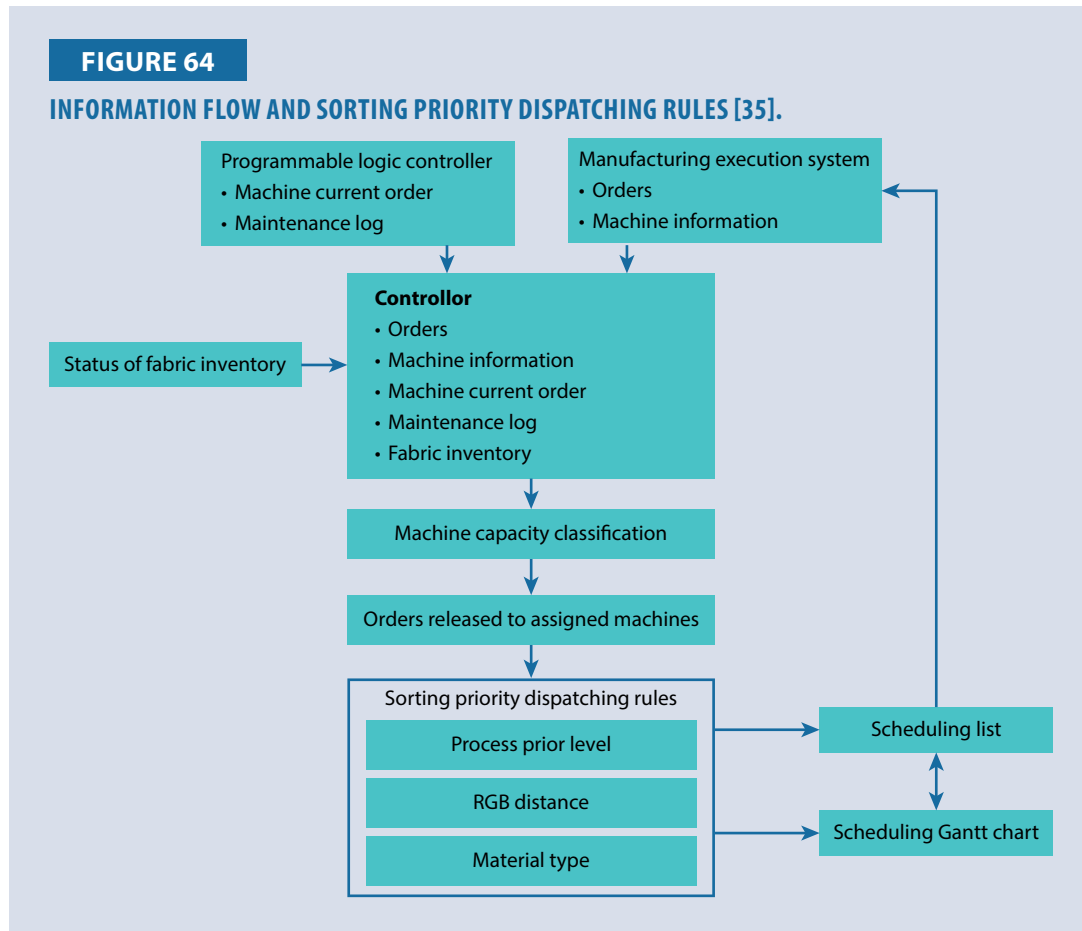


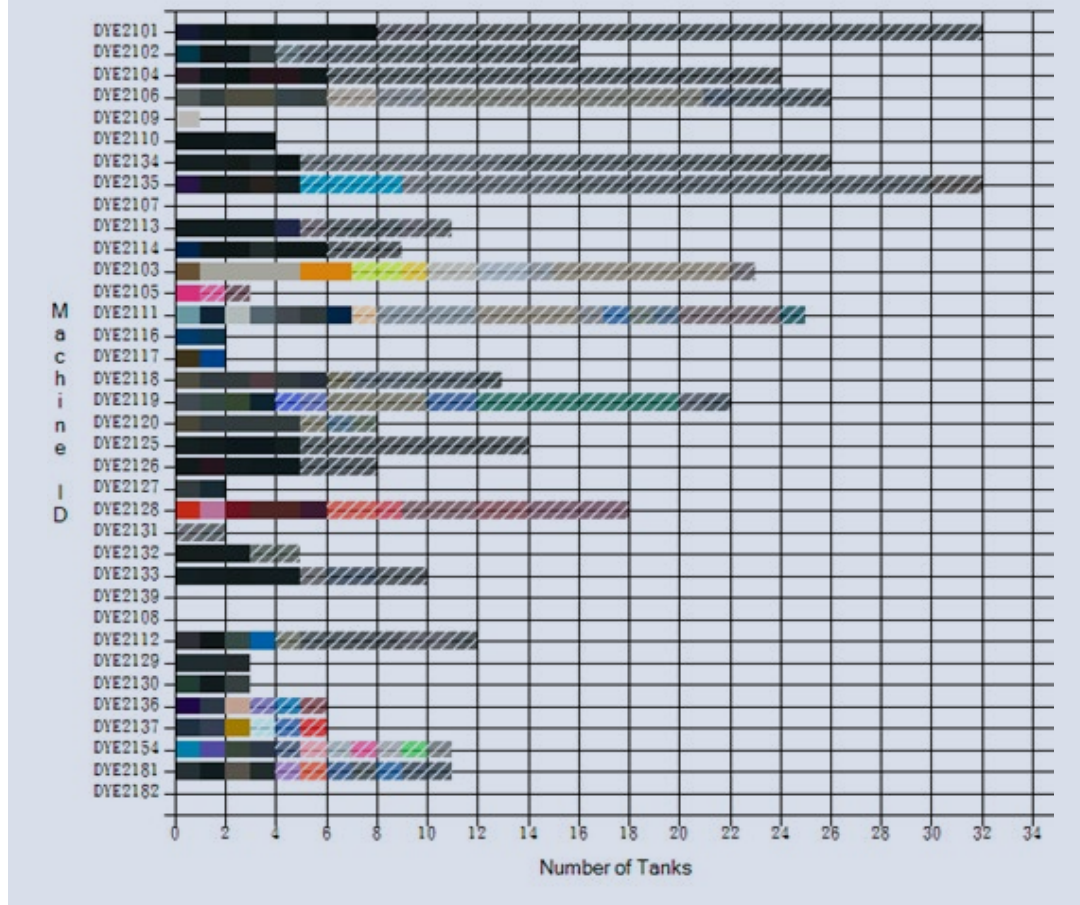
Figure 65 illustrates the overall dyeing machine process workload with color visualization Gantt chart. In particular, the x-axis represents the number of dyeing tanks, defined by the order lot count number divided by machine capacity, while the y-axis is the machine ID. All orders are sorted by fabric material type, color, and process priority, according to current dyeing order information, and can be changed dynamically. The 'slash' parts mean grey fabric orders, which indicate the potential workload and will be used for determining further order assignments according to the current order color and line balance. With visualization of Gantt chart, any inappropriate color orders can be easily found and reassigned to another dyeing machine.

In order to validate the proposed solution, data is collected from six dyeing machines, 527 times, in 60 days. The results show the practical viability of the proposed approach. The proposed decision support system for dyeing machine scheduling revolutionized smart manufacturing to integrate production information between individual systems and maximized the utilization of dyeing machines. By using the integrated system to identify a machine's current order information, each dyeing machine can be rescheduled dynamically. The Euclidean space was applied to calculate the distance in the RGB space to determine the color depth and dyeing priority between two consecutive dyeing orders in each machine. The proposed approach has an average of more than 4.5% improvement in utilization compared with the existing practice. The priority workload list can identify the status of dyeing machines and help users focus on terminated machines. With Gantt chart displaying the RGB of all orders and dynamic dyeing machine scheduling list, it is easy to reserve time and observe abnormal colors for scheduling in advance. Indeed, the developed solutions have been implemented in the case company.



FIGURE 65

WORKLOAD GANTT CHART [35].



## Food and Beverage Sector in Indonesia

Indonesia has the highest number of SME industry players. Economic growth in Indonesia is significantly contributed by more than 57 million SMEs, which have been the primary source of employment creation. So, SMEs are the focus for the case study. In the food and beverage sector in Indonesia, we chose Azzahrah and D&D Bakery to represent the implementation of smart manufacturing in SMEs for the sector.

### Azzahrah (Fish Meatball and Shredded Fish Producer)

Azzahrah, based in Maros Regency, South Sulawesi Province, produces tuna meatball and tuna shredded. The idea of using tuna as the main ingredient is a part of the owner's innovation. Tuna is considered a source of high protein. It contains asam amino, omega 3, minerals, and vitamins that provide high nutritional value for the customers. In fact, according to the article from the Ministry of Health, the high-quality nutrition from tuna does not necessary influence the price of tuna itself, so fresh tuna's price remains stable. It means that the price is affordable, along with an abundance of benefits for health. Considering the benefits, the owner considered how this product could be positioned as a value added.

Initially, the business was running with a manual production method, producing only around 25 packages a week. Later, the business improved its productivity up to 50 packages in a week. The improvement came when the business owner changed the production method, using machines. He realized that the quality and

quantity of production must be in line with customer demands. Thus, the business invested to buy more machines to enhance the operational process. “A great decision to invest,” said the owner. In this case, it is critical to underline the sustainability of businesses by investing money to improve productivity.

In terms of production costs, the owner is able to cut labor costs because of automation. In addition, the owner can also enhance efficiency with intelligent machines to meet market demands. However, in terms of raw material, the challenge is that it is difficult to source tuna, which is the main ingredient of the product, at any given time.

### **D&D Bakery**

Another case from this sector is D&D bakery in Makassar. D&D combines the manual method and automatic machinery operations for its business. It uses an automatic tool to mix the ingredients, as this process is much more efficient. If it still used the manual method, it won't be able to meet consumer demand every day. Interestingly, the mixing process uses a sophisticated mixer that can adjust the time of mixing the ingredients. By having a precise time to control the mixing process, the dough quality can be controlled accurately and consistently. During the process of looping and cutting, the dough must be in a good condition to produce a high-quality product. Moreover, this new technology used in the baking process, along with modern ovens, increases the quality of the product and the precision of its quality. This modern method can also reduce the risk of overcooked products, which can be major detriments to a bakery business.

## **Textile and Apparel Case Studies from Indonesia**

Bugis Silk from South Sulawesi province has been popular for centuries. South Sulawesi is also known as a silk province. Silk woven fabric is one of the commodities in Wajo Regency, South Sulawesi. Nowadays, Bugis silk is also made for fashion, accessories, scarves, handbags, etc. Advances in technology and information also influence the fashion trend. Thus, it is important to develop the silk business with a technological approach.

In order to maintain business continuity, silk industries are required to meet the market demand every month. Based on the research in this sector in Wajo Regency, most of the weavers can only produce 1–2 pieces out of 10–20 pieces of demand per month with traditional method called Alat Tenun Bukan Mesin (ATBM) or non-machine weaver tool. The scarcity of the raw materials is become a challenge for local weavers. Thus, it is important to develop a modern technology in the silk production process. However, educating the local weaver to use the new technology is similarly important. Without a proper knowledge in using the advanced technology, the machine production will have no meaning.

Today, some develop silk businesses in the area are moving to sensor technology in the spinning process. By doing so, the business can reach tons of production each year with local weavers. Therefore, local weavers can efficiently and effectively produce more silk fabric to meet the market demand. Subsequently, the economic growth in Wajo Regency will also be supported by the silk industry.

In the context of the case study mentioned above, the core of smart manufacturing in SMEs is to offer solutions in the production process. By identifying the needs in the production process, the owner can overcome the challenge by involving new technologies, an approach which is called smart manufacturing or smart factory. Smart factory provides accurate information for all aspects of manufacturing in the production process. The production process is carried out with an automation and optimization system with the benefits provided in the form of physical quality of

goods and a good supply-chain process. Information and communication systems are also needed in monitoring the system to carry out maintenance in the system.

To emphasize the needs of the SMEs in these sectors, some key points for smart manufacturing implementation in Indonesia include 1) transformation in technology is urgently needed to fulfill the market demand and increase productivity; 2) development plan for your business is crucial in order to achieving the production target in a certain time; 3) data is increasingly the lifeblood of any manufacturing process; 4) your competitor is your lesson; 5) upgrading your people as well as your technology is important; and 6) being customer-centric matters.

## Workforce Allocation and Parallel Machine Scheduling in Thailand

In order to implement smart manufacturing, many aspects have to be considered. These include automation, robotics, IoT, AI, and intelligent production planning system. This case study focuses on developing and implementing an intelligent machine scheduling system to support a production plan in a nonalcoholic beverage company.

Typically, in a manufacturing environment, machine planning and scheduling can be extremely complex, especially when many products have to be produced. Currently, a group of planners performs this task. Sometimes, this process can be time-consuming and ineffective, resulting in high inventory. This is due to many factors that need to be considered. To facilitate the planning and scheduling process, an algorithm is developed based on the concept of optimization technique. The integrated problem of workforce allocation and parallel machine scheduling with sequence-dependent setup time and machine eligibility restrictions is considered. Due to the complexity of the problem, a rule-based heuristic is employed to arrange production schedules in practice. Although this heuristic could make the planner arrange the schedule effortlessly, much time is wasted on unnecessary setup that causes the completion time of all jobs to fall behind an expected schedule. To overcome this, the problem is formulated into a mathematical model with the aim to minimize the make span. Based on the result of the experiment, it can be concluded that the proposed model could obtain significantly more effective results than those based on rule-based heuristic and LPT.

In previous studies of machine scheduling problem, the setup time is often assumed to be ignored or considered to be a part of the processing time. These assumptions might be inappropriate for some manufacturing industries, where setup time is essential for cleaning and changing fixtures before processing, such as those in chemical processing, metal processing, and beverage industries. In addition, setup times become more crucial when the amount of setup time required depends strongly on the sequence of jobs to be processed on the machine (called sequence-dependent setup time).

A typical example is the printing or painting industry, in which the setup time of changing from black job to pale color is greater than changing from pale job to black job because extensive cleaning is required. As sequence-dependent setup time is the most complicated case for machine scheduling, many researchers have developed algorithms to solve sequence-dependent setup problems on various criteria. Bowers, et al. (1994) applied a mathematical technique, cluster analysis, to a single machine scheduling with a sequence-dependent setup. With this technique, a product grouping procedure helps aggregate products that have similar setup requirements. This resulted in significantly improved production schedules. Luo, Liu, Wang, et al [41] introduced dominance rules for single-machine scheduling with sequence-dependent setup and due date and

applied the rules to the ‘branch and bound approach,’ aiming to minimize maximum tardiness of all jobs. The result proved that the optimal solution was obtained with less computational time.

Yet, there was no study on accommodating proposed rules with other computational techniques. A two-stage Ant Colony Optimization algorithm for unrelated parallel machines with sequence-dependent setup time was proposed by Arnaout, Rabadi, and Musa [4]. The performance of the heuristic was compared with those of Tabu Search and Meta-Heuristic for Randomized Priority Search proposed by [23] and [48] respectively. Another algorithm for dynamic parallel scheduling with sequence-dependent setup was developed by Lee, Lin, and Ying [40]. In this, a restricted simulated annealing algorithm that incorporates a restricted search strategy with the elimination of non-effect job that moves to find the best neighborhood schedule was presented. The computational experiments proved that the stated algorithm has higher performance as compared with common simulated annealing and the best solution from the benchmark problem obtained by Ovacik and Uzsoy [46] 1995.

However, it is an undeniable real-life problem in many industries that proper allocation of limited resources, e.g., tools and workers, needs to be involved with machine scheduling. These two problems are two sequential decisions in usual practice. First, resource allocation may be done and then the production schedule will be decided depending on the previous decision in case of some industries, while some other industries might invert the sequence. However, these approaches are inflexible and limit the possible alternatives that may provide a better solution. Moreover, in manufacturing systems, to process the task on a given machine requires the assistance of a human operator with a specific skill to process the task. Surprisingly, there are only a few studies where resource allocation and machine scheduling are considered as one. One of those is ‘Schedule Generation Schemes and Genetic Algorithm for the Scheduling Problem with Skilled Operators and Arbitrary Precedence Relations,’ proposed by Mencía, Sierra, Mencía, et al [43].

### Policy Modeling Canvas

The overall framework is shown in Figure 66.

#### Suppliers/Partners

For this beverage company, many suppliers and partners are involved. Suppliers are those who provide different types of raw materials and packages for the beverage. In addition, there are governmental partners/regulator and nongovernmental partners as well. Governmental partners are, for example, Department of Industrial Works, Food and Drug Administration, Ministry of Commerce, Revenue Department, and Excise Department. Nongovernmental partners include raw material suppliers, logistics providers, IT support, sale department, and supply chain department.

#### Input

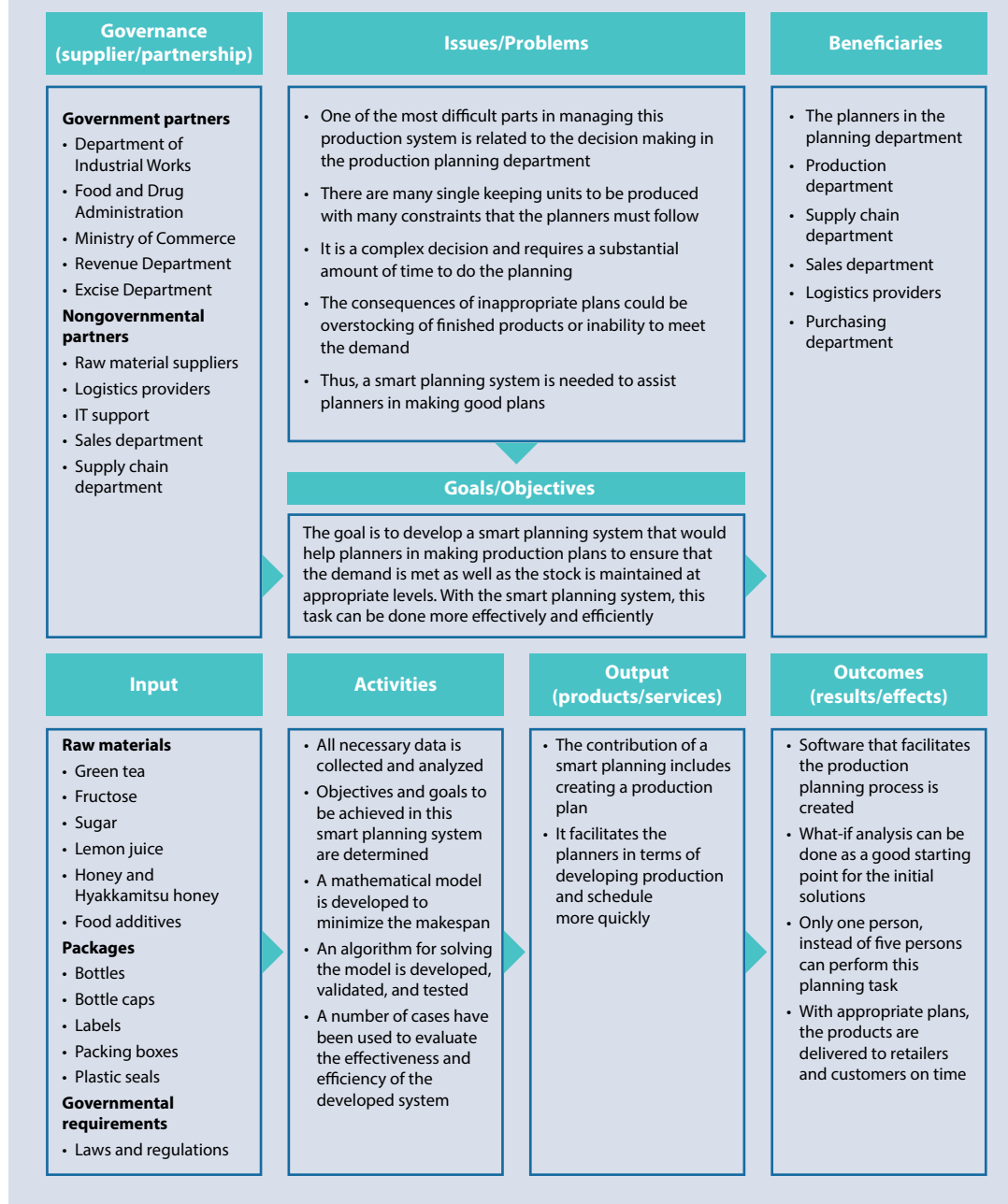
Many ingredients are used for the production of this beverage. They include green tea, fructose, sugar, lemon juice, honey, Hyakkamitsu honey, and food additives. Packages used for the beverage are bottles, bottle caps, labels, packing boxes, and plastic seals. Inputs from the governmental partners/regulators usually are law and regulations in which the company must comply and use as guidelines the production of the beverage. Nongovernmental partners provide technical assistance as well as important data and information for the production.

#### Issues/Problems

The production system of the beverage company is almost fully automated. Only few sections of the system are not automated. However, one of the most difficult parts in managing this production system is related to decision making in the production planning department. This is because there

FIGURE 66

## POLICY MODELING CANVAS FOR SMART PLANNING SYSTEM.



are many single keeping units (SKUs) to be produced with many constraints that the planners must follow. It is a complex decision and requires a substantial amount of time to do the planning. The consequence of inappropriate plans could be overstocking of finished products or inability to meet the demand. Thus, a smart planning system is needed to assist planners in making good plans.

### Goals/Objectives

The goal is to develop a smart planning system that would help planners in making production plans to ensure that the demand is met and the stock is also maintained at appropriate levels. The planning process is based on the planner's experience and is manually performed. Thus, it usually

takes time and several planners to complete this task. With the smart planning system, this task can be done more effectively and efficiently.

#### Activities

A typical process of developing a production plan and schedule for the factory starts with the supply chain department provides the planning department with a loading plan which is what the factory has to deliver in the next three months. After receiving the loading plan, the production plan and schedule must be developed by considering many factors such as the quantity of each product to be produced, capacity of each production line, setup time between production lot sizes, manpower availability, material availability, product safety stock, and product shelf life. With many factors considered in the planning process, it becomes a complex and time-consuming task to develop an effective and efficient production plan, especially without any assistance from a smart system.

To overcome the problem, the following steps have been implemented to develop a smart system in assisting planner creating production plans. First, all necessary data is collected and analyzed. Objectives and goals to be achieved in this smart planning system are determined. Then, a mathematical model as shown in Figure 67 is developed to minimize the makespan. It considers the integrated problem of workforce allocation and parallel machine scheduling with sequence-dependent setup time and machine eligibility restrictions. Next, an algorithm for solving the model is also developed, validated and tested. A number of cases have been used to evaluate the effectiveness and efficiency of the developed system with promising results.

#### Outputs

The contribution of a smart planning includes creating a production plan for each planning period required. It facilitates the planners in terms of developing production and schedule quicker. Based on the result of experiments, it is apparent that the existing rule-based heuristic is most likely to be a less-effective solution than the developed mathematical model, in terms of maximum completion time of all jobs.

#### Beneficiary

With the use of the smart planning system, the planners are the direct beneficiaries. It saves them time and effort to develop the production plans. In addition, several internal and external organization beneficiaries include production department, supply chain department, sales department, logistics providers' companies, and purchasing department. External beneficiaries are retailers and customers of the products.

#### Outcomes

A software that facilitates the production planning process is created. What-if analysis can be easily conducted, which is a good starting point for initial solutions. Only one person, instead of five persons can perform this planning task. With appropriate plans, the products are delivered to retailers and customers on time. It helps the factory maintain the safety stock at appropriate levels, thus positively impacting the production cost.

#### Suggestions, Discussions, and Future Issues

It is important to note that the proposed model could only be applied to a parallel machine scheduling production system with same speeds. For future research, the production system of parallel machines with different speed could be included. In addition, the sourcing process can be integrated into this smart planning to assist planners in managing the entire supply chain more effectively and efficiently.



FIGURE 67

## THE MATHEMATICAL MODEL TO MINIMIZE THE MAKESPAN.

$$\text{Minimize } C_{max} \quad (1)$$

Subject to:

$$\sum_{k=1}^m Q_{ik} = 1; i = \{1, 2, 3, \dots, n\}, \forall k \quad (2)$$

$$D_k = \sum_{i=1}^n Q_{ik} P_i + \sum_{i=1}^n \sum_{j=1}^n S_{ijk} X_{ijk}; \forall k \quad (3)$$

$$D_w = \sum_{k=1}^m D_k P_i; m \in L_w, \forall w \quad (4)$$

$$C_{max} \geq \max_{1 \leq w \leq W} D_w \quad (5)$$

$$Q_{ik} \geq Y_{ik}; \forall i, \forall k \quad (6)$$

$$\sum_{j=1}^{n+1} X_{ijk} = Y_{ik}; \forall k \quad (7)$$

$$\sum_{i=1}^n X_{ijk} = Y_{ik}; \forall k \quad (8)$$

$$\sum_{j=1}^n X_{ojk} = 1; \forall k \quad (9)$$

$$\sum_{i=1}^n X_{o(n+1)k} = 1; \forall k \quad (10)$$

$$X_{iik} = 0; \forall i \quad (11)$$

$$U_{ik} - U_{jk} + nX_{ijk} \leq n - 1; \forall i, \forall j \quad (12)$$

$$D_w \leq T; \forall w \quad (13)$$

$$X_{ijk}, Y_{ik} = \text{binary} \quad (14)$$

$$Q_{ik}, U_{ik}, C_{max} \geq 0$$

## Case Studies of Vietnamese Companies

### Self-assessment of Needs for Smart Manufacturing

With the advent of Industry 4.0, implementing smart manufacturing technologies have become essential, not optional. Developed countries are actively conducting research based on national strategies and policies. Large, global companies such as original equipment manufacturers (OEMs) are publishing best practices based on massive investments, time-consuming experiences, and economic benefits.

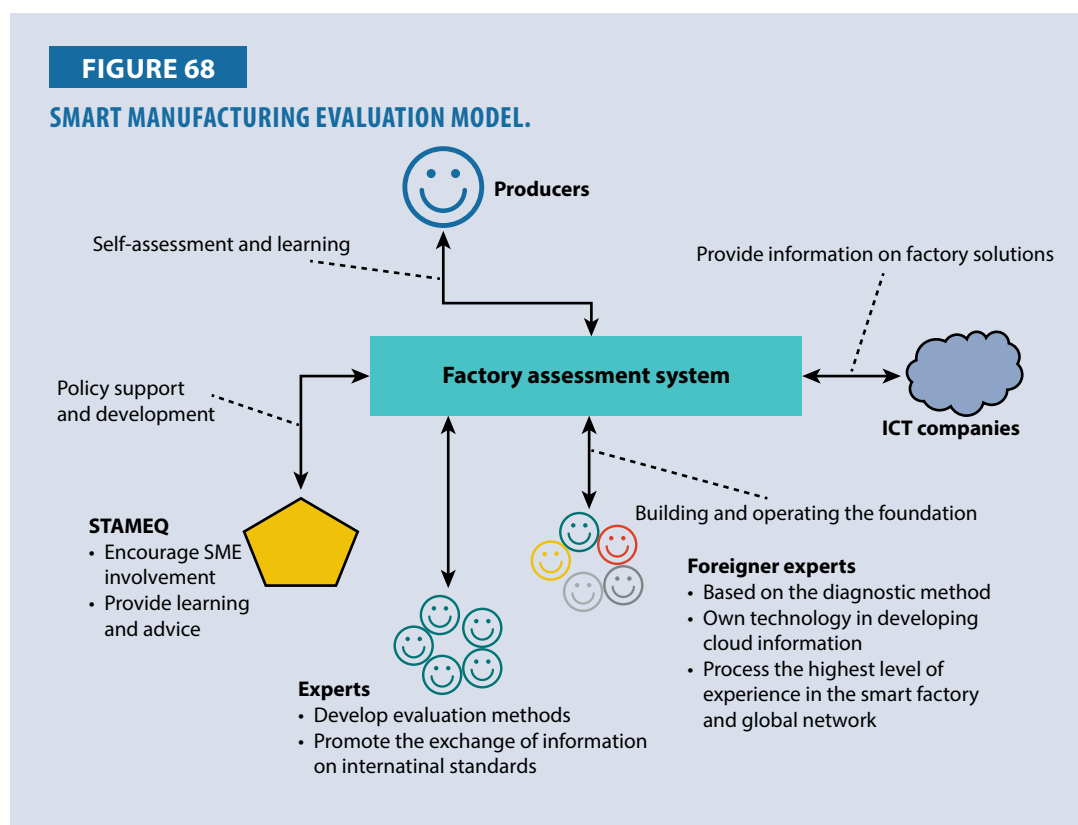
The general view is that a smart manufacturing system (SMS) is a concept that can also be implemented in small and medium-size manufacturers (SMMs) with similar benefits. SMMs, however, do not have the investments, time, or skills to realize those benefits. Each SMM will need

an improvement plan to transition from its current state to a state where it can implement SMS. Assessing that current state, therefore, is critical to developing such a plan [15, 16, 17].

We collaborated with Dr. Yangho Park and Dr. SangSu Choi (from IGI Korea), and Dr. Jungyub Woo and Al Jones (National Institute of Standards and Technology) to do a research titled ‘A Smart Manufacturing Assessment Tool: An application in Vietnam.’ This research describes a self-assessment tool that can help SMMs to perform that assessment. It also describes the results of the assessments of three Vietnamese SMMs: an apparel manufacturer, a plastic-bag manufacturer, and a precision-parts manufacturer.

Our smart manufacturing assessment model for enterprises is described in Figure 68. The evaluation process is based on the following groups of issues: equipment, KPI, labor, management, material handling system, organization, team, and personnel, process, standards, and technologies.

In February 2020, we developed a new digital tool to evaluate the ability to access smart manufacturing of Vietnamese enterprises. It was called Vietnam innovation Productivity Assessment (ViPA). This assessment was developed by Vietnam National Productivity Institute (VNPI) to support manufacturers to promote innovation, improve productivity, and prepare their roadmap to smart manufacturing. There are 16 selected criteria for enterprise management functions including enterprise management, productivity management, digital transformation infrastructure, and smart manufacturing. In addition, companies need to provide 11 more general information points about the company. These criteria are built for manufacturers in case where (1) business leaders want to self-assess the operations of their businesses and find out the innovation activities; and (2) management consultants want to assess the actual status of the business and its business readiness for digital conversion.





With the introduction of new technologies and the use of restructured business processes, smart manufacturing will be the backbone to improve effectiveness and efficiency, and spur business growth. Based on assessment results, a roadmap for implementing smart manufacturing in a company can be proposed along four dimensions of (1) business processes management; (2) productivity deployment management; (3) smart manufacturing platform (business intelligence, cyber intelligence, etc.); and (4) smart manufacturing (sensors, analytics, cyber, and wireless communication).

Personally identifiable information will not be shared publicly and be treated in accordance with the state's privacy regulations. Data will be synthesized, analyzed, and developed into reports for ministries and industries on the readiness of Vietnamese enterprises for smart manufacturing. The results will be shared with business associations, centers of excellence for innovation and creativity, and so on. This questionnaire is now open to Vietnamese manufacturers. This assessment is to be widely used in APO member countries in near future.

### Case Studies

Pilot assessments were conducted at three SMMs in Vietnam: an apparel company, a precision-machined-parts company, and a plastic-bags manufacturing company. We visited each company for about two hours, looked through their shop floors, and carried out SM assessments using our tool (see Figure 69). All three companies had low readiness levels of SM, just like SMMs in most other countries. It is important to develop and practice improvement plans based on these SM indicators rather than being aware of current low indicators.

The plastic-bags manufacturing company produces plastic bags and exports more than 90% of them to Japan. The company has only people and organizations for SM, but does not have the latest smart technologies. For example, in case of management, it is still based on exchanging text files or Excel spreadsheets. No more advanced IT systems have been introduced, and no data connection is currently available through relevant communication standards. Consequently, the company's performance indicators are at the low end of the readiness level. The company needs to make sure that task managers have the required skills and clearly defined and assigned roles.

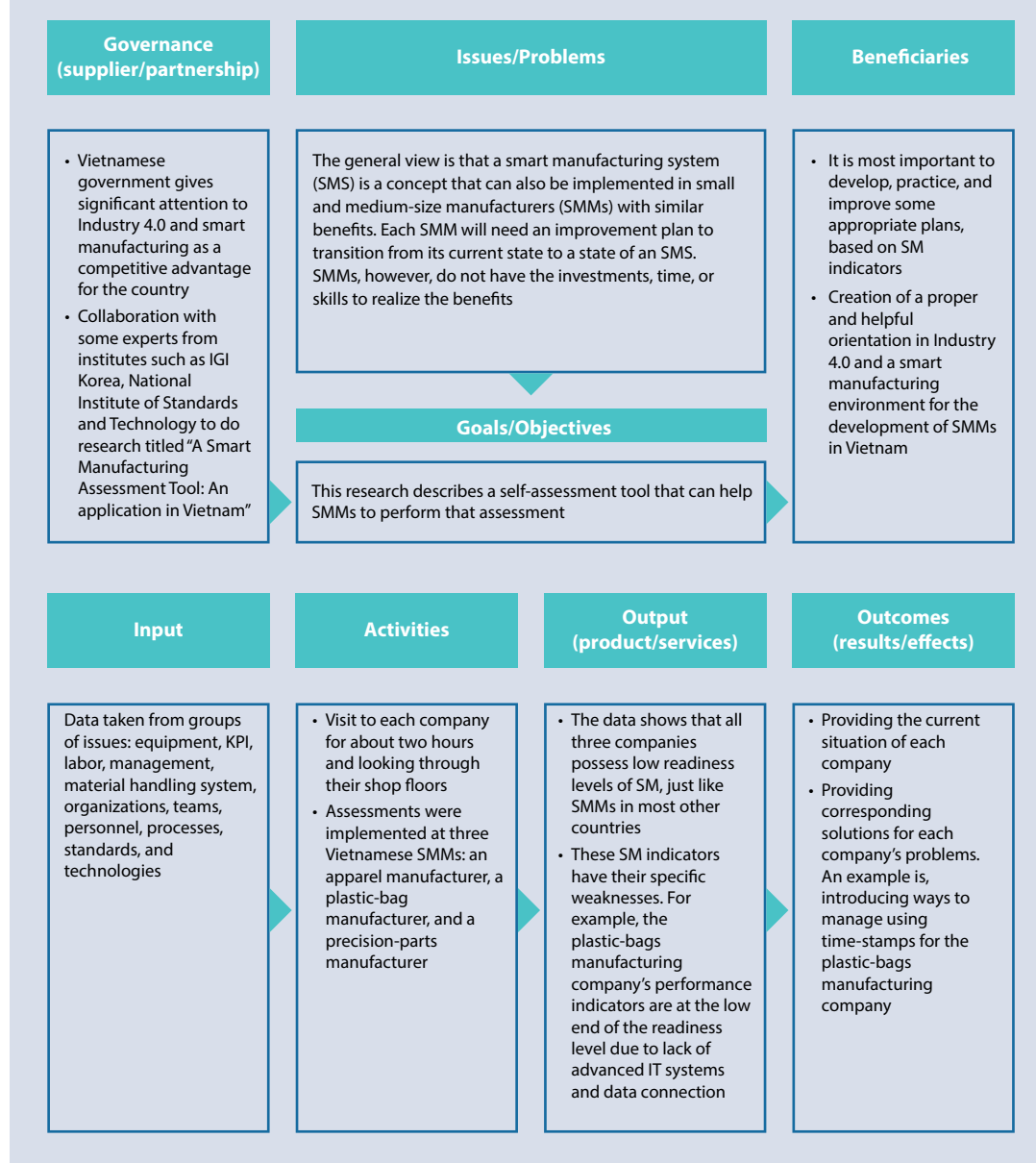
Based on the assessment results, we suggest that (1) task managers are instructed to start clarifying the data needed for the selected performance indicators; and (2) ways are introduced to manage information exchange using time-stamped Excel files. These Excel files should be accessible and verifiable from anywhere by relevant employees, including the company representatives. Our analysis shows that company has invested heavily in facilities. The equipment automation rate is 40%. Currently, both types of equipment indicate that they are semiautomatic.

The precision-machines-parts company is well situated for SM on all fronts, namely, organization, performance management, information connectivity, and information technology. Our analysis shows that company has both automated and manual equipment. Therefore, the automation rate indicator is not high. Eventually, the company can replace manual with automation, so there is no big problem. Although the construction of sensors and actuators in equipment is low, ways to obtain data from the facility must be considered.

As we looked around the factory, we discovered that many of the relevant data and performance indicators were still being managed manually. This can mean several things. First, it is possible that the functions of the IT systems have not been introduced, or have been introduced incorrectly, or

FIGURE 69

## POLICY MODELING CANVAS OF INDUSTRY 4.0 POLICY IN VIETNAM.



have been introduced but are not being used. Second, despite the existence of systems, it is very likely that the company is doing the work based heavily on the workers' current expertise and prior experiences. Third, it means that drawings, data, information and, performance indicators are not being digitized, which means they cannot be shared with other colleagues. If the company organizes them into digital files, they will be very useful in building the systems in future and will be the most valuable asset. These Excel files should be accessible and verifiable from anywhere by relevant employees, including the company representatives.

The apparel company has the right people and the right organizational structure for transitioning to SM. In case of IT systems, which are critical components of SM, the company has made some progress. Currently, MES is applied only to some processes. In cases of performance management

and information connectivity, responses indicate that these activities were being managed using MES, Excel spreadsheets, and numerous text files.

Despite this progress, the assessment in Vietnam shows that (1) the current performance and connectivity are still low; and (2) the use of IT is still insufficient to make that transition. This means that the company is still planning, deciding, and executing its functions based almost solely on workers' current expertise and prior experiences. Due to the nature of the fashion industry, there are many skilled workers in every factory; and it is inevitable, therefore, that they depend almost exclusively on those skills. Nevertheless, to improve performance and connectivity, workers need new skills, especially IT-related skills. Therefore, the company should train workers to acquire those needed IT skills and nurture them as multifunctional workers.

### Summary

The accuracy of the assessment results varied, depending on the knowledge and understanding of the individuals. Consequently, it is a good idea for individuals, including executives, IT managers, plant managers, and workers to 1) perform their own assessments; and 2) compare individual results together before developing an improvement plan. The self-assessment system is made available to any SMM, but prior training will be necessary for their workers to be successful.

Due to time constraints, the three companies, aided by experts, were able to use their own assessment results to draw up initial improvement plans. In general, SMMs will need training before they can draw up improvement plans on their own. The self-assessment tool is based on factory layout. The larger factories took significantly more assessment time. Reducing the number of repeated questionnaires and automating them will shorten that time.

Results indicate that SMMs' awareness of IT technologies or standards related to SM is very low. Users will be able to first see each terminology through assessment, receive training on each technology and standard, and improve their understanding. The self-assessment system has the advantage of being able to prepare SMMs through training, unlike traditional, expert-dependent methods. This has the advantage of preventing the initial overinvestment and cultivating professional personnel in the company.

## Case Study from India

### United Cores

United Cores is an integrated supplier of castings and stamping to OEM and tier-1 companies. Its business verticals include aluminum die casting, electrical stamping, and precision machinery. After shop floor observation and office discussion, as shown in Photos 1 to 4, the key manufacturing processes for its specific and general topics were identified.

The key process for its specific topic is the aluminum die casting, as shown in the Photo 3.

The targeting process for its general topic of energy saving is the electrical stamping using pneumatic power, as shown in the Photo 4.

Also, through the shop floor observation and office discussion, an assessment of United Cores' Industry 4.0 readiness level was conducted with the results of the status and the project's expected achievement as shown in Figure 70.

**PHOTO 1**

**SHOP FLOOR OBSERVATION IN UNITED CORES.**



**PHOTO 2**

**OFFICE DISCUSSION IN UNITED CORES.**





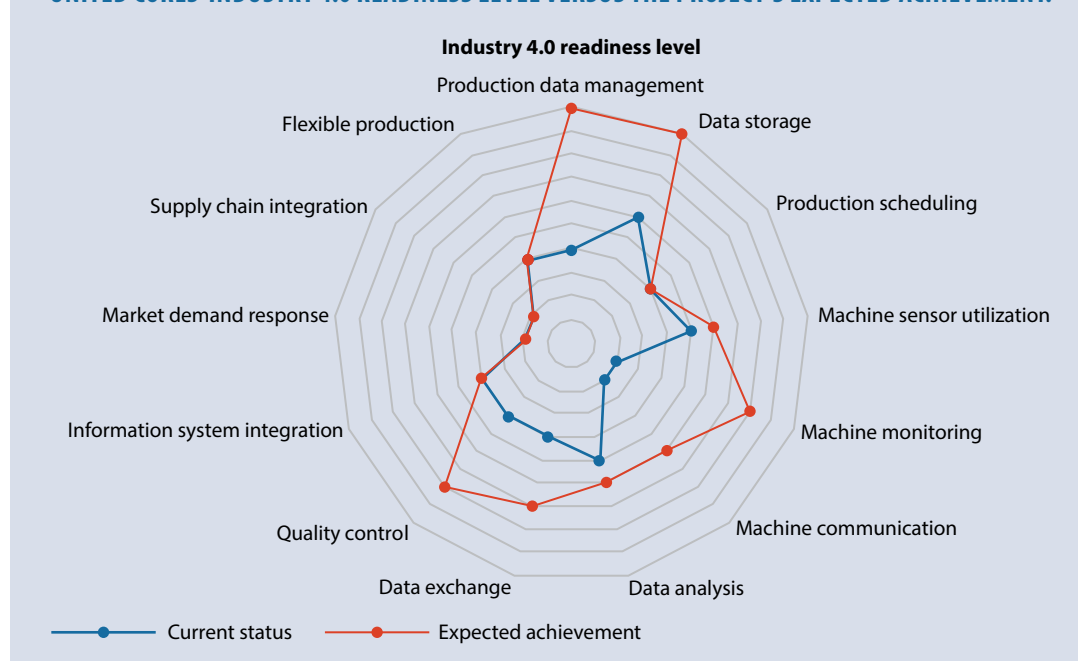
**PHOTO 3**

**KEY PROCESSES AND EQUIPMENT FOR ALUMINUM DIE CASTING FOR SPECIFIC TOPIC IN UNITED CORES.**

**PHOTO 4**

**TARGETING PROCESS AND EQUIPMENT FOR ELECTRICAL STAMPING FOR ENERGY SAVING IN UNITED CORES.**



**FIGURE 70****UNITED CORES' INDUSTRY 4.0 READINESS LEVEL VERSUS THE PROJECT'S EXPECTED ACHIEVEMENT.**

It can be observed from Figure 70 that United Cores' unmet needs are mainly

- machine communication; and
- machine monitoring.

The major achievements in this project will strategically be

- production data management;
- quality control; and
- machine monitoring.

#### Pain Areas

The pain areas of unmet needs identified by United Cores are summarized as

- predictive maintenance;
- automatic and real time monitoring the parameters of machines (e.g., air and hydraulic pressures); processes (molten metal and die temperatures); tools (e.g., die's air vent and over flow blockages); and energy (e.g. electricity and compressed air);
- automatic inspecting quality and then making corresponding decisions; and
- traceable and efficient material storage.

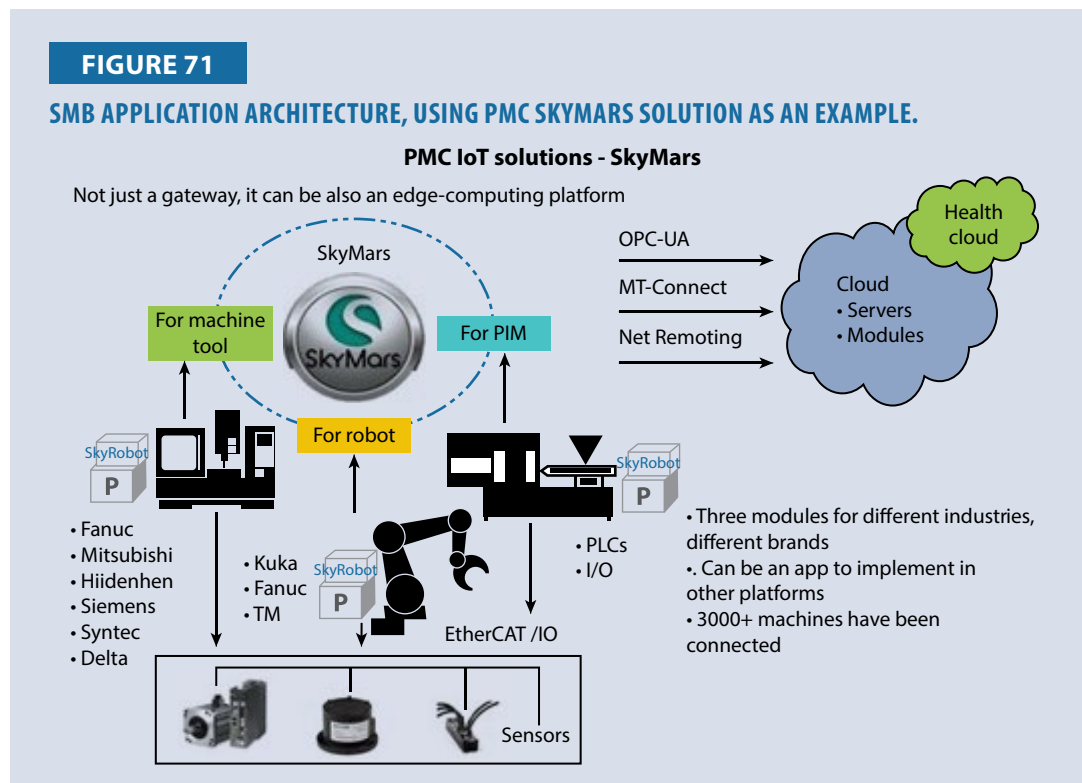
After shop floor observation and office discussion in United Cores, the focused pain areas of unmet needs were identified as

- preventive maintenance on 3~7 ZITAI die casting machines;
- installation of temperature sensors into the dies and molds of the above mentioned ZITAI machines;
- automatic and real-time recording of data for the above mentioned ZITAI machines; and
- reduction of pneumatic power consumption.

## Industry 4.0 Interventions

### Smart Machine Box (SMB)

SMB is the solution for demonstration companies to collect data from machines through corresponding controller interfaces, monitor statuses, and calculated figures for production management, and then report them through Ethernet interface to the shop floor server for visualization, further analysis, and cloud connection. The SMB application architecture is shown in Figure 71.



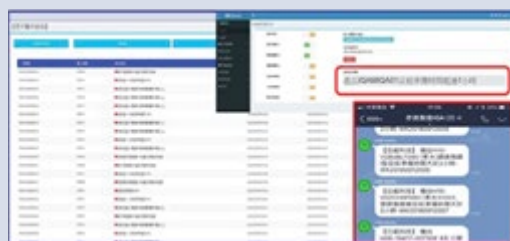
Inside SMB are embedded several interfaces of mainstream controllers such as FANUC, Siemens, Mitsubishi, Heidenhain, etc., so the demonstration companies do not have to take care the interface related issues. Furthermore, production management software modules such as equipment utilization management and proactive fault alert, depending on requirements, can also be embedded inside SMB, as shown in Figure 72.

**FIGURE 72****PRODUCTION MANAGEMENT SOFTWARE MODULES CAPABLE OF EMBEDDING INSIDE SMB.**

## 1. Equipment utilization management



## 2. Proactive fault alert



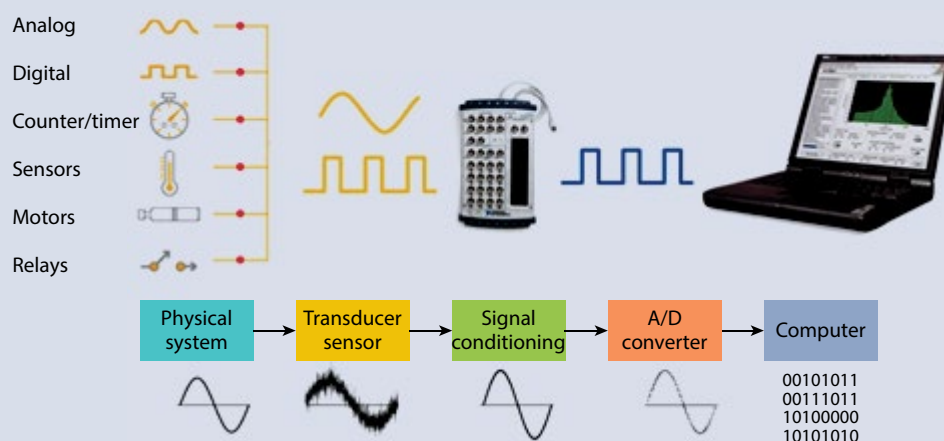
## 3. Job completion measure management



## 4. Prediction of job finish time

**Data Acquisition System (DAS)**

If a machine controller cannot provide required information, e.g., die or mold temperature inside the machine, the demonstration companies may have to install suitable sensors, read out their analog signals, and then transmit them to the SMB in a digital format. DAS is the solution for the demonstration companies to process sensors' analog signals, including noise removal and signal amplification, and then convert them into digital signals ready for SMB to receive, as shown in Figure 73.

**FIGURE 73****DAS RECEIVING ANALOG SIGNALS AND CONVERTING THEM INTO DIGITAL SIGNALS.**



# CONCLUSION

Industry 4.0 migration is deeply challenging the existing business ecosystems of globalization between nations and collaboration between supply chain partners. Global manufacturing networks have been empowered by vertical collaborations between many fragmented but complementary and specialized manufacturers in emerging countries where industry structures may not be ready for a migration to Industry 4.0. APO member countries are actively looking for ways to move up the industry value chain to respond to the fast-changing business environment. These countries focus on strengthening the core competencies related to smart manufacturing and develop conditions crucial for the development of smart machinery industries.

While vertically integrated enterprises are outsourcing manufacturing in order to focus on engaging with end customers directly, the manufacturing service providers in APO member countries are accumulating subcontracted manufacturing services to enhance scale for operational excellence and cost reduction. Indeed, leading economies and global companies are battling for dominant positions in this newly created arena by providing novel value propositions and/or employing new technologies to construct ‘manufacturing platforms’ and attract partners and user companies. Thus, little room is remaining for SMEs, which will affect the sustainability of industry ecosystems in APO member countries. As smart production demands small-lot-sized and high-mix production, most of the existing research efforts are focused on equipment capability and information systems to enhance manufacturing intelligence. Furthermore, the developments of new technologies such as AI, big data/analytics, etc. also provide opportunities for disruptive innovations to support smart production.

In addition, a number of case studies in different segments are used for validation to address some of the needs for smart manufacturing and flexible decision-making in the new value chains of global manufacturing networks.

More studies and international collaborations are needed to address strategic plans to empower smart manufacturing and flexibility in light of business dynamics for sustainable migration. Indeed, the CoE on SM in the ROC, in close collaboration with APO member countries, can integrate the supports of corporate leaders and private non-profit organizations to collect, compile, and provide information related to smart machinery. This will surely benefit the development of small and medium enterprises in member countries. Moreover, the CoE on SM can combine the domestic and foreign resources to provide assistance to member countries in the knowledge transfer process as the latter adopt smart manufacturing and related management models for migration from Industry 3.0 to Industry 3.5 and finally to Industry 4.0. The focus will be on constant learning and exchange of experts’ experiences to realize the ultimate objective of improving competitiveness for industries in the Asia-Pacific region.

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In the sensor and nanotechnology field, he published a book (Optical Nano-sensors, Labor-Social Publishing House); a book chapter (Nano/micro biosensors, Advances in Biochemical Engineering/Biotechnology, edited by I. Endo and T. Nagamune, Springer-Verlag), and 12 international papers in ACS Nano and Analytical Chemistry, among others.

In the smart manufacturing field, he has published two books on smart manufacturing (Smart Manufacturing in the Fourth Industry Revolution, National Political Publishing House; and Enterprise Roadmap to Approach the Fourth Industrial Revolution, National Political Publishing House), several papers in high-technology, smart manufacturing, and smart city, and so on. He has developed a new digital tool called Vietnam innovation Productivity Assessment (ViPA) to evaluate the ability to access smart manufacturing of Vietnamese enterprises.

“Having been working in the field of IoT for many years but for the first time meeting with Dr. Ha Minh Hiep, I knew that he is passionate on raising awareness of stakeholders in Viet Nam especially Vietnamese enterprises on Industry Revolution 4.0.” said Dr. SangSu Choi, Founder and CoE, IGI Korea.





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