WORLDWIDE

DATA COLLECTION SURVEY ON UPGRADING MANUFACTURING INDUSTRY USING THE LATEST TECHNOLOGY

FINAL REPORT

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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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TABLE OF ABBREVIATED WORDS

Abbreviation	English	Countries
2/3/4IR	The 2nd/3rd/4th Industrial Revolution	Worldwide
ARM	Augmented Reality Manufacturing	Worldwide
CAGR	Compound Annual Growth Rate	Worldwide
CICC	Center of the International Cooperation for Computerization	Japan
DEPA	Digital Economy Promotion Agency	Thailand
DIP	Department of Industry Promotion	Thailand
DOIT-HCMC	Department of Industry and Trade, Ho Chi. Minh City	Vietnam
DX	Digital Transformation	Worldwide
EEC	Eastern Economic Corridor	Thailand
ERP	Enterprise Resource Planning	Worldwide
FA	Factory Automation	Worldwide
FMM	Federation of Malaysian Manufacturers	Malaysia
FTPI	Foundation for Thai Productivity Institute	Thailand
GAFA	Google, Apple, Facebook, Amazon	Worldwide
GMI	German-Malaysia Institute	Malaysia
HAPI	Hanoi Authority for Planning and Investment	Vietnam
IIoT	Industrial IoT	Worldwide
IoT	Internet of Things	Worldwide
IVI	Industrial Value Chain Initiative	Japan
JETRO	Japan External Trade Organization	Japan
JICA	Japan International Cooperation Agency	Japan
KIC	Kobe Institute of Computing	Japan
KMITL	King Mongkut's Institute of Technology Ladkrabang	Thailand
LASI	Lean Automation System Integrator	Thailand
MARii	Malaysia Automotive, Robotics & IoT Institute	Malaysia
MCF	Myanmar Computer Federation	Myanmar
MDCR	Myanmar Daiichi Computer Resource	Myanmar
MES	Manufacturing Execution System	Worldwide
MIDA	Malaysian Investment Development Authority	Malaysia
MIGHT	Malaysian Industry-Government Group for High Technology	Malaysia
MIMOS	Malaysian Institute of Microelectronic Systems	Malaysia
MJIIT	Malaysia-Japan International Institute of Technology	Malaysia
MPC	Malaysia Productivity Corporation	Malaysia
MRP	Materials Requirements Planning	Worldwide
MTDC	Malaysian Technology Development Corporation	Malaysia
NECTEC	National Electronics and Computer Technology Center	Thailand
NIA	National Innovation Agency	Thailand
NICT	National Institute of Information and Communications Technology	Japan
NSTDA	National Science and Technology Development Agency	Thailand
PIDI 4.0	Indonesia Digital Industrial Center 4.0	Indonesia
PoC	Proof of Concept	Worldwide
RECOTVET	Regional Cooperation Programme to Improve the Quality and Labor Market Orientation of Technical and Vocational Education and Training	ASEAN
RFID	Radio Frequency Identifier	Worldwide
RPA	Robotic Process Automation	Worldwide
RRI	Robot Revolution Initiative	Japan
SEAMEO	Southeast Asia Ministers of Education Organization	ASEAN
SEED-Net	Southeast Asia Engineering Education Development Network	ASEAN
SIRIM	Standard and Industrial Research Institute of Malaysia	Malaysia
SIer	Systems Integrator	Worldwide
TGI	Thai German Institute	Thailand
ToT	Training of Trainers	Worldwide
TVET	Technical and Vocational Education and Training	Worldwide
UIT	University of Information Technology	Myanmar
UMP	Universiti Malaysia Pahang	Malaysia
VOCTECH	SEAMEO Regional Centre for Vocational and Technical Education and Training	ASEAN

1. Program Outline

1.1 Program Background and Objectives

The rapid development of new technologies such as the Internet of Things (IoT) and Artificial Intelligence (AI) is transforming the manufacturing industry worldwide nowadays. Amid the current situation, the importance of the manufacturing industry to strengthen industrial infrastructure and to secure employment has been refocused and each country has been launching measures to strengthen manufacturing industry. Many Japanese manufacturing companies have their eyes particularly on "Advanced Manufacturing Initiatives" by the USA and "Industry 4.0" by Germany. Furthermore, the EU has been discussing about the future of manufacturing industry ahead of other countries, and China has also launched manufacturing industry strategy "China Manufacturing 2025" with the next generation in mind, working on advancement of the manufacturing industry based on upgrading information and communication technology.

Under such circumstances, Japan also proposed "Society 5.0" and the government of Japan is calling for "Connected Industries" which aims at creating new values by connecting people, goods, technologies, organizations, etc., as a role model (concept) for industry. In "Monozukuri (manufacturing) & robotics" area which is one of the five key areas to be addressed, new technologies and business models are introduced rapidly and breakthrough technology innovations and new forms of industrial creation are occurring in Asian region where supply chains of many Japanese companies are concentrated. While interests in these are growing fast, emerging countries are at a transition stage to reconsider the concept of conventional economy development model driven by manufacturing industry which is to attract foreign investment to mass produce at low cost with cheap labor on the preconditions that population will increase and flow from rural to urban areas.

Considering these factors, emerging countries including those in Asia have growing needs to focus on competitive manufacturing and improving productivity, upgrade industrial structure, and consider the formulation of new development models using new technologies in order to catch up with the change in environment of manufacturing and to accelerate economic growth in the future.

Therefore, as JICA extends its cooperation to the field of industry development in the future, its main aim is to analyze and summarize the impact of rapidly advancing new technologies such as IoT and AI in the field of industry development (especially manufacturing industry), while implementing a pilot project to promote "smartification of Monozukuri (manufacturing)" using the new technology that is bringing the 4th industrial revolution (hereinafter referred to as 4IR), as well as considering and proposing a medium to long term cooperation program (draft).

Because of the outbreak of the COVID-19 pandemic during the study period, a survey on the impacts of COVID-19 on the advancement of the manufacturing industry in each target country of the Study

was added to the originally planned study contents. Overall procedures of the Study is shown in the figure below.

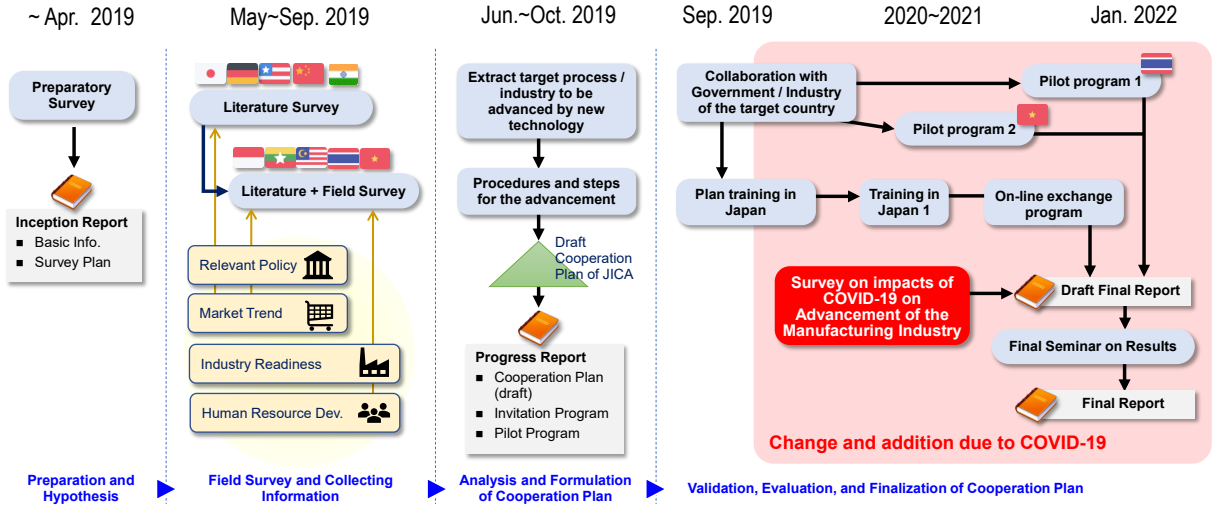

Figure-1 Overall procedures of the Study

1.2 Target Regions

Although the Study targeted the entire world, the actual work was conducted in those countries listed in the following table.

Table-1 Target Countries of the Study

Category	Countries	Desk Research	Field Survey
Country where advancement of the manufacturing industry or its element technologies have relatively progressed	Japan, Germany, USA, China and India	✓	
Asian country where advancement of the manufacturing industry is at the development stage	Indonesia, Myanmar, Malaysia, Thailand and Vietnam	✓	✓

1.3 Target New Technologies

The new technologies covered in the Study and their definitions are shown in Table-2.

Table-2 Targeted new technologies for survey and its definition

Technology	Definition	Role of the technology in manufacturing
IoT	Enable capturing conditions of things via network, controlling its movement and communicating/processing among things autonomously by adding autonomous communication feature and connecting to internet with various things in this world, not limited to ICT equipment such as computers.	Before IoT era, various equipment in manufacturing industry has been connected to network in the world of FA (factory automation). IoT enables completely new way of communication by connecting it to office LAN and worldwide network beyond FA boundary.

Technology	Definition	Role of the technology in manufacturing
AI (Artificial Intelligence)	A machine (information processing system) that has the same intelligent processing ability as humans, such as reasoning, recognition, and judgment, not just processing numerical calculation. At the moment, it is not something that leads to a precise answer that calculates all the possibilities but rather an answer that seems to be optimal within given conditions from statistical calculations and accumulation of "experience".	It will be possible to have a machine which substitutes work that requires intuition and experience and could have been accomplished only by skilled workers, or machine that gradually learns the optimal behavior and method by trial and error even if humans do not define its motion. The former is expected to be one of the answers to the successor problem of skilled workers.
Big Data Analysis	Big data is either a high-volume, high-speed, high-variety (or all of them) information asset that requires a new form of processing for its analysis, and contributes to sophistication of decision making, insight discovery and process optimization.	In the field of manufacturing industry, data generation speed is generally more important than data volume and how to analyze data constantly generated from IoT etc. in real time is a challenge. Rather than accumulating data, it is necessary to analyze it on the spot and apply it immediately to the advancement of the manufacturing process.
Robotics	Collective term centering on control engineering including sensor technology and machine mechanism. It refers to the engineering fields that design, fabricate and operate machines (robots) with autonomously controlled motion as a whole and its application to the industrial field.	Industrial robots are already widely used in the FA in manufacturing industry and new directions are emerging with the application of new technology. For example, it is possible to perform flexible operation according to the situation by applying AI, and to automatically learn a necessary operation, or to use simulation in a virtual world for defining an operation.
On-demand Manufacturing Technology (3D printer, etc.)	A technology that automatically produces the objects defined by 3D data (without requiring human work). A typical device is a 3D printer which forms an object by molding a three-dimensional shape defined by 3D data little by little like a printer.	There is no need to separately create jigs and equipment necessary for manufacturing, such as molds. Therefore it is suitable for high-variety low-volume production, custom made production, and it is also useful for mass production to create prototypes and products that require trial and error.
Manufacturing Execution System	In the manufacturing line consisting of multiple versatile manufacturing equipment and machines, a system that can centrally control and manage the setting, position and use of each equipment according to the required product while automatically configures and executes the lines required to manufacture products under the minimum human intervention.	Since the system can automatically calculate the equipment layout in the physical plant required for manufacturing products and the settings of each equipment from the product specification data ordered from customers via network and execute the production, it is ultimately possible to automatically execute from accepting orders to producing products with unspecified variety without requiring much human intervention.
RPA (Robotics Process Automation)	Basically, it is a system that records and reproduces operations performed by humans (mouse and keyboard operations). Although systems with similar functions (macro and test automation tools) have been around for the last 20 years or so, it is rapidly spreading in recent years particularly because of the advancement of the recognition technology for operation screen which enables versatile system that can be widely applied to office work and the routine work that were done by humans but can be replaced by machines.	It enables automation of machine operation and routine work that were done by humans at the manufacturing sites because they can automate coordinated operations between different systems that were difficult to automate in the past, as well as routine tasks for various programs that were done by human beings individually without changing the target system.

Technology	Definition	Role of the technology in manufacturing
VR (Virtual Reality)	A technology that allows users to experience a computer-generated virtual world as if it were a reality. Although reproduction of vision and hearing by 3D images and sounds is the mainstream, there are also technologies that support five senses such as tactile sense. In general, it is essential that the motion of the user be constantly detected by sensors and that world generation synchronized with the motion be performed.	It can be applied to a wide range of fields, such as remote control of robots that handle hazardous materials and maneuver simulations. At the manufacturing site, it can be applied to virtually defining the motion of industrial robot without using a real machine, or simulating the motion of a manufacturing device, etc.
AR (Augmented Reality)	A technology that uses computers to extend the real environment perceived by humans. Usually, similarly to VR, images and sounds that are generated in synchronization with the movement of the user are delivered through superimposing on the real environment of the user. While VR provides a completely virtualized world, AR aims to mix the virtualized world and the real world.	Some systems are already in practical use such as ARM (Augmented Reality Manufacturing) which displays the work procedure and instruction of the target working location over the real vision by AR when workers need to perform different tasks each time in a multi-product, low-volume production, or one-item production site. It can also be used as work assistance for unskilled workers in the case of mass production.
Block Chain	Peer-to-Peer distributed ledger technology that can ensure the integrity of recorded information by using PoW (Proof of Work) without requiring a third party such as a certification authority. At the same time, availability can also be realized, but confidentiality is actually low[1], and it takes processing time, so it is not suitable for real-time processing.	Application to real-time processing of equipment at manufacturing sites is difficult. On the other hand, there is a possibility that the method can be applied to processing for which time is not critical and reliability is required, such as digital contract between manufacturing companies.

2. Results of Literature Survey in the Countries Targeted in the Desk Research

2.1 Situation regarding Initiatives by Governments, etc. Regarding New Technology

Conditions regarding initiatives by the governments, local public authorities, corporations, private sector organizations, education and research agencies, international agencies, etc. of Japan, Germany, USA, China, and India are summarized here according to the following viewpoints: ① Central policies/ principles, ② Related policies, preferential measures, etc., ③ International cooperation, ④ Public/ private partnership, ⑤ Laws and regulations, and ⑥ Human resources development and employment measures.

Each country also conducts support for developing countries. Such support for developing countries is described in Chapter 3.

[1] https://blockchain.denen.com/2018/05/09/blockchain-disadvantages/

(1) Japan

- Central policies/principles:

  "Connected Industries"[2]: Japan has three main pillars: ① Realizing a new digital society in which people cooperate with machines and systems, ② Resolution of issues through cooperation and collaboration, and ③ Active promotion of human resources development in line with the advance of digital technology. Five areas have been selected for the implementation of priority initiatives: ① Automatic driving and mobility services, ② "Monozukuri" (manufacturing) & robotics, ③ Plant and infrastructure security, ④ Bio and materials, and ⑤ Smart life. Japan is distinguished from other countries in that it **aims to build a human-centered industrial society in which the "field capability", such as flexible problem-solving ability and ongoing KAIZEN activities, backed up by thorough knowledge of conditions on the ground, can be utilized.**

- Related policies, preferential measures, etc.:

  ➢ Policies

  Japan aims to create added value of approximately 30~40 trillion yen by advancing into 4IR-related fields through "Japan Revitalization Strategy 2016"[3], "Basic Policies for Economic and Fiscal Management (the Basic Policies)"[4], "Japan's Plan for Dynamic Engagement of All Citizens"[5] and so on, while in "Society5.0"[6], it aims to realize an ultra-smart society. Furthermore, as its "artificial intelligence technology strategy", it has compiled an industrial roadmap in three priority areas including productivity.

  ➢ Research and development

  Concerning the research and development themes that need to be addressed primarily under the initiative of the National Research and Development Agency (contents that need to be addressed in a concerted effort from basic research to social application; contents that do not promise short-term profits and cannot be advanced through private sector initiative alone ; and contents that entail cooperation in terms of international standardization, common base technologies and so on), three centers, i.e. NICT, RIKEN, and AIST (National Institute of Advanced Industrial Science and Technology) are implementing concerted initiatives.

  ➢ Subsidies, preferential measures, etc.

  Concerning "Connected Industries", the following initiatives are implemented: "the program for promoting utilization of industrial data" (budget amount: 1.8 billion yen), which applies

2 https://www.meti.go.jp/policy/mono_info_service/connected_industries/index.html
3 https://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/2016_zentaihombun.pdf
4 https://www5.cao.go.jp/keizai-shimon/kaigi/cabinet/2019/decision0621.html
5 https://www.gov-online.go.jp/tokusyu/ichiokusoukatsuyaku/plan/
6 https://www8.cao.go.jp/cstp/society5_0/index.html

a broad range of subsidies and preferential tax schemes to initiatives for collecting and utilizing digital data, which is fundamental to 4IR; "the program for supporting joint development of AI systems" (budget amount: 2.4 billion yen), which subsidizes the costs of joint development activities between major and middle standing enterprises and AI ventures; and "the program for supporting construction of startup factories" (budget amount: 3 billion yen)[7], which targets operators that conduct hardware manufacturing processes from planning to mass production in new businesses. In addition, there is support for survey of private sector companies primarily by the Ministry of Economy, Trade and Industry via "Lean Automation System Integrators (LASI) in Connected Industries" in the "Project for Nurturing New Industries in ASEAN and Japan"[8], the "Next Generation Smart Plant Engineering as a New Export Industry" local survey program by the Engineering Association under support by JETRO, and so on

- International cooperation:

  With a view to building a framework for bilateral cooperation related to 4IR, Japan and Germany signed the Hannover Declaration (March 2016)[9] calling for the formulation of IoT technology and AI technology standards and collaboration in the field of cyber security. In addition to cooperation between governments, cooperative relations are being developed and a joint declaration has been announced[10] between the Robot Revolution Initiative (RRI) and Germany's Platform Industries 4.0. Also, an MoU has been signed (February 2017) between Japan's IoT Promotion Consortium and India's National Association of Software and Services Companies (NASSCOM) concerning cooperation in the IoT field[11].

- Public/ private partnership:

  ➢ Formation of related organizations

  Based on the "Japan Revitalization Strategy (Growth Strategy) 2015 – Revolution in Productivity by Investment in the Future-" (adopted by Cabinet resolution on June 30, 2015), the IoT Promotion Consortium was established in 2015 to promote utilization between industry, government and academia corresponding to the age of IoT, big data, and artificial intelligence. Also, the Robot Revolution Initiative (RRI) was established in 2015 under private sector initiative based on the new robotics strategy announced by Prime Minister Abe, and the "Next Generation Smart Plant Engineering Research Group" was established under the Engineering Advancement Association of Japan.

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7 https://www.meti.go.jp/policy/mono_info_service/connected_industries/pdf/economic_measures.pdf
8 https://www.jetro.go.jp/jetro/activities/support/aseanjapan.html
9 http://www.soumu.go.jp/main_content/000473188.pdf
10 https://www.jmfrri.gr.jp/info/rri/255.html
11 http://www.soumu.go.jp/menu_news/s-news/02tsushin01_04000456.html

- Laws and regulations:

  In “Connected Industries”, work is being advanced on establishing “legal systems for utilizing industrial data in cooperative fields”. This aims to promote the utilization of data, quantities of which are increasing dramatically due to the advance of IoT, etc., with a view to resolving social issues. Also, Japan is the first country in the world to announce a “Cabinet order concerning virtual currency exchange operators” with the aim of encouraging the appropriate utilization of blockchain technology, which is viewed as key to the digital economy.

- Human resources development and employment measures:

  One of the pillars of “Connected Industries” is, ③ Active promotion of human resources development in line with the advance of digital technology. With a view to nurturing human resources related to AI, where needs are especially high among new technologies, it is planned to implement initiatives based on cooperation between government, industry and academia, including “expansion of human resources supply based on utilization of online education”, “deployment of practical education with participation by industry”, and “securing of human resources through offering preferential conditions to AI human resources”[12]. In particular, in its policy for reform of national universities, the Ministry of Education, Culture, Sports, Science and Technology is requiring that data science and mathematical principles be taught as AI basics in all faculties, both in the sciences and humanities.

(2) Germany

- Central policies/principles:

  “Industry 4.0 Strategy (Industrie 4.0)”: This aims for the social implementation of the “4th industrial revolution” by networking industrial machines, equipment and production processes and **linking the value chain by managing from ordering to shipping in real time** via the introduction of IoT to manufacturing (also entailing partnership with private sector companies).

- Related policies, preferential measures, etc.:

  ➢ Policies

  In the “National Industrial Policy 2030” (awaiting Cabinet decision)[13], “digitalization” and “utilization of artificial intelligence (AI)” are defined as the most important areas of basic innovation. Key fields are storage battery production, AI, and automated driving. In “AI Made In Germany”[14] (2018), it is planned to advance Germany’s AI development by deploying a total 3 billion Euros of investment by 2035 (specifically, construction of an AI

12 https://www8.cao.go.jp/cstp/tyousakai/juyoukadai/14kai/siryo6.pdf
13 https://www.jetro.go.jp/biznews/2019/02/1d10c113ff3700b4.html
14 https://www.jetro.go.jp/biz/areareports/special/2019/0502/9d342ff5304e10e0.html

center, new technology research and development, support for startups and so on). "High-Tech Strategy".

➢ Research and Development

The Fraunhofer Society[15], which is the largest applied research agency in Europe having 72 research laboratories and units throughout Germany, implements various research activities and experiments geared to promoting 4IR initiatives among enterprises. In particular, Industry 4.0 Readiness Online Self-Check for Business[16], which measures the readiness of enterprises to introduce 4IR, is well known and influences efforts by countries around the world to create similar indexes for measuring the readiness of companies. The Fraunhofer Society also conducts research into practical systems that enterprises can use in their work; for example, the Fraunhofer Institute for Experimental Software Engineering (IESE) is implementing the "BaSys 4.0" project[17] aimed at developing a general-purpose 4IR platform, the "IUNO" project[18] for researching information security measures, which are vital to 4IR, and so on.

➢ Subsidies, preferential measures, etc.

The Ministry of Research and Education is implementing the "German Advanced Cluster Competition Program", under which it has provided 40 million Euros of subsidies over five years for promoting open innovation in internationally competitive industrial clusters (mutual cooperation between corporate groups concentrated in specific areas and universities and research agencies). The "it's OWL" project[19], which offers training and joint research opportunities with universities on advanced FA and AI technologies to SMEs, has greatly enhanced the 4IR readiness of enterprises and succeeded in increasing productivity via FA by 10% or more[20]. In addition, "Smart Service Welt" and "Smart Service Welt II"[21] are projects intended to subsidize technology and prototype development for promoting innovative ICT support services. Although these activities are not specific to 4IR, they offer subsidies for IoT device development, prototyping, testing and so on.

- International cooperation:

Apart from the Hannover Declaration with Japan described earlier, Germany is engaged in the following international cooperation as it aims to export plants that are based on Industry 4.0 specifications.

15 https://www.fraunhofer.de/
16 https://www.industrie40-readiness.de/?lang=en
17 https://www.dfki.de/en/web/research/projects-and-publications/projects/project/show/Project/basys40/
18 http://www.fraunhofer.jp/content/dam/japan/ja/documents/media/publication/Trends-in-Industrie-40.pdf
19 https://www.its-owl.com/home/
20 https://mono-watch.com/17124/
21 https://www.acatech.de/projekt/smart-service-welt/

Table-3 International cooperation regarding German Industry 4.0

Country	Announcement Date	Outline
China	October 2014	Announcement of the Sino-German Cooperation Action Plan aiming to strengthen cooperation concerning the stipulation of standards with China, which has formulated China Manufacturing 2025.
	July 2015	It signed an MoU geared to cooperation for promotion of Industry 4.0 with China's Ministry of Industry and Information Technology (MIIT). Companies in both countries have launched pilot projects and are implementing high-level meetings once a year to coordinate policies.
India	April 2015	It signed an MoU geared to promotion of Industry 4.0 between Germany and India at Hannover Messe in 2015.
Czech Republic	October 2015	It signed an MoU geared to promotion of Industry 4.0 with the Czech Ministry of Industry and Trade. This aims to promote general cooperation in the industrial and academic fields. In August 2016, Germany and the Czech Republic established a joint research institute concerning partnership between humans and robots.
Egypt	September 2016	The Federation of Egyptian Industries (FEI) visited DIN and announced cooperation related to standardization.
Thailand	May 2017	The Thailand Ministry of Science and Technology and Ministry of Industry signed an MoU geared to promotion of Industry 4.0 with Germany.
Vietnam	March 2019	The German Federal Ministry of Economics and Technology (BMWi) and the Vietnamese Ministry of Industry and Trade (MOIT) signed a joint declaration on trade cooperation, including strengthening cooperation in promoting Industry 4.0 and supporting DX for SMEs, the digital economy, and supporting domestic TIVET.
Singapore	October 2020	Singapore's Enterprise Agency signed an MOU with the German Standards Institute (DIN) and others for cooperation in emerging fields including Industry 4.0.
Indonesia	April 2021	Participated in Hannover Messe 2021 in Germany as the first ASEAN partner country. Introduced "Making Indonesia 4.0".

Source: Prepared based on the following materials:
Nomura Research Institute's "Special Feature: Latest Trends concerning the 4th Industrial Revolution and Issues in responding to IoT in Japanese Manufacturing"
Joint Declaration of Intent to deepen trade and economic relations between Vietnam and Germany (March 25, 2019)
JETRO BizNews (April 22, 2021)

- Public/ private partnership:

  Realization of "Industry 4.0 Strategy (Industrie 4.0)" itself is predicated on public/private partnership. Platform Industry 4.0 (PI4.0), which was established in 2013 as German's central organization for promoting the digitalization of manufacturing by three industrial bodies, namely the Mechanical Engineering Industry Association (VDMA), the Federation of Information Technology, Communications and New Media Industries (BITKOM), and the German Electrical and Electronic Manufacturers' Association (ZVEI), plays the central role in implementing this strategy. From 2015, the federal minister of economy and energy and minister of education and science became the chief executives, and work was started on building a setup of cooperation between industry, government and academia including research agencies, such as the Fraunhofer Society and private sector companies such as Bosch.

- Laws and regulations:

  Germany seems determined to take the initiative in establishing legislation that covers the entire EU. In particular, the EU General Data Protection Regulation (GDPR)[22] is imparting a major impact on 4IR-related industries, and huge sanctions are imposed on enterprises that monopolize or illegally use data. Cooperation related to necessary regulatory reforms is also mentioned in the Hannover Declaration with Japan.

- Human resources development and employment measures:

  "Arbeiten 4.0" (2016), which is the white paper that compiles the results of a dialog project commenced by the federal ministry of labor and society (BMAS) in April 2015, presents the vision for labor and social policies in the era of digitalization looking to Industry 4.0 in the form of eight policy ideas: 1) employment capacity, 2) working hours, 3) service industries, 4) healthy work, 5) data protection, 6) joint decision and participation, 7) protection of self-employed persons, and 8) social welfare state. In terms of public support for human resources development related to 4IR, "Academy Cube" (now finished) is a site for generally supporting the matching and training of human resources, while "Software campus"[23] offers a high-level human resources development program based on cooperation between industry and academia for free of charge.

(3) USA

- Central policies/principles:

  It wasn't until recently that the Government of the United States compiled any basic policy specific to 4IR. The Advanced Manufacturing Strategic Plan[24] was eventually compiled in October 2018. This stipulates the following three goals: 1) Development of and transition to new manufacturing technologies, 2) Education, training and linkage of manufacturing workers, and 3) Expansion in capacity of the domestic manufacturing supply chain. Among the science and technology policy highlights for the second year of the Trump administration announced in the same year[25], six out of 21 items are related to 4IR, i.e. 5G, advanced manufacturing, AI, advanced transportation, cyber security, and digital economy.

- Related policies, preferential measures, etc.:

  ➢ Policies

  Under "Smart America Challenge" (2013) and "Global City Teams Challenge" (2014), initiatives geared to social implementation of the Cyber Physical System (CPS) were

22 https://www.meti.go.jp/policy/it_policy/privacy/downloadfiles/18datewg08.pdf
23 https://softwarecampus.de/
24 https://www.whitehouse.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf
25 https://www.whitehouse.gov/wp-content/uploads/2019/02/Administration-2018-ST-Highlights.pdf

commenced. In "Innovation Strategy" (2009), emphasis is placed on research and development and innovation creation.

➢ Research and development

In the United States, research into advanced technologies such as AI is primarily conducted by IT majors such as Google, Amazon, Facebook and Apple (GAFA) at a level that exceeds that of universities and other advanced education institutions. Particularly concerning research of big data and AI, which require collection and analysis of huge amounts of data, the GAFA corporations (especially Google and Facebook) lead the world due to the huge data resources they control. The industrial big data platform software and AI libraries that have so far been used in industries throughout the world are largely composed of open source software that were provided by these two companies. However, in many cases, the departments that conduct such research are often research and development enterprises that have been acquired through vigorous M&A activities by the said majors. A case in point is the AI research and development enterprise DeepMind[26], which is now under the umbrella of Google.

➢ Subsidies, preferential measures, etc.

Since the United States naturally attracts outstanding human resources in cutting edge technological fields, there is little need for the government to adopt subsidies and preferential measures; hence 4IR initiatives are currently led by the private sector. On the other hand, NPOs and other non-government organizations provide support to small and medium enterprises; for example, sme.org offers an advanced manufacturing technology support program for SMEs in the manufacturing sector.

- International cooperation:

International cooperation in industry is conducted through partnerships with international 4IR-related industrial groups, for example, a 2016 agreement to share information necessary for promoting standardization in industrial sectors between Germany's "Platform Industry 4.0 (I4.0)" and America's "Industrial Internet Consortium (IIC)". The American government, on the other hand, implements hardly any cooperation, but rather has been adopting a protectionist approach in recent years.

- Public/ private partnership:

In industrial circles, the "Industrial Internet" that was first proposed by General Electric (GE) in 2012 was the first time that 4IR was purported as a concept. This placed emphasis on the **collection and utilization of post-sale product data** in five priority fields, i.e.① manufacturing,

[26] https://deepmind.com/

② energy, ③ healthcare, ④ transportation, and ⑤ public services. Later, the Industrial Internet Consortium (IIC) was established in March 2014 by AT&T, Cisco, GE, IBM, and Intel with cooperation from the National Institute of Standards and Technology (NIST) with the aim of promoting the sophistication of IoT. This subsequently grew into the world's largest open consortium of enterprises with the added participation of SAP and Bosch from Germany and major corporations from Japan.

During the Obama administration, as policies for strengthening cooperation related to advanced manufacturing technologies between industry, government and academia, the Advanced Manufacturing Partnership (AMP) was launched in 2011, followed by "The National Network for Manufacturing Innovation (NNMI)" in 2012. Under these policies, a total budget of approximately US$2 billion was allocated to establish 45 research hubs. The AMP is still being implemented on the state level in some places (such as in Southern California[27]).

- Laws and regulations:

The American Fair Trade Commission has stated that it does not intend to examine legal systems dedicated to CPS. However, it has called on businesses to implement adequate security measures in the development stage and to comply with principles of privacy protection, such as data minimization and thorough provision of notifications and choice. In 2018, the Export Control Reform Act (ECRA[28]) was passed, leading to strengthening of export controls with the aim of protecting America's emerging and foundational technologies. Out of 14 technological fields targeted by ECRA, five are connected to 4IR, i.e. AI, data analysis technology, transport technology, added manufacturing technology, and robotic engineering.

- Human resources development and employment measures:

The government is not implementing any salient policies. Almost all training of human resources in the kinds of cutting edge technologies utilized in smartification of manufacturing is undertaken by universities and leading enterprises in the field.

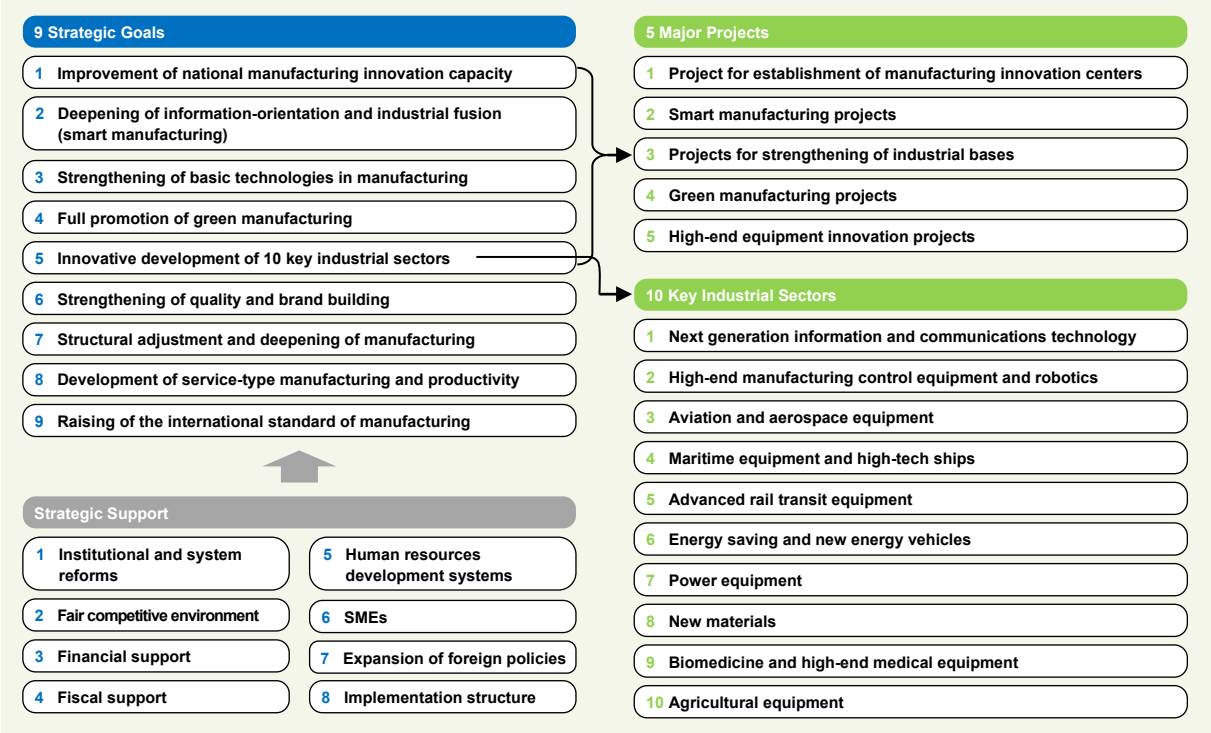
(4) China

- Central policies/principles:

"Made in China 2025" and "China Manufacturing 2025: Priority Fields Technology Roadmap" (2015): This aims to build China's status as a "Global Manufacturing Superpower" by 2049, the year it celebrates the 100th anniversary of the People's Republic of China. Ten key industrial sectors have been earmarked: ① next generation information technology (semiconductors, 5G, AI), ② high-end manufacturing control equipment and robotics, ③ aviation and aerospace

[27] https://ampsocal.usc.edu/
[28] https://www.congress.gov/bill/115th-congress/house-bill/5040

equipment, ④ maritime equipment and high-tech ships, ⑤ advanced rail transit equipment, ⑥ energy saving and new energy vehicles, ⑦ power equipment, ⑧ agricultural equipment, ⑨ new materials, and ⑩ biomedicine. At the same time, numerical goals have been established in the four fields of information orientation (fusing of information and communications technology and manufacturing), promotion of innovation, improvement of quality and efficiency, and eco (environmental protection). Features of this policy are that it sets longer term goals than in other countries, while in the short term, it includes improvement of production efficiency, FA introduction and other initiatives that have already been implemented in Germany, USA and Japan.



Source: From the "Manufacturing Superpower Strategy seen in the Continually Evolving 'World's Factory' 'China Manufacturing 2025'", Hitachi Review

Figure-2 Strategic Goals and Priority Fields in Made in China 2025

- Related policies, etc.:

  ➢ Policies

  Under the umbrella of Made in China 2025, the "Internet Plus" Action Plan (2015) aims to promote mobile technology, internet, cloud computing, big data, IoT, AI, etc. in 11 fields, i.e. ① company innovation, ② cooperative manufacturing, ③ modern agriculture, ④ smart energy, ⑤ financial inclusion, ⑥ public services, ⑦ smart logistics, ⑧ electronic commerce, ⑨ traffic, ⑩ ecosystems and environment, and ⑪ AI. It especially places emphasis on implementation of AI in all areas of industry and society. Moreover, in the "Industrial Internet

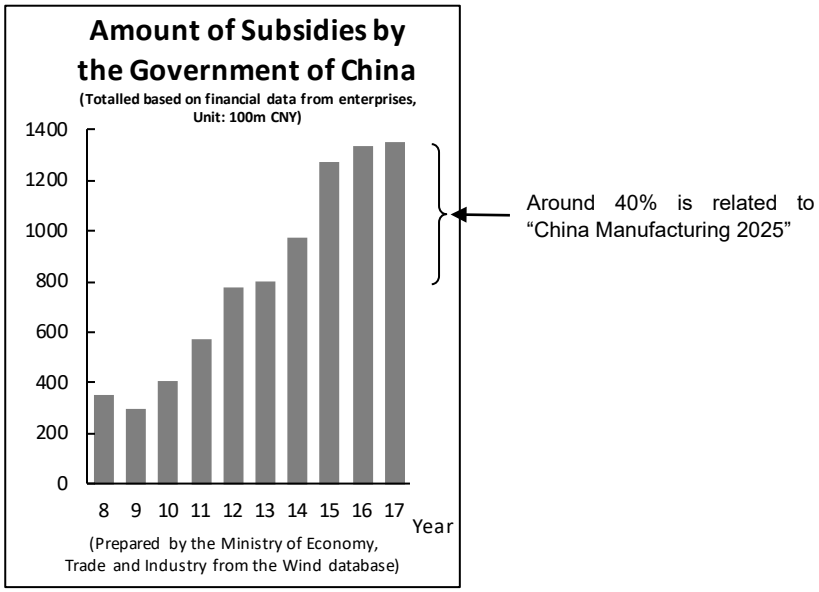
Development Action Plan" (2018), China aims to complete its industrial internet infrastructure base and foundations for industrial systems to support the upgrading of industry by 2020.

➢ Research and development

As in the United States of America, research and development of the kind of cutting-edge technologies used in 4IR is largely conducted by major corporations in the ICT field. For example, Huawei is highly influential in the field of 5G and other next generation communication technologies, while Alibaba and Baidu are strong in the area of AI research. Many of these corporations pay massive salaries to hire outstanding Western researchers.

➢ Subsidies, preferential measures, etc.

In Made in China 2025, subsidies are provided in the 10 priority fields indicated earlier. The amount of such subsidies is increasing every year. According to the 2019 white paper by the Ministry of Economy, Trade and Industry, the amount of subsidies in 2017 was 135 billion CNY (approximately 2.1 trillion yen), four times higher than it was 10 years earlier.



Source: From "Nikkan Kogyo Shimbun June 7, 2019"

Figure-3 Changes in Amount of Subsidies by the Government of China

However, there is a strong possibility that these subsidies are protective in nature, i.e. they are used more for protecting export industries and promoting exports than introducing advanced technologies, etc. to SMEs.

- International cooperation:

  As was mentioned earlier, China announced the Sino-German Cooperation Action Plan in October 2014. Also, the "Alliance of Industrial Internet (AII)"[29], which was launched in 2016, is conducting a wide range of initiatives, including education in specialist knowledge from the viewpoint of industrial needs, promotion of technology standards, dissemination of internet applications, security measures, promotion of international cooperation projects and so on. It also cooperates with the "Industrial Internet Consortium" in the USA and Germany's "Platform Industry 4.0".

- Public/private partnership:

  The above-mentioned AII is an industrial organization, however, as is usually the case in China, it is placed under government control. It is under the jurisdiction of the Ministry of Industry and Information Technology (MIIT) and functions under the initiative of the China Academy of Information and Communications Technology (CAICT)[30]. It is composed of 13 members, including China Telecom, Huawei, Haier, and Alibaba. Hardly any information is available online concerning specific public-private partnership activities.

- Laws and regulations:

  In China, because regulations concerning private information protection and technical experiments are loose, it is relatively easy to implement social experiments and PoC (Proof of Concept) experiments entailing cutting edge technologies. In that sense, it has an excellent environment especially for conducting big data analysis and AI-related product development based on that. On the other hand, however, this indicates that the government widely conducts identification of individuals based on constant facial recognition in public places. Laws and regulations related to 4IR are almost always enacted for the purpose of protecting own country exports. An example is the adoption of retaliatory tariffs in response to sanctions imposed on China by the USA based on Section 232 of the Trade Expansion Act.

- Human resources development and employment measures:

  There are no salient initiatives, however, from the viewpoint of developing advanced technology engineers, major ICT corporations such as Huawei utilize abundant finances to secure outstanding people and build luxurious in-house R&D environments[31].

[29] http://en.aii-alliance.org/
[30] http://www.caict.ac.cn/english/
[31] https://www.asahi.com/articles/ASM351RR0M35UHBI003.html

(5) India

- Central policies/principles:

  "Make in India": Targeting 25 industrial fields, including automobiles, biotechnology, oil and gas, railways, and aerospace, this aims to promote investment and innovation, protect intellectual property, and introduce new preferential measures geared to building the manufacturing infrastructure. The manufacturing infrastructure it envisages comprises industrial corridors, industrial clusters, smart cities and so on.

- Related policies, preferential measures, etc.:

  In the "100 Smart Cities" plan, which aims to build 100 smart cities by 2020, IoT plays an important role. (However, this is not dedicated only to manufacturing).

- International cooperation:

  As was mentioned earlier, an MoU was signed in 2017 between Japan's IoT Promotion Consortium and India's National Association of Software and Services Companies (NASSCOM) concerning cooperation in the IoT field.

- Public/private partnership:

  There are no salient initiatives.

- Laws and regulations:

  There are no salient initiatives.

- Human resources development and employment measures:

  "Make in India" raises the following goals: ① creation of employment for 100 million people in manufacturing by 2022, and ② imparting of appropriate skills to migrants from rural areas and poor people in cities with a view to facilitating comprehensive growth.

(6) Comparison between Japan and the other desk research countries, and observations

- Japan's strengths:

  As is shown in the following table, Japan's approach to the 4th Industrial Revolution (4IR) differs from that in Europe and America. Japan should advertise its strengths to the rest of the world while actively highlighting such uniqueness. However, since Japan's strengths are not necessarily compatible with all companies in every country, JICA will need to target those companies in which Japan's strengths can be utilized in its cooperation efforts.

Table-4 Strengths and Risks of the Western and Japanese Approaches to Industry 4.0

	Western Approach	Japanese Approach
Thinking	・Predicated on standardization ・Application of greatest common divisor-type systems to all players ・Data sharing and its open handling ・Smartification functions on a high dimension upon removing barriers in companies ・Best practices and patterns (standardization and optimization of procedures)	・Predicated on the field / production lines and the people who work there ・Built through combining least common multiple-type parts ・Clear distinction between parts that can be shared and parts that can't ・Smartification first becomes operational inside companies and then moves onto cooperation between companies ・Best effort and flexibility
Merits for emerging countries	・Companies in emerging countries can participate in global 4IR network and easily conduct business on the global stage.	・Companies in emerging countries can cooperate at a gentle pace without losing their identity, while learning the good points of Japanese companies.
Risks for emerging countries	・Companies in emerging countries are required to conform to standards, coercing them into subsequently purchasing solutions from major Western corporations. [32]	・If Japanese companies err in their response to standardization, there is a risk that their technologies will become dispersed.

- Countries in the stage prior to full-fledged operation of 4IR promotion policies:

  Looking at the 4IR initiatives of each country in the desk research, since detailed information is not forthcoming concerning such fields as legislation and systems, human resources and employment, it is thought that each country including Japan has not yet implemented concrete initiatives in these areas. Conversely, in developing countries, if Japan were able to conduct cooperation in such areas, not only would this generate differentiation with other nations, but it may also have the secondary effect of enabling initiatives in developing countries to be fed back to Japan.

- Merits and demerits of limiting assistance to manufacturing:

  Looking at policies related to cutting-edge technologies such as IoT and AI, all countries do not target manufacturing as an isolated case, but rather they seek to create greater impacts through linking it to other areas (smart cities, etc.). Since the abovementioned cutting-edge technologies can impart big impacts not only on manufacturing but also other fields (agriculture, etc.) that were previously thought to be far removed from ICT technology, JICA's cooperation should be expanded from manufacturing alone to include other fields in which additional effects can be anticipated through synergies.

2.2 Market trends related to New Technologies of IoT, AI, etc.

Information on the new technology market trends in Japan, Germany, USA, China, and India, information is summarized here in terms of ① market players, related equipment and software, and ② market size. For the market size, information on the IoT market and AI market (targeting all sectors) is

[32] "Industry 4.0 is strengthening the control of major enterprises and accelerating the depletion of profits for lower level enterprises" https://biz-journal.jp/2019/06/post_28496.html

shown as a reference in case it is difficult to obtain data on market size specific to manufacturing or 4IR.

(1) Japan

- Market players, related equipment and software:

  The market is driven by SIers and major machine tool manufacturers (although participation by venture enterprises is conspicuous in the AI field, etc.). These majors tend to develop solutions with a bias towards their own original technologies; moreover, Japanese manufacturing tends to be restricted to in-company or group platforms that are at risk of becoming isolated and dispersed. There are numerous instances of cooperation between companies, however, initiatives do not cover the entire country. Rather, cases where companies seek their own unique partnerships with overseas companies tend to be more conspicuous. Moreover, apart from Komatsu[33] and other exceptions, there is little evidence of business models and solutions that can be internationally applied. However, Japan's strength lies in being able to develop solutions that are responsive to the detailed needs of manufacturing lines, and since Japanese machine tools are introduced in many developing countries, it is thought that Japan's strengths can be better utilized in line-related settings.

  The following table gives an outline of the major market players and each company's related equipment and software in representative 4IR fields.

Table-5 Principal players in the 4IR market in Japan

Player	Corporate initiatives and related equipment, related software
Hitachi, Ltd.	It is developing the **"Lumada"** platform for realizing IoT solutions not only in manufacturing but also the electric power and energy fields, railways, finance, public works, healthcare and more.
NEC	It is developing the **"NEC Industrial IoT platform"**, which digitizes various data from manufacturing line settings and provides a database for realizing manufacturing DX. Also, the **"Colsos"** remote monitoring system that offers a package of the necessary functions for remote monitoring and control also targets SMEs in developing countries.
Fujitsu	It is developing the **"Intelligent Dashboard"** solution, which aims to improve production through connecting and visualizing the data of multiple plants via internet. In 2018, its local corporation in China (Fujitsu (China)) and the major Chinese state-owned company INESA established a jointly funded enterprise – Display Materials Co., Ltd. Fujitsu cooperates via a "smart manufacturing project" and has introduced an intelligent dashboard to that company.
Toshiba Digital Solutions	It is developing the **"MeisterSeries"** system for collecting and accumulating IoT data and realizing its efficient and effective utilization in manufacturing, not only improving quality and productivity in manufacturing processes but also assisting the overall business lifecycle.

[33] In the smart construction field utilizing IoT, etc., Komatsu has pioneered the deployment of solutions such as the Autonomous Haulage System (AHS) for operating unmanned dump trucks mounted with wireless network systems, and the KOMTRAX network system for construction machines (service in which users and Komatsu share information concerning the position and operating condition of Komatsu machines and collected data is utilizes to propose efficient operating methods and provide maintenance services before machine failures occur).

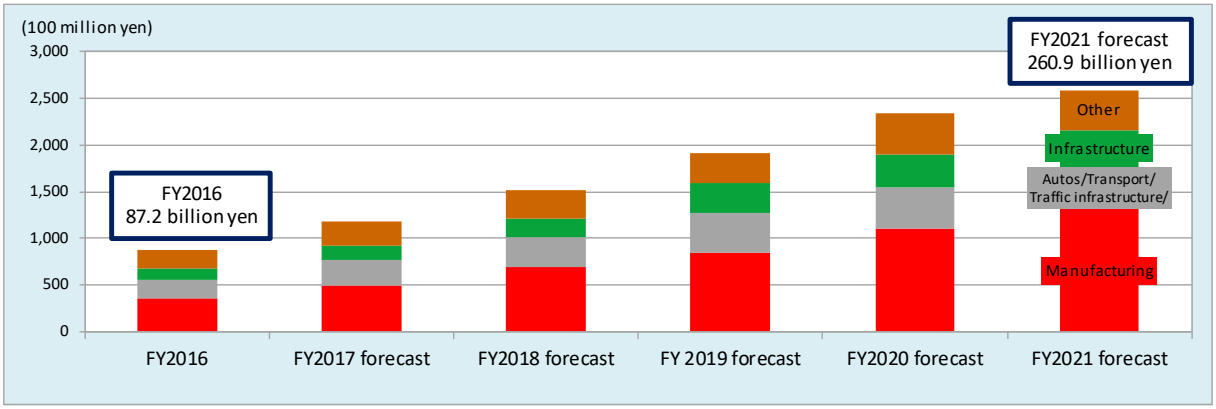
Player	Corporate initiatives and related equipment, related software
Mitsubishi Electric	It has developed the **"e-F@ctory"** system for linking its own devices and equipment by IoT and analyzing and utilizing data with a view to realizing overall optimization. This has also been selected as one of the "10 major advanced technologies for smart factories" by the China Association for Science and Technology. Mitsubishi Electric (China) and Mitsubishi Electric Automation (China) have formed a partnership with the Instrumentation Technology and Economy Institute (ITEI) under the direct jurisdiction of the Chinese government for the promotion of smart factory standardization. It is strengthening links with other companies both in Japan and overseas, as demonstrated by its participation in the American IIC, its underwriting of the "Edgecross[34]" IoT software platform consortium for utilizing data in edge fields and harmonizing FA and ICT in manufacturing line settings, and so on.
FANUC	It has launched operation of the **"Field System"** open platform for manufacturing which aims to utilize data in edge fields for boosting productivity and efficiency. This can be connected not only to FANUC products but also various devices regardless of generation and manufacturer. This is an open use environment in which third parties can also register as partners and conduct the development, sale and operation of applications. This has been jointly developed by seven companies, namely Cisco Systems, Rockwell Automation, Preferred Networks (Chiyoda Ward, Tokyo), and NTT Group (NTT, NTT Communications, and NTT Data), while numerous partners including app development companies and systems integrators cooperate in providing products.
YASKAWA Electric Corporation	It is developing the **"i3-Mechatronics"** solution based on utilization of edge data. This gathers and analyzes line data from core devices on production lines, such as robots, servo motors, and inverters, and utilizes it to boost productivity through predicting equipment failures, etc.
DMG MORI	It started selling network-compatible machine tools in 2013 following a merger with the major German machine tool maker Gildemeister. Simply by connecting to the **"DMG MORI Messenger"** system, it is possible to grasp the operating condition of machine tools in real time. Moreover, together with the German companies Carl-Zeiss and Duerr, ASM Pacifico Technology of Hong Kong, and German software company AG, it has established a joint venture – ADAMOS -in Germany, and this company is developing the **"ADAMOS"** system capable of using IoT to perform integrated management of machine operating data development.
Denso	As an undertaking under the "Project for Nurturing New Industries in ASEAN and Japan", it implements "Verification of training of Lean Automation System Integrators (LASI) in Connected Industries". It also deploys the lean automation it has developed in Thailand.
Yamaha Motor Co. Ltd.	Due to delays in field bus standardization and a high degree of dependence on the instruments of certain manufacturers, realization of "Connected Plants" is behind schedule. To resolve this issue, it is developing the **"Advanced Robotics Automation Platform"**, which is an integrated control robot system for efficiently realizing automated production in a short time and at low cost
Asahi Tekko (iSmart Technologies)	It has succeeded in improving work operations through creating its own system for using inexpensive general-purpose sensors to visualize plant information. Based on values sent by optical sensors and magnetic sensors, this works to optimize production processes and greatly improve operating rates. It utilizes this original know-how to assist the IoT upgrading of other companies. Also, under assistance from the Ministry of Economy, Trade and Industry, it is deploying this technology to Thailand.

[34] With six companies, namely Mitsubishi Electric, Advantech, Omron, NEC, Japan IBM, and Japan Oracle, acting as launch underwriters, this consortium was established in 2017 (Hitachi, Ltd. also later joined as an underwriter). Through creating and disseminating the "Edgecross" edge computing software platform for realizing coordination between production lines (FA systems) and value chain (IT systems), it aims to promote IoT upgrading of manufacturing settings. Through gathering data from all machines and equipment, regardless of manufacturer, in production line settings, it enables real-time diagnosis and feedback and features an open environment in which anybody can conduct app development and sales (apps can be sold on the Edgecross Marketplace website). It is envisaged that this will be used for, among other things, improving operating rates in production line settings through utilizing preventive maintenance apps, and enabling the early detection of failure signs in locations all over the world.

Player	Corporate initiatives and related equipment, related software
Toyo Business Engineering (B-EN-G)	It has developed the **"mcframe MOTION"** motion and posture analysis system that utilizes motion sensors installed in work settings to convert the motions and postures of operators into 3-dimensional data and assist in efficiently improving lines and work operations. Also, under assistance from the Ministry of Economy, Trade and Industry, it is deploying this technology to Thailand.
KMC	It has developed an IoT/M2M system geared to line settings in Japanese manufacturing companies and supplied it to numerous major manufacturers in Japan and overseas. It offers its original **"Σ (Sigma) Gunji i"** system capable of collecting shot-separate load and vibration data, etc. from mold and press processing machines, etc., and an electronic record for gathering and consolidating such manufacturing data into a cloud and conducting analysis and evaluation of manufacturing QCDP (production). Focusing on the East Asian market, it has established a subsidiary in Malaysia, and it also deploys operations in China, Vietnam, Thailand, etc.
ABEJA	This influential venture company is expected to be a driver of Connected Industries. Its main services are its original and already commercially developed **"ABEJA Platform"**, which enables any company to utilize AI technology, and **"ABEJA Insight"**, which is an industry-specific service package.
Preferred Networks	This influential venture company is expected to be a driver of Connected Industries. As an AI venture, it has built a partnership on equal footing with FANUC and Toyota Motors and is a leading player in the area of AI research. It conducts research and development from basic research to actual application in areas of both software and hardware.

- Market size:

  Numerous survey companies have compiled forecasts of the domestic IoT market and, although there are disparities in survey findings, all surveys point to a high growth rate. Especially in the field of manufacturing, it is predicted that IoT utilization will drive markets. For example, according to the survey of the domestic market for IoT-related businesses conducted by Fuji Chimera Research Institute, the market for IoT solutions in fiscal 2016 was worth 87.2 billion yen. Looking forward, it is forecast that the fields of manufacturing and infrastructure will expand and that the market will grow threefold to be worth 260.9 billion yen by fiscal 2021. In terms of separate fields, the highest growth rate is expected in manufacturing, which is forecast will come to account for approximately half of this figure.



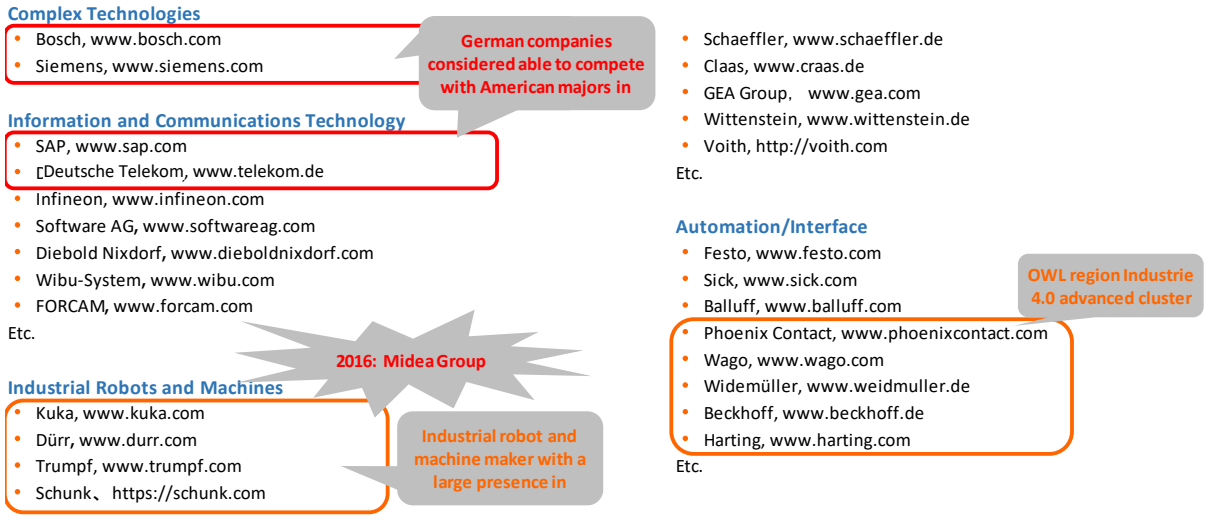
Source: From the "2017 Sensor Device/Big Data and IoT Market Survey Overview (Part 2)"

Figure-4 Domestic Market for IoT Solutions (by Industrial Field)

(2) Germany

- Market players, related equipment and software:

Compared to other advanced nations, manufacturing accounts for a high share in Germany. Since industrial robots are widely adopted mainly in the automobile industry, it is viewed as a major market for 4IR. American companies are also actively engaged in the German market[35], however, the following paragraphs primarily describe the activities of German companies. Market players are divided into four categories: information and communications technology, industrial robots and machines, automation/interfaces, and services that combine these three. In particular, Bosch and Siemens, which provide complex services, and SAP and Deutsche Telekom in the information and communications technology field, are major players thought to have the ability to compete with American majors in global IoT markets[36].



Source: From Prudentia Marketing Research Ltd. "Current Conditions in Germany surrounding Industrie4.0" (April 24, 2018)

Figure-5 Companies related to German Industry 4.0

The following table gives an outline of the major market players and each company's related equipment and software in representative 4IR fields.

35 Prudentia Marketing Research Ltd. "German Industry 4.0/I and IoT Trend Report" (May 2017)
36 Prudentia Marketing Research Ltd. "Current Conditions in Germany surrounding Industrie4.0" (April 24, 2018)

Table-6 Principal players in the 4IR market in Germany

Player	Corporate initiatives and related equipment, related software
Bosch	It has developed **Production Performance Management Protocol** (PPMP) (easy to understand machine language) and has made it an open standard, which facilitates mutual communications between machines and sensors that use different languages. This protocol makes it possible for even small and medium enterprises to conduct data communications with the production management systems of major companies. Also, it deploys **"Bosch IoT Suite"** and **"Bosch IoT Cloud"** as IoT platforms applicable to a wide range of uses.
Siemens	It launched its **"MindSphere"** industrial IoT platform service in 2016. It originally developed a PaaS (Platform as a Service) system based on the SAP IaaS environment, however, it developed this platform with a view to enabling use of various devices and software regardless of environment, and has also released an AWS version. The license fee is set at 30,000~50,000 yen per month, which is an affordable price range for mainstay SMEs[37]. Also, based on advance virtual simulation of plant construction utilizing VR and plant modules, it constructs power plants with short lead time and at low cost in ASEAN countries. It also analyzes operating data from power plants all over the world to realize predictive maintenance. It contributes to minimizing downtime and improving efficiency in plants[38].
SAP	This is the world's largest ERP (it is said that almost 90% of major companies utilize its software). It is particularly strong in assembly-type manufacturing fields such as automobiles, electronic devices, and industrial machines. It offers numerous solutions, including the manufacturing execution system (MES)[39] for linking SAP HANA with SAP Cloud Platform. Currently, SAP is said to be the only company capable of providing totally integrated solutions from the machine level to ERP[40].
Germany Telecom	It deploys solutions that utilize the **IoT communications standard NB-IoT** (a new communications standard capable of transmitting small-volume data while saving power) which utilizes mobile phone networks.
Midea Group	The Chinese domestic electrical appliance manufacturer Midea Group acquired the old German industrial robot maker KUKA (founded in 1898) in 2016. This company's industrial robot **"LBR iiwa"** can perform precise movements that until now could only be done by humans; for example, it can act as an intermediary between plant engineers and software.

- Market size:

  The Federation of Information Technology, Communications and New Media Industries (BITKOM) made an announcement concerning the market size of Industry 4.0 in a press conference held at Hannover Messe on April 24, 2017. According to this, Germany's Industry 4.0 market in 2016 was worth 4.9 billion Euros, forecast to expand to 5.9 billion Euros in 2017, and 7.2 billion Euros in 2018 (these figures include the hardware, software and IT services required for Industry 4.0)[41]. Looking forward, there is a strong possibility that annual growth in excess of 20% will continue from now on.

37 https://monoist.atmarkit.co.jp/mn/articles/1805/28/news047_3.html
38 https://www.rolandberger.com/publications/...pdf/roland_berger_hiyaku_vol12_2.pdf
39 MES (Manufacturing Execution System): This system monitors and controls the work of factory machines and workers through linking them to the various parts of factory production lines.
40 https://mono-watch.com/15079/
41 Prudentia Marketing Research Ltd. "German Industry 4.0 and IoT Trend Report" (May 2017)

(3) USA

- Market players, related equipment and software:

Major enterprises are important players in the American market, for example, the world's largest conglomerate General Electric (GE), which launched the IIC (Industrial Internet Consortium) on March 27, 2014, the IT major IBM, the network major Cisco Systems, the semiconductor major Intel, and the communications major AT&T. Moreover, participation by the platformers GAFA (Google, Apple, Facebook, Amazon) in this field cannot be ignored. Companies such as GE that have manufacturing solutions are cooperating with platformers to achieve dominance of upstream IoT platforms (moreover, they are targeting a wide range of industries limited not only to manufacturing).

The following table gives an outline of the major market players and each company's related equipment and software in representative 4IR fields.

Table-7 Principal players in the 4IR market in the USA

Player	Corporate initiatives and related equipment, related software
GE	This is the company that first coined the phrase "Industrial Internet" in 2012. In 2011, GE invested US$1 billion in establishing GE Software and developed **"Predix"** as the core basic software for the Industrial Internet. Predix is a basic system that corresponds to OS that networks machines (things), and GE Software has released numerous industrial applications with Predix as the core. It has collaborated with AWS and Microsoft to disseminate Predix. Other companies, too, are involved; for example, Pivotal, which was established through joint funding by EMC and VMware, have developed Data Lake -a database for collecting and storing huge volumes of data on Predix. Furthermore, GE has signed a strategic partnership with Softbank Telecom, and the decision has been made to handle Predix in the Softbank Group.
Cisco Systems	Converting huge quantities of data into useful information requires a lot of effort and cost, and rather than seeking a solution in a data center cloud, it is more effective to do this via a system of nearby nodes. Cisco System has named such a system "Fog computing ("fog" as opposed to "cloud"). It is deploying this via the platform of **"Cisco IOx"**, which integrates its own network OS "Cisco IOS" and "Linux OS". Rather than consolidating data through a network into one location, it is possible to efficiently convert data into appropriate information at processing nodes placed prior to the data center.
Intel	As a means of linking all machines (things) to IoT, it offers the IoT terminal platform **"Edison Module (a small hand-sized computer)"**. Equipped with an SoC (system on chip) that integrates wireless LAN/Bluetooth communications functions, etc. on an Atom processor, it can be easily acquired by anyone for a price of around 7,000 yen. In 2015, it released an even smaller button-size computer – **"Curie".** Intel has also announced that it will cooperate with Mitsubishi Electric on development of a future generation FA system, and it aims to develop a "preventive maintenance solution" based on information gathered from manufacturing equipment.
IBM	Among various solutions it provides, its basic technology is the **"IBM Watson IoT™"**, which uses IBM Cloud. Utilizing the Watson's high-level analysis and machine learning, it offers services that realize higher efficiency in production quality inspections. Also, utilizing block chains, it offers services for improving reliability and transparency in verification of business information and use of reliable ledgers that cannot be falsified.

In addition, the GAFA companies have also entered the smart factory market with the goal of collecting real data from various industries. Google has developed the manufacturing VR device **"Google Glass Enterprise Edition"**, while Amazon offers the manufacturing work efficiency improvement service **"AWS for Manufacturing".** In the field of SMEs productivity improvement, each company deploys the following services.

Table-8 4IR-related services by GAFA

Player	Corporate initiatives and related equipment, related software
Google	It deploys the corporate cloud groupware **"G Suite Business"**.
Apple	Cloud service "iCloud"
Facebook	Business SNS "Workplace"
Amazon	AWS-based corporate groupware "desknet's on Cloud"

Source: Daiwa Institute of Research "GAFA sped up advances into different fields"[42]

- Market size:

It is estimated that the Industrial Internet will create business opportunities worth up to US$2 trillion (more than 225 trillion yen) throughout the world by 2020. By 2025, it is forecast that the number of business-related assets connecting to the internet, including all kinds of devices, will be more than 45 billion, comprising 16 billion catering to consumers, 12 billion aimed at advertising, and 17 billion geared to industry.

GE thinks it can offer value to customers by analyzing huge amounts of data from network-connected machines such as trains, shipping, aircraft engines, power station turbines, and medical instruments (which are the pillars of GE business) and improving the efficiency of such machines, and it estimates that a "1% improvement in efficiency will generate profits worth US$20 billion (2.2 trillion yen) per year". Moreover, GE has announced a forecast that the future market size of the Industrial Internet will come to account for 46% of global GDP 46% (US$32 trillion)[43].

(4) China

- Market players, related equipment and software:

The feature of China is that it is simultaneously striving for development of manufacturing based on Germany's Industry 4.0 model and development of ICT industry based on the American model as typified by GAFA. In manufacturing, differences and characteristics can be seen in different fields, however, according to the report of cases by the Alliance of Industrial Internet (AII) under the Ministry of Industry and Information, 17 companies are introduced as precedents of Industrial Internet model enterprises, and 30 platforms have already been completed. As for the ICT industry, the Communist Party has designated Baidu, Alibaba, Tencent, iFlytek (voice

[42] https://www.dir.co.jp/report/research/policy-analysis/human-society/20190226_020656.pdf
[43] https://pub.nikkan.co.jp/uploads/book/pdf_file5c6fa4ce2fda1.pdf

recognition) and Sense Time (facial recognition) as the "BATIS" five majors in the national AI strategy; moreover, it is investing huge amounts of money in universities and other research agencies to support business ventures. In this way, based on a national approach entailing cooperation between industry, government and academia, China is striving to raise its advanced ICT technology base.

The following table gives an outline of the major market players and each company's related equipment and software in representative 4IR fields.

Table-9 Principal players in the 4IR market in China

Player	Corporate initiatives and related equipment, related software
Baidu	It aims to develop entirely autonomous cars, for example, in July 2017, it launched the **"Apollo Project"** – a large-scale federation for development of automatic drive cars. Rather than developing automated driving technology internally, it uses the open source method to provide its proprietary technology and tools in areas such as accurate, extensive mapping, route determination, obstruction detection, and simulation to partner companies. More than 90 companies are participating in the "Apollo Project" (as of December 2017). These mainly comprise Chinese companies, but American and German automobile and IT companies, such as Ford, NVIDIA, Microsoft, Intel and Daimler, are also involved. From Japan, Renesas Electronics and Pioneer are participating.
Alibaba	It develops Internet Plus-related applications; for example, in 2016, it announced that it would conduct solutions development related to smart manufacturing in partnership with Shenzhen City. The ultimate goal is to realize the upgrading of manufacturing in Shenzhen City. It also possesses a similar smart manufacturing center in Beijing and is thus contributing to the sophistication of China's manufacturing sector. It has also announced establishment of open data centers in Indonesia and India and has an eye on deploying smart manufacturing solutions throughout Asia.
iFlytek	Originating out of the prestigious University of Science and Technology of China, this venture company is attracting attention in the field of AI. It is a software company specializing in voice technology and AI technology and is mainly engaged in developing voice message software, chip products, information services, communications equipment etc. based on voice recognition and voice synthesis technologies, etc. Among its achievements, it has achieved voice recognition and automatic translation accuracy of 97%, and it has a 70% share of the Chinese market in voice-based technology.
Huawei	This major player has 180,000 employees and conducts business in more than 170 countries. Huawei Enterprises, which is in charge of the corporate IT solutions business, deploys IoT platforms and places emphasis on Industry 4.0 solutions. It is also a core member of America's Industrial Internet Consortium, while in Europe, it cooperates with SAP and has become an important presence.
Midea Group (Midea Group)	This manufacturer of large household electrical appliances conducts business activities in more than 200 countries and has the world's second largest share in terms of sales volume (2016). It acquired the German company KUKA, which is a leading player in promotion of Germany's Industry 4.0 (KUKA is the world's fourth biggest manufacturer of industrial robots[44]), through TOB (94.55% of shares). Also, it has acquired the Israeli company Servotronix Motion Control (hereafter, Servotronix) (50% of shares), which manufactures control devices such as encoders and servo drives. It has also concluded a tie-up with the Japanese company YASKAWA Electric Corporation in the fields of industrial robots and service robots. In the same year, it purchased the household electrical appliance division of Toshiba. Based on its production technology and KUKA's robot production knowhow, it is expected to promote Industry 4.0 from now on. Through such activities, it is capturing the control technology business targeting assembly of robots and electrical appliances, semiconductors, machine tools and so on.

[44] In addition to KUKA, FANUC (Japan), YASKAWA Electric Corporation (Japan), and ABB (Switzerland)

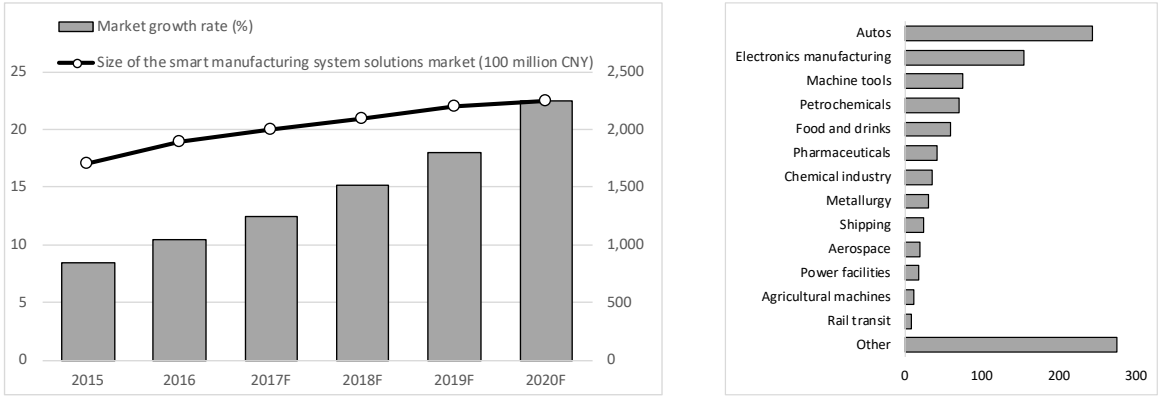
Player	Corporate initiatives and related equipment, related software
Haier	This manufacturer of large household electrical appliances conducts business activities in more than 100 countries, and has the world's largest share in terms of sales volume (2016). It has expanded through major acquisitions such as the household electrical appliances division of SANYO Electric, GE Appliance Inc. and so on (at this time, it signed a strategy concerning Industrial Internet with GE). In recent years, based on the concept of "**Transparent Factory"**, it has advanced development of internet-connected factories and already achieved operations responding to customized production in numerous facilities. **"COSMOPlat"**, which is its large-scale order-made production model primarily intended for users, is introduced by the government as a particularly sophisticated case. Demand, orders, production, and supply are conducted in real time, with all processes being visualized and seamlessly implemented. (Using the company's **"U+ Smart Living"** app, users can directly convey their preferred colors, styles, etc. to the manufacturing division and have personalized products made for them).
CATL (Contemporary Amperex Technology)	This battery company, which has its headquarters in Ningde city, has the top share in the world together with BYD. As a supplier for BMW it has built an R&D center in Germany. In addition to local OEM, it aims to advance into Europe while, looking further ahead to the future, it intends to build a model whereby the mother plant in China manages production hubs in various countries. It has already introduced automated production lines and systems utilizing CPS.
Baosteel	This steelmaker has announced a business tie-up with Siemens.
CiXing	Based in Ningbo City, this company drives China's development of automated lines. It is a global presence regarding automation of textiles and shoes manufacturing and is also devoting attention to production automation and visual sensing development in fields of large household electrical appliances, etc. It has announced that it will aim for the development of robots and automated equipment for responding to the unique needs of China.
INESA	This state-owned major provides smart city solutions. In partnership with Fujitsu, it has launched the **"Smart manufacturing project"**. Ever since the Chinese government announced its "China Manufacturing 2025" strategy, INESA has actively conducted joint research into establishment of smart factories utilizing IoT, big data and other information communications technology. In March 2018, it established a joint-stock company in partnership with Fujitsu's local corporation (Fujitsu (China)).
Sany	This company has been involved in the Industrial Internet since 2008 and has developed **"iRootech technology"** as an open industrial IoT platform. This connects to more than 3 million devices in various industries, including energy, textiles, automobiles, agriculture, machinery, etc.
Shenyang Machine Tools	A core company in the field of machine tools, Shenyang Machine Tools has developed **"i5 system"**, which links machines with humans. This platform, which shares from machines to factories, and from factories to intelligent manufacturing, makes it possible to conduct manufacturing without being fettered by time or space limitations.
Black Lake	Based in Shanghai, this company sells software-as-a-service (SaaS) applications since 2016, such as manufacturing data analysis tools. Its cloud-based Manufacturing Execution System (MES) can be installed in two months without having to purchase new production lines or conduct upgrading. It also says that it can reduce the production cycle and penalty rate by 35% in average. Its clients include the state-owned China Resources Group, global beer manufacturer Anheuser-Busch InBev, MacDonald's and so on.
SW	This German company is an industrial machine maker and provider of metal processing solutions. It has constructed a new plant in the Chinese city of Suzhou, where the manufacturing sector is growing. Against the backdrop of the partnership between Industry 4.0 and China Manufacturing 2025, SW will introduce outstanding production technologies to Chinese industries and build even more advanced manufacturing ecosystems together with local partners from now on.

- Market size:

  According to the National Bureau of Statistics, the share of high-tech manufacturing industrial added value production in the whole industry has increased from 11.8% in 2015, to 12.4%

(2016), 12.7% (2017), and 13.0% (July 2018), demonstrating that the upgrading of manufacturing is steadily progressing.

Moreover, according to a thinktank attached to the Ministry of Industry and Information, it is forecast that the Industrial Internet-related market in China will impart GDP worth at least US$3 trillion over the next 20 years, thereby becoming a driving force behind the upgrading of manufacturing and sustainable economic growth.



Source: Institute of Developing Economies: "IDE Square – Exploring Public-Private Exchanges in Sino -Japanese Smart Manufacturing Fields"

Figure-6 Size of the market for solutions for the smart manufacturing system in China

(5) India

- Market players, related equipment and software:

Unlike in China and other rising nations, India has witnessed growth of the service sector more than the manufacturing sector. A major factor behind this has been India's emergence as an exporter of IT services to the USA from the 1990s. However, due to growing disparities between urban centers and regional areas and so on, the Modi administration has announced the "Make in India" policy which proposes to also strive for economic growth through development of manufacturing from the viewpoint of creating employment opportunities and sharing the fruits of economic growth for low-income classes. Based on this background, a major pillar of this policy is attraction of overseas manufacturing by investment promotion, and it aims to link this to the upgrading of manufacturing based on synergistic effects through encouraging collaboration by the domestic ICT industry. In response to this policy, business tie-ups between major Indian IT companies and German and American companies are conspicuous. For example, global IT companies, such as Google and Microsoft, attracted by Indian technology, are establishing IoT-related research institutes and venture companies and nurturing startups in the country. Indian IT companies, such as Wipro and HCL, have established laboratories specialized in IoT, and are looking to the IoT market not only in India but globally. In addition, since many of the rapidly increasing startups in India are tech startups, they are providing fertile soil for the advance of IoT-related innovation.

The following table gives an outline of the major market players and their related equipment and software in representative 4IR fields.

Table-10 Principal players in the 4IR market in India

Player	Corporate initiatives and related equipment, related software
Infosys	This IT services company was founded in Pune in 1981 and employs 200,000 people around the world. It also participates in the American IIC, playing a core role in developing test beds and so on. In 2016, it signed a partnership with KUKA of Germany aiming for joint development of Industry 4.0-compatible solutions.
Tata Consultancy Services	This IT services and consulting company is a member of the Tata Group. It is based in Mumbai and has business centers in 40 countries around the world. Through developing applications by utilizing platforms of major European and American Industry 4.0 companies, it is boosting its global presence. Specifically, in collaboration with GE, it jointly develops applications for use on GE's IoT platform Predix, and these are actually used for improving efficiency and quality in GE's gas turbine manufacturing plants. It also conducts similar activities with Siemens, and the two companies have announced a tie-up geared to the development of solutions utilizing Siemens' cloud-based IoT platform MindSphere.
Reliance Industries	This conglomerate was founded in 1966. It has signed a partnership relating to Industry 4.0 with GE with a view to jointly developing Industrial IoT applications for use on GE's IoT platform Predix and providing these to the petroleum, gas, fertilizer, electric power, healthcare, Telecom sectors, etc.
HCL	Together with Infosys and Tata, this major IT company is a representative ESO (Engineering Service Outsourcer). Based on a strategic partnership with Siemens in the Industry 4.0 solutions field, the global IT services company HCL Technologies (HCL) has developed applications, solutions and systems connecting to Siemens MindSphere, and both companies are cooperating on a strategy to open up the global market.
Tech Mahindra	As a leading IoT technology services company, Tech Mahindra is boosting its presence through combining products with ICT. Based on broad understanding of communications technology centered on connected devices and focusing on Industry 4.0, Tech Mahindra is a leading solutions provider counting some of the top global players in the IoT field among its clients.
INDO-MIM	Based in Bengal, the capital city of Southern Karnataka State, this local maker manufactures precision metal components through the metal injection molding (MIM) method. Since 2016, it has introduced the "Industry 4.0" concept for promoting factory smartification and succeeded in boosting production efficiency and shortening work times. Looking forward, it aims to expand sales of its proprietary IoT systems.
HMT	In April 2015, it concluded an MoU with Enit GmbH of Germany and announced that it would deploy business in the field of total engineering solutions. It has also concluded an MoU for manufacture of CNC control devices, systems and drives with the Swiss company Num Controls, and an MoU for manufacture in India of shear spinning machines with FT Machine Tools of Germany.
GE	It has announced that it will invest US$200 million for construction of a multi-modal factory in Pune. Utilizing shared infrastructure, lines, 3D printers, inspection machines, etc. and human resources, it aims to manufacture product groups for diverse sectors such as aviation, railways, electric power and oil. The company intends to promptly conduct procurement and launch lines according to business conditions and demand, and share information and make decisions in real time by connecting devices to the internet. It is planning to invest an additional US$120 million into the plant. Similarly, it has announced plans to invest US$450 million for construction of a new factory in the State of Maharashtra.

Player	Corporate initiatives and related equipment, related software
Bosch	It has announced plans to introduce smart manufacturing to all 14 of its manufacturing bases in India at a cost of 6.5 billion rupees (approximately 11 billion yen). In partnership with Tech Mahindra of India and Cisco of the USA, it is promoting the networking of industrial tools as a member of the Industrial Internet Consortium. The largest Bosch research and development centers outside of Germany has been constructed in Bangalore and Coimbatore in the south of India, and it employees approximately 15,000 workers. One of the fields that the center is focusing on is solutions for Connected Industries. For example, it has developed software for networking all machines in a plant and conducting real-time data collection and analysis, making it possible not only to monitor manufacturing conditions but also provide rapid solutions to materials shortages, machine troubles and so on. The company is also putting effort into big data analysis and has developed a software model for analyzing the big data that is collected from manufacturing processes.
Toshiba Digital Solutions	Having agreed to cooperate with Tech Mahindra Limited (head offices: Mumbai, India) in the field of smart factories, it has commenced activities aimed at providing smart factory solutions. With Toshiba Digital Solutions being an ICT company with a background in manufacturing, together with Tech Mahindra, these two companies are utilizing their respective group know-how and experiences to advance the smart factory solutions business. Based on the Toshiba IoT architecture **"SPINEX™"**, it is deploying the future generation manufacturing solution **"MeisterSeries™",** which brings together production technology and related knowhow that have been nurtured in the Toshiba group. The "**MeisterSeries"** is a system for collecting and accumulating IoT data and realizing its efficient and effective utilization in manufacturing, not only improving quality and productivity in manufacturing processes but also assisting the overall business lifecycle.

- Market size:

  The following goals are raised under "Make in India": ① increase the annual growth rate of manufacturing in the medium-to long-term to 12~14%, and ② extend the share of manufacturing within gross domestic production (GDP) to 25% by 2022 (it is currently 16%). Moreover, under Digital India, which was announced in 2015 as an initiative for promoting digitalization in various fields, India aims to promote an IoT industry that is worth US$15 billion by 2020. Concerning the AI market, this has the potential to grow to US$957 billion by 2035 (not only limited to manufacturing). Moreover, according to India Brand Equity Fund (IBEF: a trust fund established by the Indian Ministry of Commerce and Industry), it is forecast that the domestic IoT market will grow at a rate of 28% per year in average between 2015~2020 and that the Indian market will come to account for approximately 20% of the global IoT market over the coming five years (not only limited to manufacturing).

3. Results of Document and Interview Research in Target Countries of Field Survey

3.1 Situation regarding new technology initiatives by governments, etc.

Information on initiatives by governments and others in the five target countries of field survey are summarized here from the following viewpoints: ① Core 4IR policies, ② Related policies, preferential measures, etc., ③ Basic industrial promotion policies, ④ Situation regarding 4IR initiatives, and ⑤ Issues. In terms of general findings, as is shown in the following quick reference table, the five countries are broadly divided into three categories. First, there is Myanmar, where the manufacturing sector is still in the midst of development; second, there are Vietnam and Indonesia, where

manufacturing sector has achieved a certain degree of development but 4IR initiatives are feeble; and third, there are Thailand and Malaysia, where manufacturing sector has developed and concrete preparations are being made for 4IR. However, even in the third-stage countries of Thailand and Malaysia, there are numerous issues, regarding change in awareness of SMEs, human resources development (SMEs side and SIers side), communications infrastructure, cyber security, rectification of regional disparities and so on. Also, to realize 4IR in the true sense, cross-factory and transnational communications are essential, and for such communications to happen, it is necessary to have regulations on communications infrastructure including 5G, communications specifications, cyber security and data handling. However, in all countries, no concrete progress is being made regarding 4IR-related cyber security and data handling laws and regulations; hence, it is thought that 4IR in the true sense will not be realized until far into the future.

Table-11 Quick Reference Table of Local Survey Findings concerning 4IR

		Myanmar	Vietnam	Indonesia	Thailand	Malaysia
Government 4IR promotion measures		Not yet addressed	Measures planned	Inadequate response	Adequate response	Good response
Japanese companies	4IR measures in manufacturing	Still no manufacturing industry on a scale that requires measures	Not yet addressed	Minority response	Minority response	Minority response
	4IR measures in SIer	None Securing of IT human resources	None Mainly offshore	4IR products Start of sales	Numerous field tests	Linkage with government
Local companies	Manufacturing	Not yet addressed	Large companies only	ERP only	Very few	Very few
	SIer	ERP only	ERP centered	ERP only	Now being developed	Needs improvement
Human resources	Manufacturing	Unskilled labor	Influx of foreign nationals	High labor costs	Influx of foreign nationals	Influx of foreign nationals
	ICT	Supplied overseas	Many in numbers but not enough skilled people	Insufficient leading to high personnel costs	Overwhelming shortage	Lack of domestic engineers

Table-12 Government Measures to Address 4IR in Each Country (Summary)

	Myanmar	Vietnam	Indonesia	Thailand	Malaysia
Name of 4IR policy	None	None	Making Indonesia 4.0	Thailand 4.0	Industry 4WRD
Responsible government agencies	Ministry of Industry	Ministry of Planning and Investment	Ministry of Industry	Ministry of Industry	Ministry of International Trade and Industry
Supporting ministry/ agency	Ministry of Transport and Communications	Ministry of Industry and Trade Ministry of Information and Communications Ministry of Science and Technology	Ministry of Communication and Information Technology	Ministry of Science and Technology Ministry of Digital Economy and Society	Ministry of Information, Multimedia and Education Ministry of Human Resources Ministry of Finance **Ministry** of Energy, Science, Technology, Environment & Climate Change
Basic industrial promotion policies	Securing, creation and expansion of labor-intensive employment (measures to address ethnic minorities) / attraction of foreign investment	Support for SMEs / Support for innovation	Support for SMEs/ Promotion of exports/ Improvement of the local procurement rate	Support for SMEs /EEC/ Investment in robots and automation	Support for SMEs/ High-tech industries / Advanced technology
Subsidies and preferential measures	None	Some	Under examination	Multiple subsidies and measures	Multiple subsidies and measures

Conditions in each country are briefly described in the following sections.

(1) Indonesia

- Central 4IR policies/principles:

  Making Indonesia 4.0: Through this, Indonesia aims to become one of the top 10 economies in the world by 2030. Not a plan for introducing IoT and AI to manufacturing, it is better described as preparations for enabling Indonesia to enter the digital industry age by 2030. There were originally five priority fields: ① foods and beverages, ② textiles and apparel, ③ automobiles, ④ chemicals, and ⑤ electric appliances, but later ⑥ pharmacy and ⑦ medical devices are added to become 5 plus 2. In addition, the following ten items have been identified as national priorities for the 4IR.

  ① Reform material flow (increasing the domestic production rate of industrial raw materials)
  ② Redesigning industrial zones (creating a unified industrial area roadmap at the national level)
  ③ Embrace sustainability (follow global trends)
  ④ Empower SMEs (improve e-commerce and technology for SMEs)
  ⑤ Build nationwide digital infrastructure (e.g. 4G/5G networks)
  ⑥ Attract foreign investments (attracting top-level global manufacturing companies)
  ⑦ Upgrade human capital (redesign education curriculum, create talent mobility program)
  ⑧ Establish innovation ecosystem (enhance R&D centers in industry, academia, and government)
  ⑨ Incentive technology investment (tax exemption, subsidies, etc.)
  ⑩ Reoptimize regulations and policies (consistent policies across ministries)

- Related policies, preferential measures, etc.:

  Medium-Term National Development Plan (RPJMN) 2015-2019, Indonesia Broadband Plan (IBP) 2014-2019, E-Commerce Road Map (EC Road Map), National Payment Gateway (NPG), Palapa Ring Project, etc.

- Basic industrial promotion policies:

  It is focusing efforts on “support for SMEs, promotion of exports, and improvement of the local procurement rate”. The government implements promotion policies, however, it is basically encouraging development based on private sector initiative (there is hardly any cooperation between ministries and government agencies). After the new administration came to power in 2015, since personnel expenses have increased dramatically at an annual rate of 8% on average and wages are expected to double over the next 10 years, it is deemed necessary to move away from conventional labor-intensive industries towards industries that pursue added value. Indonesia’s manufacturing has experienced rapid development over the past half-century in

differing sectors from textiles, electric machines, motorcycles, to automobiles, however, technology transfer has failed to keep up with the furious pace of development. Compared to other ASEAN countries, supporting industries in Indonesia have failed to develop sufficiently in terms of both quantity and quality, so the bolstering of such supporting industries will be key to future development.

➢ Policy planning and implementation:

Indonesia formulated "Making Indonesia 4.0" with assistance from A.T. Kearney (USA), Schneider (Germany), etc. It has compiled the company Readiness Index (INDI 4.0) with support from Singapore, recognizing companies that score highly on the Index, and the Ministry of Communication and Information Technology is currently implementing the "Digital Talent Scholarship" related to human resources development (see 3.4 for details). In addition, it introduced support for participation of SMEs in the online market (E-commerce) and constructed PIDI 4.0 (a 10-story building for showcasing cutting-edge technologies and equipped with training equipment, co-working spaces and so on).

➢ Availability of subsidies:

There are no salient initiatives.

- Issues:

・ Although the government has announced Making Indonesia 4.0, it is encouraging private sector initiative but does not offer many concrete measures.

(2) Malaysia

- Central 4IR policies/ principles:

It announced Industry 4WRD in October 2018. The supervisory office for this is the Ministry of International Trade and Industry. This is the blueprint for 4IR up to 2025, aiming to raise the base for manufacturing, construct infrastructure, and elevate Malaysia's ranking in the world. It analyzes current conditions and clarifies the country's core policies and division of roles of ministries and related government agencies. It states target values, however, fails to give clear details regarding action plans. Priority fields are as follows: electrical and electronic sector (electronic components, CE, industrial electronics, electric products), machine apparatus (special machines for specific industries, general machines and components, power generating machinery, machine tools), chemicals (petrochemical products, plastic products, rubber products, chemical products, oleochemical products), medical devices (expendables, surgical tools, medical tools, implants, healthcare products), aerospace (design, engineering, aircraft manufacturing, system integration, repair, maintenance and operation), and other fields (automobiles, transportation, textiles, pharmaceuticals, metals, food processing, and services).

- Related policies, preferential measures, etc.:

  The 11th Malaysia Plan and so on. In this plan, 4IR is regarded as an industrial field with high latent potential for promoting the national development of Malaysia. In the subsequent 12th plan, one of the measures is to strengthen vocational training (TVET), as the presence of skilled engineers will be important in the application of Industry 4.0.

- Basic industrial promotion policies:

  It is focusing efforts on "support for SMEs, high-tech industry, and cutting-edge technologies". Since the government wants to reduce the number of foreign workers, even Japanese companies are needing to conduct mechanization and automation.

  ➢ Policy planning and implementation:

  Industry 4WRD has already been formulated (it appears that the German Chamber of Commerce and Industry was largely involved). Various working groups are established and active according to Industry 4WRD, and related government agencies and industrial groups are busy educating SMEs all over the country.

  Moreover, receiving cooperation from a consortium of five European and American companies, i.e. (BOSCH (Germany), Deloitte (USA), Digital McKinsey (USA), Roland Berger (Germany), and Rainmaking (Denmark), it has prepared a Readiness Assessment indicator and the MPC has implemented a Readiness Assessment pilot (49 companies). Currently, based on the results obtained in the pilot, a Readiness Assessment targeting 500 SMEs is being implemented. In terms of the relationship with Japan, the Japan-Malaysia Cooperation Platform, which is intended to introduce solutions by Japanese enterprises to Malaysian SMEs with a view to building a platform for realizing smart manufacturing, was launched in May 2019 based on cooperation between JETRO, the Malaysia-Japan Chamber of Commerce and Industry, and the Japanese Embassy. This entails staging seminars for introducing initiatives in Japan and the need to improve productivity, and conducting matching with local enterprises. Participants on the Malaysian side are SIRIM, MITI, and the Malaysia Investment Development Authority (MIDA).

  ➢ Availability of subsidies:

  There are systems whereby MIDA and MTDC provide various types of subsidies and, combined with the abovementioned Readiness Assessment, the activities of SMEs are encouraged.

- Issues:

  ・ Issues are recognized from diverse perspectives, for example, the change in awareness of SMEs, human resources development (SME side, SIer side, government employees),

sharing of common awareness and cooperation among ministries, related agencies and companies, human resources and institutional matters, strengthening of cyber security, and bolstering of communications infrastructure.

- Moreover, because disparities exist between urban centers and regional areas in all aspects of awareness of SMEs, human resources, and communications infrastructure, the rectification of regional disparities is another major issue.

(3) Myanmar

- Central 4IR policies/principles:

  None: The Ministry of Industry is the supervisory agency, but it currently has no concrete 4IR policies. At a 4IR-related event held in May 2019, the Minister of Industry presented a vision for addressing 4IR. However, this vision, which was compiled by Roland Berger of Germany, only described the situation of 4IR in political circles and its current position in Myanmar, without indicating any specific future policies at all.

- Related policies, preferential measures, etc.:

  The "Digital Economy Development Committee" (DEDC), which was established in July 2017, is advancing formulation of a master plan for promotion of the digital economy,[45] and some are already created. There is also a document compiled jointly with UNIDO on strategies and directions for industrial promotion.[46]

- Basic industrial promotion policies:

  It is focusing efforts on "labor-intensive employment securement and creation and expansion (measures to address ethnic minorities) and attraction of foreign investment". However, no industries have as yet been targeted.

  ➢ Policy planning and implementation:

  It has established the Digital Economy Development Committee and announced a vision for responding to 4IR (this only confirms the current position in Myanmar). It receives assistance from Roland Berger (Germany), however, this has not yet resulted in any clear initiatives (only implementation of a seminar and so on).

  ➢ Availability of subsidies:

  There are no salient initiatives.

[45] https://www.mmtimes.com/news/myanmar-drafts-digital-economy-master-plan.html
[46] https://www.unido.org/sites/default/files/2017-06/_F_MYANMAR_SD_2017_0.pdf

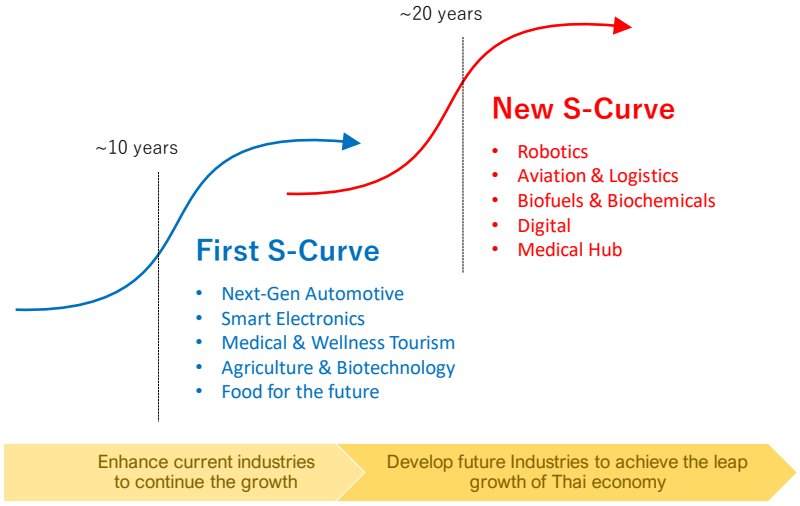
- Issues:

  Since manufacturing is still developing and the most important issue facing the country concerns securement, creation and expansion of labor-intensive employment to address ethnic minorities, Myanmar is not very positive about 4IR because it fears it will lead to the loss of jobs.

(4) Thailand

- Central 4IR policies/principles:

  Thailand 4.0 was announced in 2015.The supervisory agency is the Ministry of Industry. This is a wide-ranging and long-term strategy that targets various fields in addition to manufacturing. It aims to extricate Thailand from the trap of semi-developed countries through realizing the upgrading of industry based on development of the digital economy and nurturing of competitive fields offering high added value. There are 10 priority fields: ① next generation automobiles, ② smart electronics, ③ medical and wellness tourism, ④ agriculture and biotechnology, ⑤ food processing (advanced foods), ⑥ robotics, ⑦ medical care hubs, ⑧ aviation and logistics, ⑨ biofuels and bio chemicals, and ⑩ digital, divided into 2 staged development model consisting of the 1st S-Curve and the New S-Curve according to the level of industry advancement.



Source: Combined information from Thai Board of Investment, OECD CFE, etc.

Figure-7 Priority fields of Thailand 4.0 and the two S-Curve development model

- Related policies, preferential measures, etc.:

  It is focusing efforts on development of the East Economic Corridor (EEC) with a view to realizing Thailand 4.0. It has constructed “Digital Park Thailand” -an industrial estate for high-tech IT companies – in Sri Racha in Chonburi Province. Also, it is encouraging eight digital clusters, promoting digital human resources development through the training of startup entrepreneurs and provision of settings for interaction between digital nomads and experts, etc. In this way, it is advancing plans to grow through vitalizing digital-related trade primarily in

ASEAN. As the policy of the BOI, it intends to include Fintech and electronic money among investment targets and appears to be aiming to attract a broad range of digital-related activities limited not only to digital clusters.

Thailand launched the "Digital Economy" development plan, which aims to promote the upgrading of communications infrastructure, in 2014 prior to Thailand 4.0. Following establishment of the "National Digital Economy Committee" chaired by the prime minister, it has constructed infrastructure in the areas of hardware, software and services, encouraged development of the digital economy and accelerated realization of the digital society. Also, it has signed MoU with the Shenzhen municipal government in Guangdong Province, China and the Government of Japan's Ministry of Internal Affairs and Communications in an effort to develop the digital economy.

- Basic industrial promotion policies:

  It is focusing efforts on "support for SMEs/EEC (digital, innovation) and investment in robots and automation". Thailand is currently striving to launch Thailand 4.0 with a view to escaping from the trap of semi-developed countries and propelling itself into the next phase of growth. Three eastern provinces (Rayong, Chonburi, and Chachoengsao) have been designated as Eastern Economic Corridors (EECs), and the policy is to promote the accumulation and development of advanced industries. Typical examples are the establishment of ARI Polis, which deals with AI, and a university related to robotics in EECi, a special innovation zone in Rayong Province, and the establishment of various digital technology demonstration sites in EECd, a digital park in Chonburi Province.

  ➢ Policy planning and implementation:

  Numerous initiatives are being implemented by related agencies as described below.

  - Ministry of Industry: Implementation of the 3 Stages Rocket Approach (support by Japan's Ministry of Economy, Trade and Industry), construction of a mentor system by major companies, operation of a business matching platform between domestic SMEs and overseas companies. In future, it is possible that LASI will be deployed in regions too.
  - FTPI: Implementation of a Readiness Assessment with support from the Fraunhofer Society (Germany) and FTPI's own Readiness Assessment, implementation of PoC in cooperation with NEC, implementation of PoC using inexpensive IoT solutions made in South Korea.

- DEPA: Provision of various subsidies and awareness promotion activities, etc. Established Thailand Digital Valley[47] in the EEC (Laem Chabang Industrial Area) to conduct research and incubation on cutting-edge technologies such as AI, IoT, and Fintech.
- NIA: Implementation of disseminating LASI to universities and nurturing of SIer based on cooperation between industry, government and academia, etc.
- TGI: Implementation of awareness promotion activities and provision of training for SMEs, etc.

➢ Availability of subsidies:

DEPA, NIA, NSTDA, etc. offer subsidy schemes mainly intended for SMEs, while the Ministry of Industry offers low-interest loans.

- Issues:
  - Awareness raising of SMEs, human resources development (SMEs side, SIer side), communications infrastructure, cyber security.
  - Various ministries and related government agencies are conducting vigorous activities, and differing government agencies offer similar subsidy schemes, however, these are not properly differentiated and cooperation between ministries and agencies is loose.
  - The following needs have been voiced regarding assistance by JICA : human resources development (SME side, SIer side, production technology engineers, data scientists), creation of industry-separate 4IR guidelines, expansion of SME businesses, financial cooperation (4IR subsidies) and so on.

(5) Vietnam

- Central 4IR policies/principles:

None: As of the first visiting survey, the government planned to announce its strategy during 2019. No policy name has yet been given, however, the ministry with jurisdiction is the Ministry of Planning and Investment (currently formulating the strategy). As related offices, the Ministry of Industry and Trade, Ministry of Information and Communications, Ministry of Science and Technology, etc. are involved with promoting policies and so on. Priority fields are: ① ICT high-level human resources development, ② promotion of investment, ③ e-government, ④ support for startups, and ⑤ 4IR-related education. The concrete particulars have not yet been announced, however, it is planned to include the following measures in the strategy: ① policies and regulations for

[47] https://www.depa.or.th/en/thailand-digital-valley

facilitating introduction of innovation and technology, ② communications infrastructure, ③ improvement of government services through utilization of e-government and technology, and ④ support for innovation.

Subsequently, the "Resolution on Actively Participating in Industry 4.0" (Resolution No. 52, 2019), Guidelines and Policies to Actively Participate in the Fourth Industrial Revolution, and the "Prime Minister's Decision on the National Strategy for Industry 4.0 towards 2030" (Decision No. 2289/QD-TTg, 2020, dated December 31, 2020) were released in turn.

- Related policies, preferential measures, etc.:

  On May 4, 2017, the government issued Prime Minister's Directive No. 16/CT-TTg related to strengthening of capacity for accessing the 4th industrial revolution. This includes numerous policies related to Industry 4.0: specifically, a scheme for digitalization of the Ministry of Information and Communications, a program for technological innovation of the Ministry of Science and Technology and so on.

  Moreover, the master plan for state-led promotion of IT and realization of an information and communications technology superpower is being forcefully advanced. The national strategy on "Transforming Vietnam into an advanced ICT country" was decided in 2010. Major pillars of industrial policy are "nurturing of the IT industry" and "strengthening of the IT environment", and the goal is to raise the GDP share of the information and communications industry to 8~10% by 2020. To realize "industrialization and sustainable economic growth by 2020", the government is focusing efforts on "developing global human resources" and "developing science and technology" to the global standard. Moreover, it has formulated a national administration digitalization plan and is advancing measures for construction of e-government.

- Basic industrial promotion policies:

  It is focusing efforts on "support for SMEs, and support for innovation". In its 10-year Strategy for Social and Economic Development (2011~2020), Vietnam earmarks "three breakthroughs", i.e. establishment of a society-oriented market economy system, development of human resources, construction of infrastructure, and it aims to become a modern industrial nation by 2020. It is thought that Vietnam's industrialization strategy aims to break away from the conventional model of economic growth, which saw the country develop as an unskilled processing and assembly base reliant on cheap labor, to a growth model that entails producing and exporting products with high added value. For that purpose, much emphasis is placed on linkage between industries in the upstream (raw materials), midstream (components) and downstream (final products) of the manufacturing process.

  Moreover, components industries in Vietnam are fragile and, even if major companies build product assembly plants in Vietnam, which offers inexpensive personnel expenses, cost merits are

lost if they cannot locally procure components and need to rely on imports. Accordingly, to increase the domestic procurement rate, it will be essential for the parts processing industry to develop from now on.

Apart from manufacturing, the government is committed to strengthening the IT industry and it aims to dramatically expand the IT industry market size. Accordingly, its policies are directed towards upgrading industry based on utilization of IT (it is advancing the "national software park construction project" and offers preferential measures such as exemption of taxes for four years to IT companies).

➢ Policy planning and implementation:

In June 2020, the Prime Minister announced the basic policy, "National Digital Transformation Program until 2025 including the direction until 2030"[48]. In addition, the Ministry of Planning and Investment, in cooperation with USAID, launched the "Supporting Enterprises' Digital Transformation from 2021 to 2025" program within the SME Support Project[49]. In addition, a company Readiness Assessment has been implemented with support from the UNDP.

➢ Availability of subsidies:

As was mentioned above, preferential measures are offered to IT companies, however, there are no measures that are specifically intended for 4IR operations.

- Issues:
  - Issues concerning the promotion of policies are avoiding loss of employment and recognition of the importance of human resources development.
  - The national strategy concerning Industry 4.0 that was drafted by the Ministry of Planning and Investment leans towards support for innovation in the areas of e-government, Fintech, mobile services, etc., however, not much mention is made regarding the upgrading of manufacturing (and the Ministry of industry and Trade, which is in charge of this area), indicating that there are major differences in awareness of Industry 4.0 between ministries and agencies.

[48] https://english.luatvietnam.vn/decision-no-749-qd-ttg-on-approving-the-national-digital-transformation-program-until-2025-with-a-vision-184241-Doc1.html

[49] https://www.usaid.gov/vietnam/program-updates/dec-2020-usaid-helps-vietnamese-small-and-medium-enterprises-smes-digital

3.2 Market Trends concerning New Technologies of IoT, AI, etc.

Information on market trends concerning new technologies in the five targeted countries of field survey is organized from the viewpoints of ① market players, related equipment and software, and ② market size.

(1) Indonesia

- Market players, related equipment and software:
  - There is a feeling that Indonesian industry is around 10 years behind Thailand, and the market for new technologies such as IoT, AI, etc. in manufacturing is limited to Japanese companies, Japanese suppliers, and local major companies (see 3.3 for details).
  - Concerning Japanese SIers, NEC, NTT Data, and small and medium SIers deploy sensors, IoT solutions, production schedulers and so on, and they are now starting to see the sales.
  - The major SIer business is sale of ERP to major companies. Three types, i.e. SAP Business One, Microsoft Dynamics, and Sage ACCPAC, are mainly sold to Japanese companies. In particular, Sage ACCPAC is primarily sold to SMEs.
  - The government offers support to startups and local startups are emerging, but these are mostly concerned with e-commerce, and there are no manufacturing-related companies.
  - Looking forward, it would be possible that defective product identification systems based on AI will be sold in future. In Indonesia, since labor cost is increasing, AI solutions for creating skilled engineer clones are a promising field. Moreover, responding to the boom in RPA that started last year, there has been a large increase in operators that handle RPA. An AI seminar organized by NS Solutions attracted a lot of participants. Qunie, which is under the umbrella of NTT Data, is also intending to sell AI solutions.

Table-13 Examples of Players in Indonesia

Player	Corporate initiatives and related equipment, related software
GE	GE Indonesia's earnings increased from US$300 million in 2008 to more than US$1 billion in 2013[50]. Aviation is one of its most lucrative fields. GE's business strategy is to cooperate with Indonesian companies or other agencies (universities and so on), for example, it cooperates with the domestic airline Garuda Indonesia for servicing and maintenance of CFM 56-7B engines. It is also engaged in establishing learning centers and provides training to hundreds of employees of the state-owned companies Pertamina and Perusahaan Listrik Negara (PLN). In June 2018, GE Indonesia announced plans to sell 3D printer products on the Indonesian market from the third quarter of 2018. One of its goals is to become Indonesia's leading company in 3D printing. It already uses 3D printers to manufacture spare parts for aircraft and motorbikes. 3D printers for manufacturing applications cost at least US$1 million and are as large as a refrigerator[51].

[50] https://www.indonesia-investments.com/news/todays-headlines/general-electric-ge-eyes-the-establishment-of-a-regional-hub-in-indonesia/item2016?searchstring=General%20electric

[51] https://www.indonesia-investments.com/news/todays-headlines/ge-indonesia-to-sell-3d-printers-in-indonesia-per-q3-2018/item8837?

Player	Corporate initiatives and related equipment, related software
PT Panasonic Gobel Indonesia (PGI)	It has established a showroom with the purpose of contributing to the industrial development of Indonesia, and here it offers specific proposals geared to realizing "smart factories" through the all-round capabilities of Panasonic. It displays optical inspection systems, component mounting machines, robotic welding machines and more and sells mostly to Japanese companies. Inquiries from local companies are still rare.
SAP (agent selling by a SIer)	SAP is very strong in Indonesia. It has especially introduced a lot of services to government agencies and state-owned companies. However, since SAP's maintenance costs are extremely high, SMEs seek less expensive solutions.
PT Bahtera Hisistem Indonesia	A Japanese company, it combines NEC's production scheduler solution (Asprova and work development template Hana First (its own development) to offer small lot services over the entire supply chain in purchasing, production and shipping.

- Market size:

  No specific information on market size was available during the study period.

(2) Malaysia

- Market players, related equipment and software:

  ・ Japanese SIers participating in the Japan-Malaysia cooperation platform (just under 10 companies, including Mitsubishi Electric, Fujitsu, Hitachi, Konica Minolta, Azbil, Panasonic FA and so on) are conduct business there.

  ・ Local SIers are few in number and in insufficient level. Many companies have insufficient knowledge of factories and manufacturing line settings, etc. and are unable to prepare appropriate solutions. Hence, their credibility is not high (even in Singapore, there are few quality SIers in the Industry 4.0 field).

Table-14 Examples of Players in Malaysia

Player	Corporate initiatives and related equipment, related software
Mitsubishi Electric	It has introduced various e-factory IoT solutions (edge computing technology, etc.) of Mitsubishi Electric to the semiconductor manufacturing lines of Intel's Malaysia factory. On production lines, huge amounts of big data are obtained from sensors fitted to manufacturing machines, however, since not all data is necessary, the edge computing technology is used to extract only the necessary information for processing and analysis. Through monitoring such data, it has become possible to monitor and improve production lines in real time. Furthermore, through utilizing advanced IoT technologies such as machine vision equipped with high-accuracy cameras and AI machine learning, it has succeeded in greatly improving the accuracy of conforming/nonconforming judgment. In addition, through constantly monitoring and analyzing the condition of instruments, it has become possible to replace components before problems arise in the instruments. As a result, it has cut losses on the semiconductor manufacturing lines in its factory by up to 25% (worth 900 million yen per year).

Player	Corporate initiatives and related equipment, related software
Konica Minolta	In 2016, it industrialized its new IoT-based manufacturing solution "Digital Manufacturing". Combining its proprietary core technology and manufacturing know-how, it proposes a new model of manufacturing and deploys services for supporting the resolution of issues pertaining to productivity and work quality. It utilizes various unique technologies, such as sensing technology for measuring machines and other things on production lines, and ICT and AI digital technology for analyzing collected data and images and converting them into useful data. Furthermore, it has fused such technologies to develop wearable devices, 3D laser radars and other products, and combines these to realize effective "digital manufacturing". At its Malaysian production center, which went into full-scale operation as a place for demonstrating these technologies in 2015, it has phased in "digital manufacturing" and sells its proprietary know-how as solutions.
Sophic Automation Sdn Bhd	This local company supports the smartification and FA upgrading of mainly manufacturing factories in Penang State, Malaysia. It has adopted the Japanese wearable device "Cygnus" as the terminal for connecting to its "Resource management system", and this is used by the Malaysian factory of a major American semiconductor maker. Specifically, Cygnus is mainly used for reducing work losses and "preventing data inputting leaks" in factories (resolution of risks of alarm sounds being inadvertently extinguished in factories or failure to input troubles into PCs when they occur).
MDT Innovations Sdn Bhd	This is one of the most well-known IoT companies in Malaysia too. After it became involved in factory automation in response to an order by a heavy industrial company that had business dealings with Siemens around 2008, it started deploying businesses related to automation of manufacturing, sensors and Industry 4.0. Since this company's business model requires customers only pay for solutions according to how much they use them, this allows clients to keep initial investment down. Many solutions providers do not have knowledge of factories and line settings, however, because this company's founder was formerly head of Panasonic's display monitor division, it has extensive knowledge of factories. It also conducts business with Japanese companies, such as Hitachi, Toshiba, Mitsui and Co., Ltd. Mitsui Information, Yokogawa Electric and so on.

- Market size:

  Manufacturing accounted for 22% of GDP on average over the five years leading up to 2017. Concerning Industry4WRD, among others, the following goals have been raised for achievement by 2025: ①raise the per capita productivity of manufacturing by 30%, and ② increase the contribution of manufacturing to gross domestic production (GDP). However, information on actual market size is limited.

(3) Myanmar

- Market players, related equipment and software:

  ・ As Japanese SIers, Hitachi (IoT) and Fujitsu (AI) have established permanent laboratories in UIT. However, activities of majors and SMEs alike are concentrated on offshore development and IT human resources development, while they are not deploying 4IR solutions.

  ・ Almost all local SIers are SAP sales agents, and SAP has a monopoly of ERP (since IoT/AI solutions already exist as SAP modules, agents can provide solutions even if they don't have technical knowledge).

・ The “Industry 4.0 in Myanmar Conference in Yangon” was staged on May 24, 2019 under the auspices of the “Delegation of German Industry and Commerce in Myanmar (AHK Myanmar)”. Participants included, from the German side, Siemens Myanmar, Rieckermann Myanmar (Rieckermann is a German company that provides international industry solutions, and it provided conceptual design, etc. for the latest manufacturing lines of the factory (completed in April 2019) of the state-owned pharmaceutical company (MPIE) under the supervision of the Myanmar Ministry of Industry[52]), GEA Process Engineering Myanmar (GEA Process Engineering is a German company that provides manufacturing plants and engineering for the dairy, beverage, brewing, food, drug and chemical industries, etc.), Bosch, Schaeffler Manufacturing, etc., and, from the Myanmar side, Myanmar Belle (manufacturing and sale of agricultural and fisheries products, import and sale of automobiles, cosmetics, etc. and so on), Impact Hub Yangon, etc. However, there was no participation by local companies offering 4IR solutions.

Table-15 Examples of Players in Myanmar

Player	Corporate initiatives and related equipment, related software
Myanmar Information Technology Pte. Ltd.	This local major SIer R&D center, which has obtained an official operating license (one per country) from Microsoft, has around 400 employees, including a research and development team working on IoT and AI, however, it does not yet conduct business in these areas. It has the technical capacity to develop open source solutions and its own ERP, however, in recent years, its work as a provider of SAP and Microsoft cloud solutions accounts for a large share. It has concluded business tie-ups with Microsoft and SAP, and is working with SAP in the fields of finance, banking and so on.
ATGsys	This is a provider of IT infrastructure solutions including IoT. Unlike traditional Myanmar IT companies such as ACE, MIT and so on, this is a small but young company that stresses its strengths in cutting-edge technology. Its business pillars are threefold: system integration (SI), LAN and data center design and construction, and ERP. It has supplied an ERP-base system (SAP Leonardo) that uses a Honeywell + Cisco IoT sensor network to City Mart and has also served Coca Cola and its can manufacturing company, however, it does not have much of a record concerning work related to Industry 4.0.

● Market size:

No concrete information has been obtained at the present time.

(4) Thailand

● Market players, related equipment and software:

・ Many companies including Japanese SIers have constructed 4IR showroom-type factories in Thailand with an eye on the future.

[52] https://rieckermann.com/en/news/grand-opening-of-large-volume-parenteral-solution-production-facility-in-myanmar/

- Among Japanese SIers, Hitachi, Mitsubishi Electric, NEC etc. are deploying smart factory solutions, targeting mainly other Japanese companies and major companies belonging to conglomerates.
- Some backbone Japanese SIers and SMEs (companies started locally by Japanese nationals) also sell solutions to local SMEs. However, many of the local SMEs often consign the development and introduction of inexpensive systems to local micro SIers (in a style that individual engineers form a team to immediately respond to orders).
- Although there are multiple local SIers, they lack capability and their absolute numbers are insufficient. The government of Thailand aims to increase the number of such companies from 200 in 2018 to 1,400 in 2021.
- Major robotics companies such as ABB (Switzerland), KUKA Robotics (German company acquired by Midea Group of China), Nachi Technology (Japan) etc. are expanding their business in Thailand[53].
- Within the "Project for Nurturing New Industries in ASEAN and Japan" (second subscription), four Japanese companies are conducting field tests using respective IoT technologies in Thailand. Denso's LASI has received a lot of plaudits and is linked to that company's sales of robots.

Table-16 Project for Nurturing New Industries in ASEAN and Japan

Kojima Industries	Remote monitoring demonstration utilizing the "international EDI standard (United Nations CEFACT)" and "IoT Tool" in the supply chain. ・ By utilizing the cheap "IoT Tool (remote monitoring system)" that can be easily used by SMEs between Japan and Thailand, it has demonstrated that operating conditions of equipment introduced by Japan in Thailand can be remotely monitored without having to send Japanese staff to that country, thereby making it possible to reduce maintenance costs. ・ Furthermore, to avoid situations where troubles with product supply arise due to production equipment problems following the start of local parts supply, the remote monitoring system constructed between Japan and Thailand is constructed between local companies on the ground, and the resulting improvement in productivity over the entire supply chain is verified. ・ Moreover, inside Japan, since systems for receiving and placing orders necessary for production differ between companies and the situation is inefficient, verification is being conducted on the benefits of promoting standardization in the Thai domestic parts industry based on the international EDI standard (United Nations CEFACT).
Denso	Verification of training of lean automation system integrators (LASI) in Connected Industries ・ Through establishing a future generation automation training environment (showcase, education) which combines Connected Industries and lean automation (highly efficient production system that thoroughly eliminates waste) and training local practically skilled integrators, it aims to boost the presence of Japan's Connected Industries in Thailand, enhance competitiveness through promoting automation of Japanese and local manufacturing, expand the Japanese industrial device business and so on.

[53] https://qz.com/1442763/heres-how-thailands-manufacturing-industry-is-shaping-the-future-of-robotics-and-automation/

Toyota Tsusho Corporation	Examination of an accurate route guidance system that utilizes accurate positioning technology ・ In this demonstration, utilizing accurate positioning signals from a quasi-zenith satellite system (QZSS) and MADOCA correction data, it can collect data of automobile traffic in Bangkok in units of traffic lanes. Upon analyzing such accurate probe information, it distributes accurate route guidance to local delivery trucks. ・ Through doing so, it aims to reduce truck delivery times and increase efficiency, and thereby construct a future generation high added value supply chain in Thailand.
Hitachi High-Technologies	Demonstration of share factories (smart factories) in Thailand ・ To support overseas advanced by Japanese SMEs, this company is implementing a project to industrialize share factory services incorporating IoT and other smart factory technologies. ・ Through utilizing the manufacturing technology of the Japanese side partners and training the human resources of the Thai manufacturing partners, and conducting personnel management, introducing Hitachi High-Technologies' factory infrastructure, and cooperating in procurement, sales, peripheral services, and IoT technology development, it aims to achieve cost-competitive local manufacturing with Japanese quality.
	・ Especially in the areas of production management and quality control, it has introduced IoT cutting-edge technologies, such as the latest multi-aspect wireless cameras and sensors, high-level compressed conveyance system, two-way indications and so on. Also, by conducting remote monitoring from Japan, it aims to reduce trainer costs while at the same time achieving high quality. By the time the demonstration is completed, it is anticipated that the production efficiency and cost reduction effect resulting from system introduction will be realized, the methods for remotely analyzing issues and realizing improvement will be established, and the commercial feasibility of adopting the share factory business will be demonstrated.

Source: Prepared from various JETRO reports on the Project for Nurturing New Industries in ASEAN and Japan

Table-17 Examples of Players in Thailand

Player	Corporate initiatives and related equipment, related software
Hitachi, Ltd.	In 2018, it established the Lumada center (IoT solutions room and joint creation room) for deploying IoT solutions to Thailand and ASEAN countries. In September 2018, it staged "Hitachi Social Innovation Forum 2018 BANGKOK".
NEC	In Thailand, it has just commenced business catering to local and multinational companies. It also offers inexpensive solutions (the Colsos equipment operating monitoring service is reasonably priced) to local companies. Inquiries have been received from local companies. Moreover, under the "Monozukuri Symbiosis Program" (currently with membership comprising 837 companies (around 1,100 persons)), it is deploying initiatives from Japan to the rest of the world (China/APAC). In Thailand, it conducts factory tours and seminars. In particular, it cooperates with the Foundation of Thailand Productivity Institute (FTPI) in implementing awareness promotion activities for local SMEs. NEC Platforms Thai Co., Ltd. received the "2014 (4th) GOOD FACTORY Award", which is awarded by the Japan Management Association (JMA) to factories in Japan and Asia that have been successful in improving manufacturing productivity and quality and implementing KAIZEN activities[54]. It also accepts inspection tours of SME factories in Thailand.
Bosch	It invested 43 million Euros (1.7 billion baht) in construction of a new factory and research and development center in Thailand. Facilities were completed in 2016 and scheduled to go into operation in 2017 with production capacity of 1 million units per year. This investment is part of the company's plans to invest 80 million Euros in the ASEAN region in 2016. This project includes plans to expand production and sale centers in Indonesia, Malaysia, and the Philippines[55].

[54] https://www.necplatforms.co.jp/company/news/2014/0804.html

[55] https://www.marklines.com/ja/top500/cf/s500_070_hl2016?&sitesearchKey=%E3%82%BF%E3%82%A4+%E3%82%B7%E3%83%BC%E3%83%A1%E3%83%B3%E3%82%B9

Player	Corporate initiatives and related equipment, related software
Advantech	Advantech, a Taiwanese manufactures of mother boards and industrial computers, signed an MoU with the Federation of Thai Industries (FTI) and local leading ICT player Computer Union in May 2017 and declared its intention to invest US$6 million over three years for the promotion of Industry 4.0[56].
Huawei	To support digital reform, it has invested US$15 million in building an OpenLab in Bangkok (it has 12 OpenLabs throughout the world. In ASEAN, OpenLabs are situated in Suzhou and Singapore in addition to Bangkok).
Toyo Business Engineering	Based on the "Memorandum of Intent on Eastern Economic Corridor and Cooperation on Upgrading Industrial Structure" (June 2017) between METI Japan and MOI Thailand, on May 11, 2018, it signed an MoU for cooperation in SME promotion activities (Thailand's IoT 4.0-related), which are being advanced by the Department of Industrial Promotion (DIP) in the Thai Ministry of Industry. It is participating in the Ministry of Industry's 3 Stages Rocket Approach.
CSI Thailand	This Japanese system development company was founded by a Japanese national in Thailand approximately 30 years ago. It mainly conducts business with Japanese companies in Thailand and also some local Thai companies. It is likely to increase its Thai clientele in future. Its work contents include smartification of factory, and development and introduction of solutions based on IoT, big data, AI, etc. It has knowledge and experiences on local manufacturing line settings that it offers seminars for Thai participants on PLC together with AWS (Amazon).

- Market size:
  - According to a survey by Cisco and AT Kearney, it is possible that productivity in Thailand's manufacturing sector will increase by US$50 billion (1.6 trillion baht) through the adoption of 4IR-related technology by 2028.
  - The Ministry of Industry of Thailand aims to attract 200 billion baht (approximately 674 billion yen) of investment from automated system and robot-related companies over five years from 2017. Moreover, according to the Thai Automation and Robotics Association (TARA), less than 20% of local SMEs have introduced automation at present time, however, it forecasts that at least 50% of companies will have embarked on automation over five years from 2018.
  - According to the 2017 World Robotics Report by the International Federation of Robotics (IFR), Thailand is a growth market for industrial robots and it is forecast that robot production will increase from 2,646 units in 2016 to more than 5,000 units by 2020. Moreover, currently, Thailand is ranked 10th in the world in terms of applications of A/R technology to the manufacturing field, and 45 industrial robot systems are installed for every 10,000 workers.
  - In the East Economic Corridor development plan, combined public and private sector investment of 1.5 trillion baht (approximately 5 trillion yen) is expected for construction of an airport and high-speed roads and development of the robotics and digital technology industry, future generation automobile industry and so on. It is planned to attract and foster 10 priority industries.

[56] https://buy.advantech.eu/CMS/CmsDetail.aspx?CMSID=3c34bbc8-ac58-494f-a6cf-84e83d620b0b

(5) Vietnam

- Market players, related equipment and software:
  - Japanese SIers, both the majors and small and medium enterprises alike, are active in offshore development. They also offer IoT solutions and ERP solutions, although they mostly cater to Japanese companies.
  - Local SIers (subcontractors) offer solutions mainly to major IT and communications companies (FPT, VNPT, etc.), and disparities are growing between the major companies and SMEs.
  - Prominent local SIers with Industry 4.0 capabilities are as follows:

    FPT Information Communications (FPT Holdings), MISA, NashTech Vietnam, NOVAON, Sao Bac Dau, Viettel, VNEXT, VNG, VNPAY, and DEHA Vietnam.

Table-18 Examples of Players in Vietnam

Player	Corporate initiatives and related equipment, related software
FPT Corporation	This is one of the world's largest technology and IT services groups engaged mainly in provision of ICT-related services, with sales of approximately US$2 billion and some 32,000 employees. It provides world-class services in the areas of smart factories, digital platforms, RPA, AI, IoT, enterprise mobilization, cloud, AR / VR, assembly systems, and management. In 2017, it formed a partnership with Siemens of Germany and reached an agreement to cooperate in utilization and mounting of that company's IoT platform "MindSphere". It has also signed a partner agreement with Toshiba Digital Solutions to cooperate in the field of manufacturing IoT solutions utilizing "Meister Series™". It also cooperates with Toppan Printing in providing services for enhancing work efficiency.
CMC Technology Group	With a history of more than 25 years, CMC is one of Vietnam's top information industry companies (the second largest ICT company in the country). It has 10 business centers (subsidiaries, joint ventures, research institutes) both inside and outside of Vietnam and conducts business mainly in the fields of system integration, BPO, software development, datacenter services, ICT products manufacturing and sale and so on. It implements medium-and large-scale information communications projects in such fields as government, education, tax affairs, finance, customs clearance, insurance, electric power, banking, finance, etc. In 2018, it signed a strategic agreement to introduce MES to the Vietnamese factory of Samsung SDS, a subsidiary of the Korean corporation Samsung. The Samsung factory in Bac Ninh Province uses 6,000 robots on its assembly lines. Both companies provide smart factory management and operation solutions to more than 200 Samsung suppliers in the country.
VinFast	VinFast, which is Vietnam's first automobile manufacturer, announced that it would "actively introduce cutting-edge Industry 4.0 technology for production of a high-quality domestic car" in a session on smart manufacturing at the "Industry 4.0 Summit" that was staged last year. The company has established the VinFast Engineer Training Center as part of its human resources development policy and plans to accept 200 researchers primarily in the fields of electric machine engineering. It has announced plans to adopt an innovation platform based on Siemens' PLM software tools and construct a connected digital enterprise with a view to designing future generation automobiles and transportation.
Saigon-Hanoi Beer Corporation	Saigon-Hanoi Beer Corporation, in cooperation with the Ministry of Commerce and Industry, has commenced a research project for a system to monitor and manage online production in 2018~2019.

Player	Corporate initiatives and related equipment, related software
VINATEX (Vietnam state-owned textile company group), Vietnam Electric Power Corporation Group	This group and its companies under the jurisdiction of the Ministry of Industry and Trade are taking the initiative in introducing Industry 4.0 and building cooperative relations with overseas partners to provide Industry 4.0 technology and solutions.
VNEXT	This software development company was established in Hanoi in January 2008 as a subsidiary of G-NEXT, which deploys CRM solutions in Japan. It has been selected and awarded by the Vietnam Software and IT Services Association (VINASA) as one of "Vietnam's Top 50 IT companies" and "Top 10 Industry 4.0 Companies (IT field) (2018)". Since the beginning of 2016, VNEXT has provided natural language processing, image processing, data mining and other R&D and AI services to Japanese clients. In doing so, it has achieved much success in developing AI for video identification, chat board dialog, electric power demand forecasting, automobile price forecasting and so on.
DEHA	DEHA, which was founded by Vietnamese in Japan and Vietnam, develops system applications and handles image processing, AI, block chain and so on. It provides image processing-related products to Japanese and Vietnamese manufacturing companies and was recognized as one of the "Top 10 Industry 4.0 Companies" in 2018.
NTT Data Vietnam	Established in 2008, it currently conducts business in two main areas: ① "support for introduction of IT to manufacturing and logistics", and ② "software offshore development and testing". Concerning support for introduction of IT to manufacturing and logistics, it caters to Japanese companies, local companies, and foreign investment companies, although its main clients are Japanese companies (they lack name value compared to Vietnamese and foreign investment companies and are inferior in terms of links with local IT companies). It offers work reform tools that utilize RPA technology, BI solutions etc. for the age of AI and big data, regardless of sector. A separate company – Qunie, which is established within NTT Data and has a Vietnam office, provides IT consulting services to companies.
Fujitsu	Together with Fujitsu Systems East, it introduced a new system utilizing IoT to the number one factory of TOTO Vietnam in the Tan Lon Industrial Park in Hanoi. This is regarded as a core facility in TOTO's global supply chain. Utilizing IC tags and barcodes, the system gathers and digitizes all sorts of information concerning quality, progress, humidity and temperature when mixing materials, types of enamel applied to sanitary ceramicware, performance, skilled operator work standards, know-how etc. in all processes from the mixing of raw materials to inspections. In doing so, it visualizes the know-how of skilled workers and makes it possible to conduct analysis based on statistical data.

- Market size:

  In the "Socioeconomic Development 10-year Strategy (2011~2020)", the aims are to achieve annual average growth between 2010~2020 of 7~8%, increase per capita GDP to US$3,000, and increase the share of mining and manufacturing in the industrial structure (GDP) to 85%, with the high-tech industry accounting for 45% of that.

3.3 Trends of Technology Application by Locally Advancing Foreign Manufacturing and Supporting Industries

Trends of technology application in the five countries surveyed are summarized here for ① Japanese companies, and ② local companies.

Outline:

Due to the advance of digitalization in manufacturing, countries in Asia are exploring development scenarios unlike anything they have experienced before. The ASEAN countries targeted in this survey, too, are striving to realize sustainable economic growth and industry development scenarios without falling into the trap of semi-developed countries by using digitalization and technology innovation, design development and so on to impart higher added value to their industries.

In the survey, many Japanese companies (manufacturing sector) were found to have largely complete in-factory optimization (FA, etc.) but to have made hardly any progress regarding 4IR. Concerning the reasons why, since humans still play the central role in manufacturing, they view the introduction of 4IR-related technology to the production of diverse models as a risk in terms of information security and productivity.

However, some companies have locally introduced IoT (AI) on a trial basis. Omron and VINA Acecook in Vietnam have introduced systems for gathering inventory and sales data down to the end of the supply chain.

Concerning local companies, from the viewpoint of upgrading of manufacturing, there were found to be extremely large disparities in terms of quality control and production management capacity between companies that can supply components to Japanese companies and companies that cannot.

The surveyed countries recognize the need for digitalization, albeit to differing degrees, however, they are hindered in advancing it by the costs and shortages of IT human resources. They are also in the situation that they don't know from where to begin regarding introduction.

Concerning upgrading of manufacturing, it is important to build a network with clients and supply chain companies in addition to network within the company. In particular, information sharing with supply chain companies is recognized as an issue and some companies are taking steps to address this matter (the aforementioned cases of Omron and VINA Acecook in Vietnam, etc.).

On the other hand, concerning data-driven manufacturing, many companies currently consider it to be unnecessary. There were cases of local SMEs that are already enjoying sufficient profits and managers have little interest in improvement. Such companies are not even gathering data

from the production site. Some Japanese companies did not feel a pressing need of digitalization either because they are achieving sufficient improvement in productivity, etc. through conducting KAIZEN activities in analog method (manual work by employees) of data acquisition, analysis, judgment and reflection. Another reason is that since mass production needs are still prominent in the target countries, there is little need for the data-driven approach and frequent change of production facilities.

Generally speaking, a common denominator in all countries is that safety management takes precedence to 4IR, and 4IR is something that should only be implemented based on the foundation of safety management and KAIZEN.

(1) Indonesia

- Technology application trends by Japanese companies
  - The degree of Japanese companies presence is medium, and the involvement in the automobile industry is also medium.
  - Some Japanese companies utilize IoT to visualize production volumes and product tests, and FA has progressed to a certain extent, however, Japanese manufacturing in Indonesia only entails production in many cases, and it is thought to be 10 years behind Thailand in terms of product development, exporting, and enhancement of supporting industries (hearings at Panasonic, Bahtera Hisistem, etc.). This can be seen as a result of strategic division of labor with Thailand, which is being optimized.
  - Japanese companies have introduced three types of ERP: SAP Business One, Microsoft Dynamics, and Sage ACCPAC. In particular, ACCPAC has been introduced mainly in SMEs. Reasons behind the introduction of ERP are primarily the rapid inflation of labor costs, and the change of business environment for subcontractors who must explore new customers since they will not be able to survive by supplying only to the same clients.

- Technology application trends by local companies
  - Many major state-owned companies and government agencies have introduced SAP.
  - Among small and medium manufacturing enterprises, many have not yet introduced FA. FA is only seen in large enterprises that are contracted by Japanese companies. Meanwhile, due to the soaring labor costs, many companies are feeling financially pressured and would like to introduce FA if they had the funds.
  - However, there are hardly any opportunities to learn about 4IR among manufacturing SMEs. Since many such companies only have analog operations using paper and Excel in their offices (no enterprise-level systems), they first need to introduce digitalization.
  - The 4IR in manufacturing has only been seen in a small number of Japanese suppliers.

(2) Malaysia

- Technology application trends by Japanese companies

  ・ The degree of Japanese companies presence is medium next to Thailand and Indonesia among the site survey countries, and the involvement in the automobile industry is also medium.

  ・ In line with the government's policy of reducing the number of foreign workers, Japanese companies need to consider mechanization and automation, and the progress is being made through FA and visualization of operations based on IoT.

  ・ Meanwhile, Japanese companies are also bipolarized, and many of them are unable to implement smartification due to cost-effectiveness considerations. In the automobile industry, EV and other new developments can be anticipated, however, prospects for future growth appear slim in the household electrical appliances market and so on. Even among Japanese companies, only around 30~40% are positive for smartification.

  ・ Even the Daikin factory is at such a level (equivalent to 2IR~3IR) that computerized mass production equipment has only been partially introduced, and has not yet fully introduced FA. According to survey result, only around 15% of Japanese companies including major enterprises have introduced Industry 4.0.

  ・ An example of smartification is KONICA MINOLTA BUSINESS TECHNOLOGIES (MALAYSIA) Sdn. Bhd (hereafter, KMMY) established in Malaysia in May 2014. This now conducts full-fledged operations as a production center based on the concept of "digital manufacturing" with a view to realizing a future generation innovative production system. Combining the latest cutting-edge ICT and production process automation technology, this is a model plant that optimizes QCD (quality, cost, delivery) and can flexibly respond to production without being influenced by fluctuations in people, places or countries. Specifically, four systems have been introduced in stages. First, there is a system whereby, in processes for assembling precision instruments, production line conditions are automatically managed and grasped, and appropriate production conditions are adjusted and maintained; second, there is a system for tracking the movements of things and numerically processing them for use as management indicators by ICT; third, there is a system whereby, through conducting the real-time management of production information, profit and loss and other indicators are visualized; and fourth, there is a system for networking with other production facilities in Malaysia and elsewhere, making it possible to conduct simulation and review technologies in a virtual environment.

- Technology application trends by local companies

  ・ According to the manufacturing industry organization FMM, major players such as Top Glove, Daikin, Perodua, Huawei, etc. accept factory observations by FMM member

companies, so it is thought they employ FA to a certain extent. Government agencies also consider that there is no need to offer support to major companies regarding 4IR (they can implement it on their own resources).

- In SMEs, FA has only been partially introduced. Survey of FMM member companies revealed that more than 60% of them do not know about 4IR. The first step in 4IR is digitalization, however, hardly any SMEs have conducted this. It was also commented that thorough implementation of safety management, etc. is a prerequisite for 4IR.
- Major issues include lack of knowledge regarding IT, let alone 4IR; doubts over whether investment can be recovered; shortage of success stories, and so on.
- When it comes to introducing new technology, B to C sectors such as retailing and financial services, which directly receive forceful demands from customers, tend to be more forward thinking than manufacturing. In contrast, B to B operators in the manufacturing sector are passive.

(3) Myanmar

- Technology application trends by Japanese companies
  - Many Japanese companies conduct business in Myanmar, but mostly in labor-intensive manufacturing fields. In particular, light industrial companies making clothing and shoes are conspicuous (there are also Chinese and Korean companies). As features, a large proportion of work is labor-intensive and little progress has been made in terms of advanced manufacturing. Accordingly, Industry 4.0 of manufacturing is almost non-existent.

- Technology application trends by local companies
  - When a state-owned company introduced mechanization and fired many workers, it led to a large-scale industrial dispute. With this experience in mind, there is a cautious attitude regarding mechanization in state-owned companies.
  - SMEs are still slow to introduce mechanization, and 4IR developments are almost entirely unheard of.

(4) Thailand

- Technology application trends by Japanese companies
  - Many Japanese companies conduct business in Thailand, and the same is true in the automobile industry.
  - Within JETRO's "Project for Nurturing New Industries in ASEAN and Japan" (second subscription), four Japanese companies are conducting field tests using respective IoT technologies in Thailand.

- In response to issues such as soaring labor cost, rapid ageing of society, and the possible return of cheap laborers from nearby countries (Cambodia, Myanmar, etc.) in the future, Japanese companies recognize the need for mechanization and automation and are making progress in the areas of FA and visualization of operating conditions by using IoT.

- Technology application trends by local companies

  - Shifting to FA is progressing to a certain extent in conglomerates and other major companies. For example, the CP (Charoen Pokphand) conglomerate group has introduced robots to manufacturing lines of "meat pies and gyoza dumplings" at the CP Foods factory in Hebei Province, China. It has constructed an original production system and is utilizing IoT to strengthen manufacturing. Also, Sammitr Motors Manufacturing of the auto parts major Sammitr Group uses a system for monitoring hydraulic oil leaks etc. at its factory in China, thereby making it possible to grasp employees' movements in parts areas by IT and linking this to labor saving and line improvement.

  - On the other hand, shifting to FA has only partially progressed in SMEs. There are some countries that are still unable to conduct basic activities such as adequately secure safety or implementation of proper accounting practices, let alone introducing 4IR technologies.

  - Major issues include lack of knowledge regarding 4IR (for example, companies don't know how to make use of data even if they do acquire it through IoT); doubts over whether investment can be recovered; shortage of success stories, and so on.

(5) Vietnam

- Technology application trends by Japanese companies

  - The degree of Japanese companies presence in Vietnam is medium, while the level of involvement in the automobile industry is low.

  - Since Japanese factories are more or less efficiently operating, they have little desire to newly introduce 4IR.

  - However, there are cases where companies (Omron, VINA Acecook) conduct optimized production in factories upon acquiring inventory and order data in real time (however, this occurs in the downstream of the supply chain (stores, etc.)), and there are also companies that have established a new factory equipped with IoT (TOTO Vietnam).

- Technology application trends by local companies

  - Major companies mainly comprising former state-owned enterprises are adopting FA and IT. There are also examples of smart factories that have introduced the latest technology from Germany, etc. (VinFast (Vietnam's first auto company), VinaMilk and so on).

- On the other hand, few SMEs have introduced FA and most companies haven't even managed sufficient safety or KAIZEN on lines. SMEs are at the situation with top management unaware of line conditions (more interested in profits) and no data being gathered on lines, and so on.
- Since many companies/SMEs are managing to mass produce products with a certain degree of quality, they have little interest in 4IR, and hardly any progress regarding 4IR can be seen in manufacturing.

3.4 Current Local Conditions and Issues of New Technology-related Human Resources

The current conditions and issues regarding new technology-related human resources in the five target countries are summarized here from the following viewpoints: ① Industrial human resources development policies, ② Current conditions of industrial human resources development, ③ Human resource needs from the perspective of Japanese companies, and ④ Issues.

(1) Indonesia

- Industrial human resources development policies
  - Making Indonesia 4.0 identifies the following as priority items concerning human resources development: "Improving the quality of human resources: reform of education curriculums in line with Industry 4.0, and expediting the movement of highly skilled human resources."

- Current conditions of industrial human resources development
  - ➢ Initiatives by governments, donors, etc.
    - In terms of the government structure, "Human Resources Development Agency" has been newly established and 4IR-related human resources development is being implemented by organizations under this agency while receiving assistance from Switzerland, Taiwan, Singapore, Germany and so on. In addition, PIDI 4.0 (mentioned above), which was established by the Ministry of Industry, has a training center and plans to provide training for building 4IR-related skills, mainly for corporate personnel.
    - In the Ministry of Communication and Information Technology, 4IR-related human resources development is implemented through the "Digital Talent Scholarship" project. Major IT companies such as Cisco, Amazon, Microsoft etc. are involved in compiling curriculums and supporting the conferral of qualifications (CCNA Security, IBM IoT, Amazon AWS and so on). Lecturers in this course are required to be involved with IoT in a major IT company.

- Germany is implementing capacity building for development of 4IR-related human resources for TVET lecturers in Indonesia with cooperation from Thailand's Thai German Institute and Singapore's German Training Center, etc. through RECOTVET (4IR-related technology cooperation project by GIZ targeting all ASEAN) program.

➢ Initiatives by educational institutions

- The engineering department of the University of Indonesia plans to introduce a 4IR-related curriculum from April 2020, and also to start online lessons targeting the whole country. Lessons concerning 4IR-related IoT, AI etc. are implemented in the electronic engineering department and mechatronics department.

- Human resource needs from the perspective of Japanese companies

- Some of the local IT engineers are at a very high level and are even said to be more skilled than their Japanese counterparts. There is competition among Japanese companies to recruit the outstanding local IT human resources.

- However, most new technology-related human resources including IT engineers are not sufficiently skilled, and they are also lacking in terms of absolute numbers. As a result, personnel expenses for outstanding IT human resources are skyrocketing.

- Many local staffs are not even able to attend training for technical strengthening, and local Japanese companies stated needs for the training of "trainers/teachers" who can offer guidance on the upgrading of industry. It is necessary for human resources who can offer guidance on technology to be assigned to universities, polytechnic centers, vocational training schools, etc. around the country.

- Issues

- Issues in planning introduction of IoT to local SMEs are the need for drastic improvement of safety, KAIZEN (understanding and constitution), acquisition of 5S as the basics for KAIZEN, and so on. It is necessary to fundamentally raise the level of human resources capable of understanding the basics.

- Concerning IT engineers, the shortage of IT engineers who are able to understand both manufacturing lines and IT is a major impediment to 4IR measures in Japanese companies and local companies. However, there is also a shortage of human resources capable of educating such IT engineers.

(2) Malaysia

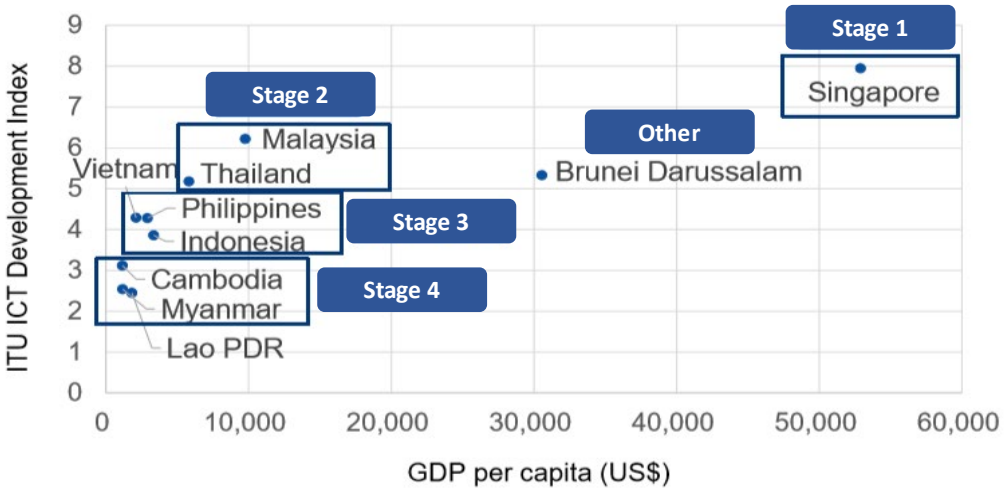
- Industrial human resources development policies
  - In Industry 4WRD, five pillars, i.e. funding, infrastructure, regulations, skills & talent, and technology are set regarding "Strategic Enablers". Under the heading of Skills & Talent, capacity building of manufacturing workers and strengthening of STEM (Science, Technology, Engineering, Mathematics) education for students are proposed. The Ministry of Human Resources and Ministry of Education have jurisdiction over measures.

- Current conditions of industrial human resources development
  - ➢ Initiatives by governments, donors, etc.
    - Germany is implementing capacity building for development of 4IR-related human resources for TVET lecturers in Indonesia with cooperation from Thailand's Thai German Institute and Singapore's German Training Center, etc. through RECOTVET (4IR-related technology cooperation project by GIZ targeting all ASEAN) program.
    - In the process of deploying 4IR, data scientists are needed to analyze the various information and big data that are gathered by sensors on production lines. Malaysia is a pioneer in the development of such human resources, and the ASEAN Data Analytics Exchange (ADAE) is working to involve the countries of ASEAN.
  - ➢ Initiatives by education institutions
    - GMI (German Malaysian Institute: established in 1992) is a technology-related vocational training school (around 5,000 students) and, as an education agency for driving 4IR, it conducts activities geared to spreading 4IR in ASEAN. 4IR-related contents are incorporated into courses for students, and there are also 4IR-related courses for working persons striving to up-skill, re-skill, and so on. Furthermore, GMI also trains teachers from Indonesia and other countries.
    - MJIIT (Malaysia-Japan International Institute of Technology), which is prominent among higher education institutions, implements education while making use of robots, simple production lines and so on.

- Human resource needs from the perspective of Japanese companies
  - The Japan Chamber of Commerce and Industry indicated the need for advanced initiatives regarding 4IR, and a mention was also made regarding the importance of support for reeducation for emphasizing basic work ethic, and reinforcement of 5S/KAIZEN and other fundamental knowledge and skills necessary for production.

- The local Japanese companies especially require industrial human resources development that include innovativeness in light of the aforementioned fundamental capacity building needs.

- Issues
  - Due to the fragile links between educational institutions (universities, etc.) and industry, education curriculums do not sufficiently reflect industry needs. Accordingly, there are calls for the 4IR-related education curriculums currently in progress to be improved.
  - Due to differences in fundamental thinking regarding 4IR, the German support strategy and Japanese support strategy (Japanese companies' needs), for example, have unique identities. The 4IR-related human resources development being initially implemented by GMI differs from the Japanese bottom-up curriculum; hence, original industrial human resources development programs are required if benefits are to be expected in Japanese companies. In this case, even assuming utilization of the existing MJIIT, reform of the instruction contents is needed.
  - Due to the low employment awareness of local human resources and the fact that they tend to quickly leave positions after they are employed, many Japanese companies refrain from assigning advanced jobs to them.
  - According to comparison of ICT development indicators (ICT infrastructure development, comprising broadband coverage and establishment of e-government) in ASEAN countries by the World Bank (see the figure), leaving aside Singapore, which is not targeted by this survey, the order of development is as follows: Malaysia > Thailand > Vietnam > Indonesia > Myanmar. However, even in Malaysia, the abovementioned issues related to 4IR new technology human resources exist in relation to the level of economic development.



Source: Prepared by the Mizuho Bank Industry Survey Department based on ITU and World Bank homepages

Figure-8 ICT and Level of Economic Development

(3) Myanmar

- Industrial human resources development policies
  - Due to the low level of industrial development in Myanmar, hardly any activities can be seen regarding policies for the training of 4IR-related industrial human resources and linkage with private sector companies.

- Current conditions of industrial human resources development

  ➢ Initiatives by governments, donors, etc.
  - There are no conspicuous initiatives by the government.
  - IT human resources development in Myanmar was vitalized as a result of activities including a survey of overseas human resources by the Center of the International Cooperation for Computerization (CICC) under Japan's Ministry of Economy, Trade and Industry. As an outcome of this, relations with Japanese companies are expanding to include internship activities, recruitment and so on. However, no measures have so far been implemented regarding the development of 4IR-related industrial human resources.

  ➢ Initiatives by educational institutions
  - Hitachi has established the "Hitachi Myanmar Laboratory" inside UIT with the objective of training future generation leaders in the IT field. In addition to dispatching engineers from Japan and holding courses for the teachers and students of UIT, it has donated the IT platform comprising servers necessary for conducting courses.
  - IT-related universities in Myanmar produce around 5,000 IT human resources a year. However, Japanese companies still view it as lagging behind in terms of the level of IT. Accordingly, Hitachi, Fujitsu and others are supporting "donation courses" aimed at raising the level of technology in the country (The "Hitachi Myanmar Laboratory" inside UIT is one example of this).
  - On the university education level, UIT has a laboratory specializing in IoT, and three projects are conducted, i.e. Smart Car Parking, Smart Billing, and Smart Traffic Lights, although it cannot be said that these themes reflect industry needs. In terms of AI-related contents, the curriculum includes knowledge engineering, robotics, cloud and big data field. However, during the survey of the university, comments were received saying that the curriculum needs to more flexibly adapt to industry needs, there are shortage of teachers, and so on. Incidentally, third-year students at UIT sit IPTEC, which is the international edition of the IPA examination for information processing engineers in Japan, and the pass rate is an outstanding 94%. Thanks to initiatives such as partnership with Nagaoka University of Technology in Niigata, Japan and internship

programs at companies in Japan, Thailand, Vietnam, etc., the employment rate among graduates is almost 100%.

- SITE (School of Industrial Training and Education) offers vocational training courses, but its curriculum at present comprises only basic education level contents and no 4IR-related contents. SITE was established with support from Sea Lion Inc., a German medical instruments retailer that has a tie-up with FESTO of the same country, and Sea Lion also funds the salaries of teaching personnel, etc.

- Human resource needs from the perspective of Japanese companies
  - Since it is reported that Toyota has already began construction of assembly plant in Myanmar and Nissan has plan to follow, it needs for acquiring Japanese style business manners and strengthening practical capacity that will be useful on production lines are pointed out, let alone strengthening of IoT-related technology.

- Issues
  - It is necessary to reinforce education of industrial IT human resources, develop IT courses specific to production lines, and have trainers who can conduct courses that place emphasis on acquiring practical Japanese style business manners in addition to theoretical learning.
  - Due to the generally low level of industrial development in the country, the government has formulated few policies for training the kind of new technology-related human resources that meet the needs of industry.
  - In Myanmar, although IT human resources development is booming and training is advancing, domestic industries are unable to utilize such human resources. As a result, human resources almost always end up going to other countries, like Vietnam and Japan.

(4) Thailand

- Industrial human resources development policies
  - In 2016, the year after the Thai government launched Thailand 4.0, the Ministry of Information and Communication Technology (MICT) [57]and the Ministry of Science and Technology (MOST) formulated the Digital Thailand Plan as a specific long-term plan for the digital sector. One of the priority themes of this is the “development of human resources suited to the digital age”, and the following human resources development goals are stated for the coming 10 years: “enable the working population to utilize digital technology at an internationally high level” and “give all citizens IT literacy”.

[57] Now changed to Ministry of Digital Economy and Society (MDES)

- Current conditions of industrial human resources development

  ➢ Initiatives by governments, donors, etc.

  - The ITC (Industry Transformation Center), which was established by the Thai Ministry of Industry to support the industrial upgrading of SME, implements the "3 Stages Rocket Approach" based on an MoU signed with Japan's Ministry of Economy, Trade and Industry.
  - In the LASI implemented by Denso at ITC, basic education is conducted on Japan's strongpoint of production technology (however, this does not have full IoT-related contents). There are plans for LASI to be disseminated to universities (with support by the NIA) and deployed to the provinces.
  - There are also digital human resources development policies that combine EEC investment with attraction of companies (companies advancing into the EEC are given preferential tax treatment, conditional on them employing and training Thai engineers).
  - Various countries conduct support in the field of industrial human resources development , for example, the advanced support strategy in the vocational training field (RECOVET) by GIZ, support by China for programming human resources through universities, and so on.
  - A technical college modeled after Japan's "Kosen" is scheduled to open in Thailand under Japan's yen loan program, "Industrial Human Resource Development Plan," with the aim of fostering industrial human resources capable of contributing to the realization of Thailand 4.0. The curriculum is expected to include fields such as mechatronics and automatic machining. [58]

  ➢ Initiatives by education institutions

  - KMITL (King Mongkut's Institute of Technology Ladkrabang) has conducted a robotics and AI course since last year. It is also focusing efforts on providing skill-up and re-skill programs for working members of society. Furthermore, it actively receives students from least developed countries and offers support for training industrial human resources in general management areas such as industrial engineering, lean manufacturing, KAIZEN, as well as in production engineering fields such as production machines, PLC, sensors and so on.
  - The Thai-Nichi Institute of Technology and Technology Promotion Association (Thailand-Japan) have supported basic capacity building for industrial human resources for 30 years.

[58] https://www.th.emb-japan.go.jp/itpr_ja/pr2020_09.html

- Human resource needs from the perspective of Japanese companies
  - According to comments by Japanese companies that conduct business locally, most SMEs do not implement KAIZEN activities, have low management capacity, and also have hardly any awareness of IoT.
  - Before deploying 4IR, it is first necessary to conduct capacity building in such areas as data utilization methods and analysis technology (analysis methods and characteristics, necessary capacity, etc.). According to a hearing survey at the Thai-Nichi Institute of Technology, which was established under Japanese assistance 12 years ago, it was belatedly commented that a basic condition for industry at the present time is the presence of industrial human resources who have understanding of Japanese monozukuri (manufacturing).
  - There is competition among Japanese companies to acquire the best Thai human resources. Employment destinations are ranked as follows in terms of popularity: 1st: European and American companies (they give fair assessments), 2nd: Thai conglomerate companies, 3rd: Companies based in Bangkok (people don't want to leave the capital), and 4th: Major Japanese companies.

- Issues
  - Thailand has numerous educational institutions that have received Japanese support over many years, however, due to conditions in the country, engineering education is not so popular and outstanding students tend to avoid this field.
  - There are hardly any human resources (teachers and so on) who are capable of teaching 4IR matters to SMEs, which are most likely to provide benefits to Japanese companies.
  - Even if human resources are trained, another problem is that they tend to switch jobs quickly.
  - Support related to industrial human resources development oriented towards 4IR is being deployed by various countries, however, contents do not match with the industrial human resource needs of Japanese companies, which require people who are endowed with preliminary knowledge about data utilization and analysis techniques necessary for smoothly deploying 4IR and practical ability for utilizing the results of analysis to advance improvements.

(5) Vietnam

- Industrial human resources development policies
  - IT human resources development is the highest priority area regarding ICT policies.

- Current conditions of industrial human resources development

  ➢ Initiatives by governments, donors, etc.

  - GIZ has incorporated CNC operating technology, NC programming, mechatronics etc. into curriculums to support TVET lecturers. Training equipment donated by Germany's Bosch, Siemens and ABB, etc. is used to implement ToT for instructors. Since this support program is nearing completion, a study is being conducted on pilot training and re-education projects inside companies to training the necessary human resources for 4IR in manufacturing.

  ➢ Initiatives by education institutions

  - Hanoi University of Industry is currently implementing an education program under support from France and USA to develop human resources that can contribute to 4IR. Specifically, the American company Keysight Technology has donated IoT training equipment, while IBM supports training in New Data Science, AI and software development. Meanwhile, Samsung has dispatched lecturers, provided support for training (AI, automation program and so on), and assisted a scholarship scheme and experiment costs. Samsung also actively deploys joint research and joint activities based on the project style.
  - Hanoi University of Industry also has vigorous overseas study programs. By utilizing various schemes such as Monbusho, JDS, HISPI, SEED-Net and so on, it conducts a program for sending around 20 students to Ritsumeikan University and Keio University. Also, it conducts a robotics program with Shibaura Institute of Technology, and also implemented a program of joint lectures on IoT-related themes with Nagoya University two years ago. In addition, utilizing SEED-Net, it implements annual programs under support from Panasonic, Hitachi, Mitsubishi Electric, etc. However, in terms of the level of teachers, it is still a long way behind Japanese universities, hence, the need for strengthening of cooperation with industry was stressed in hearings.
  - VJCC (Vietnam-Japan Institute for Human Resources Development) has been active for 20 years. For the past 10 years, it has staged a management course that has educated and trained approximately 500 graduates, including managers, from 400 companies. Recently, it also has plans to establish new training programs concerning data-driven KAIZEN in the field and management techniques.

- Human resource needs from the perspective of Japanese companies

  - Company needs in terms of industrial human resources are on the level of learning the basics of 5S/KAIZEN, however, there is little orientation towards the upgrading of industry with 4IR in mind.

- The low level of electrical engineers was mentioned, with issues regarding the quality of trainers pointed to as the reason.
- Concerning industrial human resources who can contribute towards introducing 4IR, only Samsung, which is far and away the most technologically advanced company, has human resource needs to a certain extent. Needs in Japanese companies are currently oriented towards 3IR.

- Issues
  - Universities and other institutions responsible for training skilled industrial human resources want to see curriculums reformed with an eye to 4IR, however, they have weak links with industry. For these institutions to become capable of training the kind of industrial human resources that are demanded by Japanese companies, it will possibly take some time for them to strengthen their links with industry.
  - Japan has experience of developing human resources in Vietnam through 20 years of VJCC activities, however, it is not sufficiently responding to the current speed of upgrading in industry, so the future actions are expected.

4. Study Results for Impacts of COVID-19 on Advancement of the Manufacturing Industry

4.1 Overview

Although it is clear that COVID-19 has had short-term negative impacts on advancement of the manufacturing industry due to a general lockdown of business activities, shutdown of factories, fragmentation of the supply chain, etc., it has also been discovered that some technologies and business fields have enjoyed some positive impacts of COVID-19. The dissemination of such technologies as IoT, AI, RPA and AR/VR appears to have been boosted with few negative impacts because of the prevailing remote work, reduction of manpower, promotion of automatization, etc. due to the pandemic. In contrast, such technologies which had already been disseminated to a certain extent before the pandemic as robotics, 3D printing and MES have experienced short-term negative impacts (→ 2.2) and COVID-19 does not appear to have specially raised the demand for these technologies. From the long-term perspective, however, steady market growth is expected for all types of technologies to advance the manufacturing industry and it should be concluded that COVID-19 has actually accelerated the promotion of Industry 4.0.

The efforts of each target country of the Study to achieve advancement of the manufacturing industry reflect the above-mentioned trend. Both the public sector and private sector in not only advanced countries but also developing ASEAN countries believe that the avoidance of close contact between humans directly leads to promotion of the automatization of equipment and the introduction of AI. Under such circumstances, enterprises, etc. which have been reluctant to proceed with the

advancement of their production systems are hard-pressed to reconsider their stance because of COVID-19. Nevertheless, every country recognizes that the re-education of surplus human resources likely to emerge in the near future and the development of new human resources adapted to cutting edge technologies are major issues in the short-term.

Meanwhile, the demand has especially increased under the unique circumstances created by COVID-19 for such technologies as teleconferencing, remote monitoring, remote operation, etc., all of which embrace a mechanism to perform assigned work without the on-site presence of people. It is apparent that the use of these technologies has become essential in the situation where the employees of Japanese enterprises cannot leave Japan to enter host countries.

The contents of this chapter are based on the results of research conducted as of March 2021, unless otherwise noted.

4.2 Impacts of COVID-19 on Advancement of the Manufacturing Industry in the Target Countries of the Study (Desk Research)

(Note) This research was conducted on the target countries of the Study except Japan and excluded efforts of the national government, etc. Refer to 4.3 Interview Survey Results for the study results for the manufacturing industry in Japan.

4.2.1 Impacts of COVID-19 on the Efforts of the Government, etc. to Deal with New Technologies

Here, the impacts of COVID-19 on the efforts of the government, etc. in each target country of the study are described along with the COVID-19-related responses of the UNIDO.

(0) Overview

In general, the government of each target country has introduced a fiscal stimulus as symptomatic treatment for the short-term negative impacts of COVID-19. The "Database of Fiscal Policy Responses to COVID-19"[59] of the IMF compiles the fiscal stimulus of major countries in 2020 to deal with COVID-19 (ratio to GDP in 2020) as shown in Figure-9.

[59] https://www.imf.org/en/Topics/imf-and-covid19/Fiscal-Policies-Database-in-Response-to-COVID-19

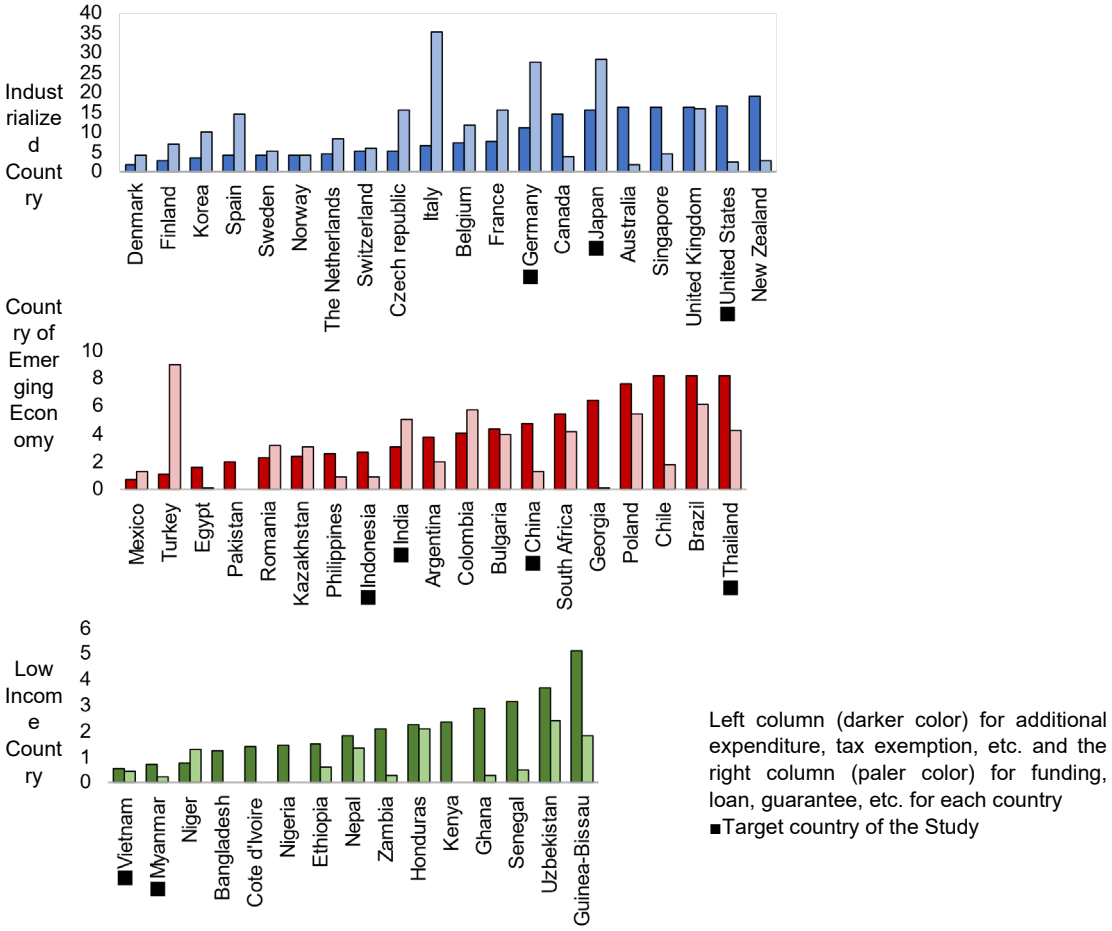


Figure-9 Fiscal stimulus of various countries to deal with COVID-19[59]

There appears to be a tendency in some countries for COVID-19 to provide a golden opportunity for digitalization of the manufacturing industry and the promotion of Industry 4.0 and many countries intend to take this opportunity to proceed with the digitalization of the supply chain in particular. The responses of industrial associations are more future-oriented as they are beginning to take the stance of concentrating on technologies to control remote work, etc. in addition to more conventional technology fields while paying special attention to the possibility of Industry 4.0 being able to perform a more proactive role in response to the pandemic.

(1) Japan

Trends of Public Policies

- The Emergency Economic Measures to Cope with COVID-19 include the stimulation of consumption which has substantially fallen due to the pandemic along with the boosting of investment in digitalization as well as remoteization to anticipate future development in advance. The supplementary budget incorporating special measures to cope with COVID-19 calls for, among others, “reform of the supply chain” and “acceleration of digital

transformation (DX) by means of remoteization, etc." to build an especially tough economic structure.[60]

- Of these, "reform of the supply chain" received a supplementary budget inclusion of 248.6 billion yen to review those supply chains which had become over-dependent on China and certain other countries and to assist the strengthening of domestic supply chains and the diversification as well as toughening of overseas (designating ASEAN in particular as the region is close to Japan) supply chains in reflection of the fact that existing supply chains are disjoined or have lost their functions due to the pandemic. Of this sum, three billion yen was allocated to "the development and demonstration of technologies contributing to the toughening of supply chains", including the utilization of IoT, and 200 million yen was allocated to "an infrastructure development project towards the real-time sharing of inventory information".

- Under the heading of "the acceleration of digital transformation through remoteization, etc.", a total of 100.9 billion yen was allocated to support for the trial introduction of EdTech (educational contents service utilizing digital technologies) to schools, etc., implementation of remote health consultations with a doctor, support for such non face-to-face or remote business activities as cross-border e-commerce, acceleration of the digitalization of administrative services and support for cyber-security measures as the basis for non face-to-face or remote activities, etc. Of this sum, 300 million yen was allocated to "technological development aimed at realizing a new delivery service utilizing automatic travelling robots" and 10 billion yen was allocated to "the SMEs digitalization support team project", both of which are related to advancement of the manufacturing industry.

Trends of Industrial Association, etc.

- In September, 2020, Keidanren published a policy proposal titled "Supply Chain in the Age of Society 5.0: For the Promotion of Digitalization of Commerce and Finance[61]". This proposal lists such future visions to be sought by Japan's supply chains as "release from analogue-based ordering, order receiving and settlement", "improvement of quality and traceability" and "building of new commercial relations and creation of values". As an activity to achieve these visions, each enterprise needs to work to improve productivity through the introduction of digital technologies (DX) which must be backed by the development of relevant human resources and the establishment and strengthening of a local support system. In the case of SMEs, they commonly face a situation where the recruitment of IT-related human resources is difficult and/or in-house motivation to commit to DX is hard to achieve. In the case of relatively large medium-size enterprises (employing 200 –

60 https://www.meti.go.jp/main/yosan/yosan_fy2020/hosei/pdf/hosei_yosan_gaiyo.pdf
61 https://www.keidanren.or.jp/policy/2020/079_honbun.pdf

300 workers), it is desirable for them to ultimately introduce DX autonomously even if there is no support of an expert. Moreover, for the introduction and utilization of digital technologies by SMEs, it is essential to develop a system whereby they can easily and swiftly obtain appropriate support which matches the particular situation of individual SMEs.

- The Robot Revolution and Industrial IoT Initiative (RRI) jointly held an expert meeting with the Research Council of Platform Industrie 4.0 of Germany and the German Academy of Science and Engineering, resulting in the announcement of the "Manufacturing Policy in the World of Post-COVID-19".[62] This joint announcement reveals the current situation of advancement sought as a mechanism to reinforce human activities. The relevant efforts appear to mostly pursue the replacement of human work and machines in Japan. IN Germany, however, advancement is being sought as a mechanism to reinforce human activities as such digital tools as engineering process automation and human-machine-collaboration are understood to support human activities.

(2) Germany

Trends of Government Policies

- Large-scale support for workers and enterprises: Federal Minister for Finance Scholz and Federal Minister for Economics and Energy Altmaier launched a comprehensive policy package to alleviate the impacts of COVID-19, proposing a limitless loan program for companies.[63] The concrete measures of this comprehensive package are described below.

  i. Relaxation of the requirements to provide working hour reduction compensation for shorter working hours
  ii. Special taxation measures to prevent worsening of the financing of companies
  iii. Large-scale financial support for companies
  iv. Strengthening of cooperation with European countries

- At the meeting of the Steering Committee for Platform Industrie 4.0, Federal Minister for Economics and Energy Altmaier stated that "Industrie 4.0 contributes to overcoming the crisis posed by the new Corona virus" and expressed his understanding that it is important to establish digital supply chains/supply chains using inter-operable data. At the same time, Federal Minister for Education and Research Karticzek expressed the intention to provide support for SMEs so that SMEs can access new technologies as a next step of government support.[64]

62 https://www.jmfrri.gr.jp/document/library/1470.html
63 https://japan.diplo.de/ja-ja/aktuelles/-/2318820
64 https://crds.jst.go.jp/dw/20200814/2020081424183/

Trends of Industrial Associations, etc.

- In May, 2020, a working group of experts on "Digital Business Model in Industrie 4.0", a WG within the framework of Plattform Industrie 4.0, compiled and announced 10 theses on the desirable future of digital business models in the post-Corona economy.[65] This position paper suggests that in the manufacturing industry, digitalization and automation are increasing, resulting in the prominence of "physical distancing" such as remotely managed plants, etc. using VR/AR technologies, robotics and industrial AI along with the increasing importance of the flexibility and agility of enterprises, establishment of local and robust value chains. etc.

- In June, 2020, Plattform Industrie 4.0 published a position paper titled "Industrie 4.0 and COVID-19".[66] The main points of this position paper are summarized below.

  - The COVID-19 pandemic ushers in increased flexibility for production processes and optimized value and supply chains on the part of enterprises. As digitalization is the decisive factor, Industrie 4.0 activities must be pursued with greater vigour.

  - Once Industrie 4.0 activities are steadily pursued along with GAIA-X[67], a digital infrastructure project, German and European industries will gain more competitiveness and greater vigour.

- SAP which has been playing a central role in the promotion of the 4IR in Germany's IT field argues that post-COVID-19 Industrie 4.0 will play a role of emphasizing the resilience (survival and recovery capabilities) of businesses by means of "helping to ensure that more companies survive", "shortening the recovery phase and helping businesses return to normal operation as soon as possible" and "providing a platform to develop new, more resilient businesses in the medium to long-term" instead of its conventional role of simply advancing manufacturing processes.[68]

- In July, 2020, the Hannover Messe was held on-line for the first time in its history as "Hannover Messe Digital Days". Accordingly, 4IR-related presentations took place on-line.[69] Indonesia was selected as the first ASEAN country as a partner country to host the

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65 https://www.plattform-i40.de/PI40/Redaktion/EN/Downloads/Publikation/Corona_Thesen.pdf

66 https://www.plattform-i40.de/PI40/Redaktion/EN/Downloads/Publikation/Positionspapier-Covid19.pdf

67 GAIA-X is a project to create European federated and secure data infrastructure for cloud data services. Of the 11 founding members in Germany, five (SAP, Siemens, Robert Bosch, Deutsche Telekom and Fraunhofer Gesellschaft) are also members of the Steering Committee of Plattform Industrie 4.0. It is launched against the background that SMEs in Germany have strong concern regarding the fact that highly confidential manufacturing know-how and client data are stored on American (such as AWS) and Chinese cloud platforms.

68 https://news.sap.com/uk/2020/04/what-is-the-future-for-industry-4-0-in-the-post-covid-19-paradigm/

69 https://www.hannovermesse.de/en/news/news-articles/successful-launch-for-hannover-messe-digital-days

event in the same year, but as mentioned above, the local hosting of the event was postponed, so Making Indonesia 4.0 was introduced as a partner country for the 2021 event.

- Announcement of the "Manufacturing Policy in the World of Post-COVID-19" as already referred to in the section describing the situation of Japan.

(3) United States

Policy Trends

- Based on the understanding that problematic points of the global supply chain, especially centering on China, have been exposed by the pandemic, the USA government intends to accelerate its efforts to reshore manufacturing industries. There is also an opinion that diversification of the supply network if not reshoring is necessary.[70] [71] Such opinions have also frequently been expressed by the private sector. The prevailing tone of the expressed opinions stresses the necessity to strengthen the resilience of manufacturing industries to enable them to flexibly respond to risks.

Trends of Industrial Associations, etc.

- In March, 2020, the National Association of Manufacturers (NAM) announced the "COVID-19 Policy Action Recommendations" based on the results of a survey with its members. The recommendations to the USA government include the creation of a fund required to ensure the continuation of business activities and economic support for quarantined employees and those dealing with the COVID-19 pandemic.

- In July, 2020, the Industrial Internet Consortium published the "Digital Transformation in Industry White Paper"[72] in which it argues that while market pressure has often been the driving force for DX, regulatory pressure has also been a significant driver of business transformation and that increased focus on "safe" working practices and social distancing in the wake of COVID-19 will further drive DX.

- An OECD report indicates the trend of accelerated digitalization as a result of a study by the USA Chamber of Commerce. For the period from April to May, the ratio of SMEs which moved some or all of their employees to teleworking increased from 12% to 20% while the ratio of enterprises which began to move their business to using digital tools increased from 10% to 17%.[73]

[70] https://eetimes.jp/ee/articles/2003/24/news060.html
[71] https://www.newsweekjapan.jp/stories/business/2020/05/post-93325.php
[72] https://www.iiconsortium.org/pdf/Digital_Transformation_in_Industry_Whitepaper_2020-07-23.pdf
[73] http://www.oecd.org/coronavirus/policy-responses/coronavirus-covid-19-sme-policy-responses-04440101/

- Carolyn Lee, President of the Manufacturing Institute, says that the forced shift to distributed work due to the pandemic has conversely brought the role of Industry 4.0 into focus, accelerating the response of businesses to Industry 4.0. She also says that as remote working is more difficult to adopt at shop floors compared to offices, the gap between office and production should not be exacerbated and that digitalization and automation do not make humans unnecessary but provide an opportunity for humans (who are engaged in the same repetitive tasks at a plant) to return to performing their original creative role.[74]

(4) China

Policy Trends

- According to a notification issued by the Chinese government to related departments, the 4th industrial revolution policy called "Made in China 2025" involving the entire country would continue even in the midst of the COVID-19 pandemic. The recruitment of new research topics on state-of-the-art technologies started on April 20, 2020 targeting domestic research institutes and enterprises while clearly indicating that this recruitment drive is based on "Made in China 2025". This notification actually lists concrete research themes and specifies that a total of 700 million CNY (approximately 10,542 million yen) will be made available for research on methods to make factory production more efficient using big data, 5G, etc. with a portion being allocated to weapons production. A further 500 million CNY will be made available for research on precision parts used for aerospace, automobiles, railways and nuclear power plants.[75]

- In June, 2020, the Chinese State Council Information Office published a white paper titled "Fighting COVID-19: China in Action".[76] In this white paper, the primary target for the manufacturing industry is a sufficient supply of materials for medical workers, placing emphasis on securing the necessary supply chains.

- The "Notice of Standardization Administration of China on Releasing Main Points of National Standardization Work in 2020"[77] issued by the Standardization Administration of China (SAC) states that both the Central Committee and the Central Economic Working Conference are earnestly promoting the prevention and control of the COVID-19 pandemic and economic and social development. These bodies are said to promote the construction of (national) standard systems in such key areas as blockchain, IoT, new cloud computing, big data, 5G, new artificial intelligence, new smart cities and geographic information and to prepare and issue the relevant guidance documents.

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74 https://diginomica.com/future-work-manufacturing-covid-19-generational-divides-and-skills-front-mind
75 https://www.sankeibiz.jp/macro/news/200518/mcb2005180500003-n1.htm
76 http://www.xinhuanet.com/english/2020-06/07/c_139120424.htm
77 https://www.sesec.eu/app/uploads/2020/04/Main-Points-of-National-Standardisation-Work-in-2020.pdf

Trends of Industrial Associations, etc.

- Because Wuhan, the city where COVID-19 considered to go rampant, is a major base for China's automobile industry, supplies of such automobile parts as seat belts, door opening and closing parts, components of transmission gear, fuel hoses and brake pedals in China and elsewhere in the world were severely hit as their dependence on Chinese manufacturers was quite strong. The difficulty of procuring these parts significantly damaged the production of complete cars. The lessons learned from such fragility of the supply chain suggests that those Japanese automobile manufacturers with a production base in China must disperse the risk associated with suppliers of parts.[78]

(5) India

Policy Trends

- After the extension in April, 2020 of the COVID-19 lockdown which originally started in March, the government planned to actively promote the domestic manufacturing program by means of raising import duty to make imported goods expensive and providing a fiscal incentive for domestic manufacturers.

- In a speech in May, 2020, Prime Minister Modi stressed the importance of promoting self-reliance (not depending on the supply chains of other countries) and using the pandemic as an "opportunity" as India's response to COVID-19. According to analysts, his message of "self-reliance" and "opportunity" was meant to welcome inward investment related to "Make in India", India's 4IR policy, and especially encourage the relocation of foreign enterprises from China.[79]

Trends of Industrial Associations, etc.

- Federation of Indian Chambers of Commerce and Industry (FICCI)

- On December 3, 2020, a webinar titled "Building Globally Competitive MSME Ecosystem Post COVID-19" was held with the cooperation of the German GIZ where presentations on necessary measures for MSMEs in India to enable the building of a globally competitive ecosystem were made by representatives of various sectors of society and were followed by discussions.[80] In this webinar, the GIZ introduced a project called "Programme for Modernization and Innovation Promotion in MSMEs in India" and described such approaches as industry-academic linkage between the MSME sector and academia, establishment of an ecosystem to promote incubators and start-ups, capacity enhancement of

78 https://www.provej.jp/column/MadeInChina-2025
79 https://www.livemint.com/news/india/pm-s-message-use-covid-19-crisis-to-make-in-india-attract-firms-exiting-china-11589441970911.html
80 https://www.youtube.com/watch?v=ywYBn05Skyk

business member organizations and policy recommendations for national and state governments.

(6) Malaysia

Trends of Public Policies

- In June, 2020, Prime Minister Muhyiddi published the "Short-Term Economic Recovery Plan June – December, 2020" via the Ministry of Finance as guidance for a concrete recovery from COVID-19 based on the understanding that the necessary approach to beat COVID-19 in Malaysia consists of six key steps and that the country is now at the fourth step of "Recovery".[81] This plan sets forth preferential measures for inward foreign investment, especially in the manufacturing sector, including such bold moves as a 0% tax rate for new investment for 10 years and a special reinvestment allowance for two years. It also promises the allocation of RM 700 million for technical and digital adoption for SMEs and MTCs and the establishment of a grant totalling RM 100 million for innovation and smart automation.

- The Malaysian Investment Development Agency (MIDA) believes that the COVID-19 pandemic provides an opportunity to facilitate the 4th industry revolution (Industry 4WRD) in Malaysia and has organized a webinar titled "How COVID-19 is accelerating Malaysia's Industry 4.0" to which business people and experts were invited.[82]

- According to the results of interviews conducted by the Study Team with government and educational bodies in Malaysia (MARii, MIGHT, MJIT, SIRIM, MTDC and GMI), Malaysia's Industry 4WRD policy itself has not been changed because of the COVID-19 pandemic but some projects and activities implemented under this policy have been affected. More concrete points clarified through these interviews are listed below.

  - The departure of almost all foreign workers (especially those from Bangladesh and Indonesia) to their own countries because of COVID-19 has caused a labour shortage which is particularly serious in labour-intensive industries such as the natural rubber industry and the construction industry. However, human resources related to the advancement of the manufacturing industry have been primarily Malaysian nationals and the impacts of COVID-19 in this aspect are not strong. The government has expressed its intention to promote the return of foreign workers to their own countries and have decided its own initiative of offering one to three month-long vocational training for new graduates (GMI).

[81] http://kpmg.com.my/tax/nerp-booklet.pdf
[82] https://events.3ds.com/how-covid-19-accelerating-malaysia-industry-4

- The industries most severely damaged by COVID-19 in terms of demand are travel, sports, entertainment and food. In contrast, the damage is much less for the electrical and automobile industries. (MARii)
- Among SMEs, those primarily engaged in exports have not been severely damaged. The most damage has been caused to labour-intensive industries with few automated processes. Meanwhile, the number of domestic unemployed exceeds 700,000 because of the traditional reliance on foreign workers (highest in history) and there is a strong need for a policy to improve their skills. (MARii)
- The 4IR Readiness Assessment of SMEs jointly conducted by the MARii, SIRIM and MPC has been delayed because of COVID-19 although this Assessment should have been already completed according to its original plan. Because on-site visits cannot take place, on-line assessment has been employed. However, as there are many SMEs which are unaccustomed to on-line links, assessment often needs to start with support work for connection, making progress very slow. In some cases, on-site assessment is necessary. According to the plan, assessment should be conducted for 1,000 SMEs in both 2020 and 2021. (MARii/SIRIM)
- As part of the activities to promote the digitalization of SMEs, a grant of RM 500,000 has been made available for the development of low cost ERP made in Malaysia and the introduction of industrial robots with the cooperation of the Korean Association of Robot Industry. (MARii)
- The GMI has intensified the 4IR-related training, incorporating on-line learning, and is conducting 17 short-term training courses. Those part of training which require actual practice are organized at the Institute while classroom teaching is conducted entirely on-line. (GMI)
- At present, the MIGHT is drafting a new SME policy which includes such subject as advancement of the manufacturing industry and plans to announce it at the end of 2021. This policy targets 27 sectors, particularly focusing on the long-term survival and resilience of SMEs. (MIGHT)
- Not only the digital divide between large enterprises and SMEs but also the digital divide among SMEs are serious problems. As particularly small enterprises (micro SMEs at the cottage industry level) are scattered in local areas with an under-developed Internet environment, it is difficult to organize on-line conferences with e-mail being the only viable means of communication. (SIRIM)

Trends of Industrial Associations, etc.

- The British Malaysian Chamber of Commerce (BMCC) organized a webinar titled "COVID-19: A Catalyst for Malaysia's Industrial Revolution (IR) 4.0" on May 22, 2020.[83] In this webinar, speakers from the Federation of Malaysian Manufacturers (FMM) and MIDA expressed their common understanding that the COVID-19 pandemic has proved the importance of digitalization and automation in the coming years and an opportunity to shape a new generation of manufacturers in Malaysia as lessons learned from the pandemic. New economic opportunities identified in the webinar are the re-orientation of global supply chains from low efficiency to resiliency, a stronger demand for medical products to enhance the health care capacity and greater reliance on technology to enable the greater consumption of digital services.

(7) Thailand

Trends of Public Policies

- In May, 2020, the Thai government unveiled a US$12.94 billion economic stimulus package to counter COVID-19.[84] Although this package includes preferential taxation and relaxed debt repayment measures, there are no specific measures targeting the manufacturing industry.

- According to "Thailand Digital Industry: Current Situation and Supporting Measures" announced by the Thailand Board of Investment (BOI) in June, 2020, Thai consumers are the most prominent group to have moved to digitalization due to COVID-19 to the extent that one on-line shopping site recorded a 479% increase of the number of users in Thailand. Moreover, increased investment opportunities in digital products and services in the coming years are identified in the health care, education, smart farming and manufacturing sectors.[85]

- In September, 2020, Suriya Jungrungreangkit, Minister for Industry, said "COVID-19 is stimulating the use of digital technology, changing the behaviour of consumers faster than expected". Moreover, this trend is awakening not only consumers but also industries to the need to develop their manufacturing techniques and the ministry is working on plans to achieve the faster development of cutting edge technology and high level services in line with Thailand's Industry 4.0.[86]

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83 https://www.mida.gov.my/covid-19-a-catalyst-for-malaysias-industry-4-0/

84 https://www.investing.com/news/economy/thailand-unveils-127-billion-stimulus-package-to-ease-coronavirus-impact-2105859

85 https://www.boi.go.th/upload/content/Thailand%20Digital%20Industry_%20Current%20Situation%20and%20Supporting%20Measures.pdf

86 https://www.bangkokpost.com/business/1984795/industry-ministry-vows-to-speed-up-4-0-strategy

- At an event titled "Thailand: Driving Towards Industry 4.0" held in November, 2020 by the Digital Economy Promotion Agency (DEPA), the Vice-President of the DEPA stated "Less than 1% of surveyed firms use the latest generation of 4IR-related digital technologies but many expect to engage with these technologies in the next five to 10 years", citing the results of a survey on the current situation of Thai enterprises in relation to Industry 4.0.[87]

Trends of Industrial Associations, etc.

- In June, 2020, the United Nations Industrial Development Organization (UNIDO) announced the "Impact Assessment of COVID-19 on the Thai Industrial Sector"[88] based on the results of a questionnaire survey with Thai industries. According to this report, small and low tech firms were most affected with the short-term biggest impact being reduced demand. The recommended policy options include job retention programmes and various preferential taxation measures. Investment in Industry 4.0-related technologies is recommended to deal with the structural transformation of industries. The UNIDO also strongly recommended the promotion of a shift towards small manufacturing in the "Industrial Development Report (IDR) 2020: Industrializing in the digital age" released in November, 2020.[89]

(8) Vietnam

Trends of Public Policies

- On May 29, 2020, the Government of Vietnam issued Resolution No. 84/NQ-CP which mandates a number of economic relief and recovery measures in the light of the COVID-19 pandemic.[90] This Resolution tasks the Ministry of Industry and Trade (MOIT) to diversify export markets, to seek new importing sources for raw materials and to facilitate trade promotion by means of fully utilizing the benefits resulting from existing free trade agreements, especially EVFTA and CPTPP, to overcome any disruption of the supply of raw materials for the manufacturing industry along with preferential taxation measures, etc.

Trends of Industrial Associations, etc.

- Vietnam Software & TI Services (VINASA)

87 https://www.unido.org/news/drive-towards-industry-40-thailand
88 https://www.unido.org/sites/default/files/files/202006/Impacts_of_COVID19_on_Thai_industrial_sector_0.pdf
89 https://www.unido.org/resources-publications-flagship-publications-industrial-development-report-series/idr2020
90 https://iclg.com/briefing/13845-vietnam-government-of-vietnam-issues-resolution-to-boost-post-pandemic-economy

- VINASA argues for the promotion of DX and the construction of national infrastructure in the post COVID-19 development stage. It especially urges the development of infrastructure for non-cash payments and on-line payments.[91]

- McKinsey & Company predicts that COVID-19 will facilitate the diversification of global supply chains and that there is a strong possibility of accelerating offshoring from China to Vietnam in the coming years, especially for labour-intensive industries.[92]

(9) Indonesia

Trends of Public Policies

- On June 16, 2020, the Indonesian government announced an economic stimulus package amounting to Rp 695.2 trillion in response to COVID-19 and for the recovery of the national economy. This package was subsequently modified several times and the amount stood at Rp 744.3 trillion in November, 2020.[93] The package consists of various tax reduction measures, economic stimulus measures for each industrial sector, preferential customs measures, etc. and those related to the manufacturing sector are listed below.
  - Workers in the manufacturing sector with income below Rp 200 million per year will be exempt from income tax for six months.
  - Import tax payment will be deferred for six months for 19 manufacturing sectors and VAT refund will be facilitated.
  - Interest subsidies for micro-credit and small loans for MSMEs.

- At the German Hannover Messe which was held on-line for the first time in its history in July, 2020, Agus Gumiwang Kartasasmita, Minister for Industry, declared that the Indonesian government remains focused on implementing priority programs on the Making Indonesia 4.0 road map as planned and that the Ministry of Industry is committed to continuing to advance all industrial sectors in the country, including those industrial sectors which currently have the opportunity for positive growth amid the COVID-19 pandemic.[94]

Trends of Industrial Associations, etc.

- Nothing special to report.

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91 https://customsnews.vn/covid-19-pandemic-will-kick-start-a-digital-life-14511.html

92 https://www.mckinsey.com/featured-insights/asia-pacific/emerging-from-the-pandemic-vietnam-must-position-itself-for-recovery

93 https://home.kpmg/xx/en/home/insights/2020/04/indonesia-government-and-institution-measures-in-response-to-covid.html

94 https://www.idnfinancials.com/news/35202/govt-remains-focused-implementing-indonesia

(10) Myanmar

Trends of Public Policies

- The government launched the COVID-19 Economic Relief Plan (CERP) comprising the following seven goals.[95]

  1. Improve macroeconomic environment through monetary stimulus
  2. Ease the impact on the private sector through improvement to investment, trade and banking sectors
  3. Easing the impact on labourers and workers
  4. Easing the impact on households
  5. Promoting innovative products and platforms
  6. Strengthening of health care systems
  7. Increase access to COVID-19 response financing

- In relation to advanced IT, the government proposes the promotion of the use of mobile payment services, especially targeting consumers, and encouragement of the use of e-commerce and social commerce systems by retail businesses as innovative products under Goal 5.

Trends of Industrial Associations, etc.

- Nothing special to report.

(11) UNIDO

In April, 2020, the UNIDO released a Director General's message on its response to COVID-19 and expressed that the UNIDO response to the COVID-19 crisis would be structured in the following three phases.[96]

- In the short-term, the UNIDO is helping its Member States in promptly responding to the health emergency.

- In the mid-term, the UNIDO provides advice on how to mitigate the impact of the disruption of productive activities and on reactivating the production and supply chains.

- In the aftermath of the crisis and in the long-term, the UNIDO will provide development support for Member States in the recovery phase.

This message was followed by the release of a position paper titled "Responding to the Crisis"[97] in May, 2020 to put forward concrete actions in these three phases. This position paper firstly

[95] https://globalcompliancenews.com/myanmar-the-covid-19-economic-relief-plan-20200504/
[96] https://www.unido.org/news/director-generals-message-member-states-unido-response-covid-19
[97] https://www.unido.org/sites/default/files/files/2020-05/UNIDO_COVID19_External_Position_Paper.pdf

calls for the gathering of information on country and global-level supply chains, targeting automotive, agro-food, textile and apparel, electronic and other sectors. Especially to ensure the business continuity of MSMEs, the paper urges better access to financial assistance packages and the promotion of innovation and implementation of the following measure for the manufacturing sector in the coming years.

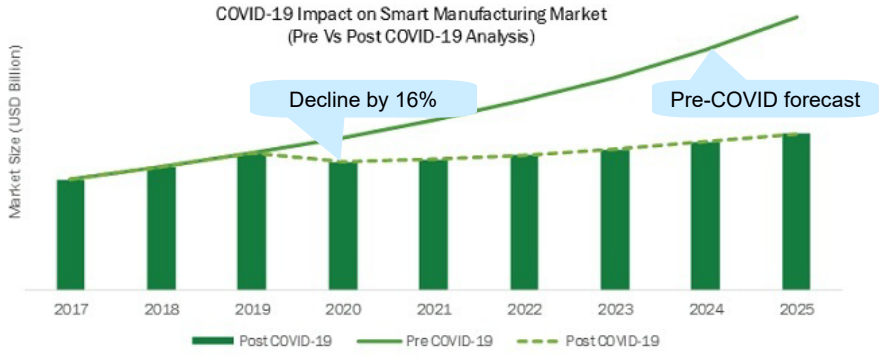
- Enabling of the manufacturing sector to build resilience by forging a partnership with the Fourth Industrial Revolution (4IR) initiatives, focusing on the reskilling of labour and leveraging instruments into digital infrastructure and innovative industrial solutions.

4.2.2 Impacts of COVID-19 on the Trends of New Technology-Related Markets

This section features those representative new technologies which are believed to contribute to the advancement of the manufacturing industry and describes how the market related to each new technology is affected by COVID-19 based on global trends as well as the trends in each target country of the Study.

(0) Global Trends

For the post-COVID-19 era, the size of the global smart manufacturing market is forecast to grow from US$ 181.3 billion in 2020 to US$ 220.4 billion in 2025 with the CAGR reaching 4.0%. Compared to the pre-COVID-19 estimate, the estimated value for 2020 has decreased by 16%. Factors to facilitate the growth of the smart manufacturing market include an increased demand for smart manufacturing products and solutions boosted by COVID-19, the importance of digital twins to maintain operations in a manufacturing ecosystem and the fresh expansion of cooperative robots in the health care and manufacturing industries.



Source: Press Release, Investor Relation Presentation, Annual Report, Expert Interview, and MarketsandMarkets Analysis

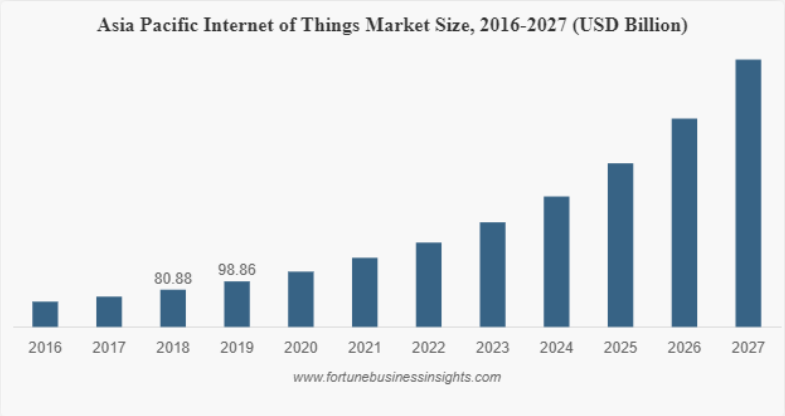
Figure-10 Predicted impact of COVID-19 on the smart manufacturing market[98]

[98] https://www.marketsandmarkets.com/Market-Reports/covid-19-impact-on-smart-manufacturing-market-131502510.html

The CAGR figure of 4% appears to be rather modest compared to the growth of the market size of individual advanced element technologies described later, suggesting that the use of cutting edge technologies has been on the conservative side in the manufacturing industry. The global market trends are described next for each new technology.

IoT

As far as the global IoT market is concerned, COVID-19 has caused relatively minor damage or has conversely acted as a promoting factor for the market. The market size actually increased from approximately US$ 150 billion in 2019 to US$ 243 billion in 2021 (CAGR: 13%) and is expected to further grow to record a high CAGR rate of 25% in 2027.[99] The forecast for the Asia Pacific IoT market size, taking the impacts of COVID-19 into consideration, is shown in Figure-11.



Source: Fortune Business Insights

Figure-11 Growth forecast for the Asia Pacific IoT market size (taking the impacts of COVID-19 into consideration)

The major factor driving market growth are acceleration of the use of the remote monitoring technology, digital twin technology and 5G based on real word information from sensors as a result of increased working from home, etc. and an expected substantial increase of such projects as smart farming, smart city projects, etc. which use a huge number of IoT devices. However, the increased number of large-scale information security incidents deeply involving IoT in recent years suggests a strong possibility that the security of IoT devices is becoming a major issue.

AI

The global AI market is expected to rapidly grow except for a minor dip due to the temporary stagnation of supply chains because of COVID-19 and the market size is forecast to grow from US$ 1.1 billion in 2020 to US$ 16.7 billion in 2026 with a CAGR of as high as 57.2%. The major factors for such phenomenal growth are the huge demand for the analysis of big data fed by a

[99] https://www.fortunebusinessinsights.com/industry-reports/internet-of-things-iot-market-100307

continually increasing number of IoT devices and the steadily increasing application fields for AI to replace activities performed by humans. The prominent use of AI in the manufacturing industry is the machine learning technology and the application of AI is expected to expand for preventive maintenance and machinery inspection. As AI is essential for the automatic driving of automobiles, the automobile industry is expected to constitute the largest AI market among all manufacturing industries.[100]

Big data analytics

The global big data size in the manufacturing industry was worth US$ 3.22 billion in 2018 and is projected to reach US$ 9.11 billion by the end of 2026 with a CAGR of 14.0% during the forecast period (2019 – 2026). The rapid advancements in the manufacturing industry in the USA and Canada are predicted to make North America command the largest share of big data in the next few years. As well as North America, the market in Europe will witness considerable growth in the coming years driven by the present of large manufacturing units in Germany and several other countries.[101]

Robotics

The global industrial robotics market is expected to grow from US$ 44.6 billion in 2020 to US$ 73 billion (CAGR: 10.4%). The projection for 2025 is estimated to be down by approximately -3% compared to the pre-COVID-19 estimate. Manufacturers are turning to automation in response to the shortage of skilled workers. With the ending of COVID-19, the demand for various industrial robots is expected to grow in all industrial segments, ranging from medium-sized automobile manufacturers to SMEs.[102]

On-Demand Manufacturing Technologies (3D Printers, etc.)

The global 3D printer manufacturing market is expected to decline from US$ 10.1 billion in 2019 to US$ 8.71 billion in 2020 (CAGR: -13.76%) mainly because of COVID-19 which has prompted such restrictive containment measures as social distancing, remote working and the closure of industries and other commercial activities. However, the market is expected to rapidly recover in the post-COVID-19 era to reach a market size of US$ 16.69 billion in 2023 (CAGR: 24.20%).[103]

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[100] https://www.researchandmarkets.com/reports/5134992/artificial-intelligence-in-manufacturing-market

[101] https://www.globenewswire.com/news-release/2020/06/04/2043472/0/en/Big-Data-in-Manufacturing-Industry-to-Exhibit-14-CAGR-till-2026-Increasing-Number-of-Company-Mergers-Will-Provide-Impetus-to-Market-Growth-says-Fortune-Business-Insights.html

[102] https://www.businesswire.com/news/home/20200424005397/en/COVID-19-Impact-on-the-Global-Industrial-Robotics-Market--Expected-to-Grow-at-a-CAGR-of-10.4-During-2020-2025-Down-by-3-on-the-Pre-COVID-19-Forecast--ResearchAndMarkets.com

[103] https://www.globenewswire.com/news-release/2020/06/30/2055349/0/en/3D-Printer-Manufacturing-Global-Market-Report-2020-30-Covid-19-Growth-and-Change.html

Manufacturing Execution System (MES)

The MES market is expected to grow from US$ 11.9 billion in 2020 to US$ 14.9 billion in 2025 with a CAGR of 4.5% from 2020 to 2025. For optimization of the output of manufacturing activities, it is essential to have process selection services in place and the introduction of MES is expected to drive such services forward amidst the COVID-19 pandemic. Meanwhile, the stance regarding capital investment is likely to be conservative because of the worsening profitability caused by a decline of the production volume and subsequent trend of saving aimed at restoring the cash flow. One typical example of declined production is observed with the automobile industry where the production volume fells as the supply chains for parts were hit by the lockdown in China. Consequently, the growth rate for the MES market is predicted not to meet the estimation of the pre-COVID-19 market scenario.[104]

Robotic Process Automation (RPA)

The global RPA market size was US$ 477 million in 2018 and is projected to grow to US$ 1,930 million by the end of 2025 with a CAGR of 21.4% between 2019 and 2025.[105] The COVID-19 pandemic has increased interest in RPA for many enterprises. As RPA can be introduced with relative ease to quickly generate positive investment effects, its market is expected to significantly grow in a short period of time. In the future, it is believed that the introduction of RPA will accelerate the financial and general affairs departments of a wide range of businesses in addition to the IT field.[106]

VR/AR

The global AR (Augmented Reality) and VR (Virtual Reality) spending is expected to increase more slowly from US$ 7.9 billion in 2019 to US$ 10.7 billion in 2020 (annual increase of 35.3% compared to the pre-COVID-19 forecast. However, the long-term outlook remains very positive as global spending is forecast to reach US$ 136.9 billion in 2024 (CAGR: 76.9%).[107] Under the prevailing COVID-19, there is a real chance of stronger long-term growth of AR/VR spending. In the manufacturing industry, AR/VR is often used for accumulation work at a factory, display of a manual in the assembly process and product inspection. More concrete examples are the use of smart glass to allow work hands to be free and checking of a manual without shifting the line of sight, enabling efficient work instructions remotely in addition to the expected positive effects of an efficient work performance and reduction of mistakes. According to a study by the International Data Corporation (IDC), investment in AR/VR in the manufacturing industry is

[104] https://www.marketsandmarkets.com/PressReleases/mes.asp
[105] https://www.prnewswire.com/news-releases/robotic-process-automation-rpa-market-size-to-reach-usd-1930-million-by-2025-valuates-reports-301078751.html
[106] https://www.gartner.com/en/newsroom/press-releases/2020-09-21-gartner-says-worldwide-robotic-process-automation-software-revenue-to-reach-nearly-2-billion-in-2021
[107] https://www.idc.com/getdoc.jsp?containerId=prEUR146720420

expected to be US$ 5.9 billion for discrete manufacturing and US$ 5.1 billion for process manufacturing in the five years from 2020 to 2024.[108]

Blockchain Services

Global blockchain services were expected to decline from US$ 1.26 billion in 2019 to US$ 1.06 billion in 2020 with a CAGR of -15.8%. This was mainly due to the economic slowdown in many countries because of the COVID-19 pandemic and measures employed to contain it, which had a negative impact on industries and resulted in low investment in technology. The market is expected to recover after the pandemic has ended to reach US$ 4.36 billion in 2023 with a CAGR of as high as 60.01%.[109]

The market trends related to these new technologies and the impacts of the COVID-19 pandemic in the target countries of the Study are described next.

(1) Germany

Table-19 Trends of New Technology-Related Markets and Impacts of COVID-19 in Germany

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	The German IoT market is expected to significantly grow with a CAGR of approximately 21% during the forecast period from 2019 to 2025 (although this forecast does not take the impacts of COVID-19 into consideration). It is estimated that 26% of German enterprises currently do not use or plan to use cloud services for their operations. This indicates the huge market potential offered by Germany's private sector for cloud adoption and the expanding need for diverse cloud services.[110] (The German IoT market is segmented on the basis of infrastructure, business type and application. Based on infrastructure, the market is segmented in platform, mobile network and access technologies, cloud solution/storage and processing, analytics and security.)
AI AR/VR	According to a position paper titled "Ten Propositions on the Future of Digital Business Models for Industrie 4.0 in the Post-Corona Economy" published by Plattform Industrie 4.0 which supports the DX-related activities of German manufacturers at home and abroad, the importance of AR/VR, cooperative robotics and industrial AI will further increase.[111]
Big Data Analytics	Although the German big data market still appears to be at an early stage, an expert group expects the German big data market to grow from € 1.4 billion in 2015 to almost € 3.8 billion in 2020. Correspondingly, the CAGR during this period is predicted to be 23%. At present, big data technology in Germany is largely driven by the Internet, e-commerce and advertising sectors. However, because of its competitiveness and export orientation, the German economy is expected to quickly adapt to the need for optimized production, logistics and sales processes to become an international "big data champion" according to BITKOM. Accordingly, the most important investment opportunity areas for suppliers are hardware and infrastructure, bandwidth and related acceleration services and, more particularly, database and analytics technologies.[112]

[108] https://www.idc.com/getdoc.jsp?containerId=prus47012020
[109] https://www.reportlinker.com/p05930668/Blockchain-Services-Global-Market-Report-30-Covid-19-Growth-and-Change.html
[110] https://www.omrglobal.com/industry-reports/germany-iot-market
[111] http://www.platform-i40.de/IP/Redaktion/EN/Downloads/Publikation/Corona-Thesen.html
[112] https://www.gtai.de/gtai-en/invest/industries/information-technologies/software#75658

New Technology	Trends of Related Markets and Impacts of COVID-19
Robotics	・ The total turnover of robotics and automation was initially predicted to decline by 10% but is now predicted to drop by at least 20% as a result of COVID-19. However, the growth prospect after COVID-19 appears to be positive.[113] ・ The European Commission has launched the AI-Robotics vs COVID-19 Initiative, providing ideas on extendable AI and Robotic Solutions and information on other initiatives which may be useful to deal with the ongoing COVID-19 crisis.[114]
On-Demand Manufacturing Technologies (3D Printer, etc.)	As Europe has several large additive industry players with strong technical expertise in additive manufacturing processes, it is expected that the status of the European market as the second largest regional market in this area will continue for a few more years.[115]
MES	Before the outbreak of COVID-19, the size of the MES market in Germany was expected to grow by more than US$ 619.6 million in 5 – 6 years. Meanwhile, the demand for German MES providers from other countries is expected to be more than US$ 877 million.[116]
RPA	The outbreak of COVID-19 pandemic has revealed the extent to which enterprises have been intensively involved in RPA. At present, budget cuts and working from home means tighter resource availability and a deterioration of the customer experience. However, by automating repetitive administrative activities and allowing employees to focus on customer-centric activities, the quality of customer experience can still be maintained at a satisfactory level. In turn, this has a positive effect on the earnings situation of enterprises in the short-term as well as long-term.[117]
Blockchain	Under the cloud of the COVID-19 pandemic, the CAGR for the blockchain market (2020 – 2027) is forecast to be approximately 43.1%.[118]

(2) United States

Table-20 Trends of New Technology-Related Markets and Impacts of COVID-19 in the USA

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	・ Scenario for the post-COVID-19 use of IoT ➢ Smart manufacturing system to optimise production and containing unplanned shut-downs to the minimum with predictive maintenance ・ Scenario for the post-COVID-19 use of digital twin ➢ Manufacturing: defining support for predictive maintenance, optimisation of operational efficiency and asset maintenance strategy ➢ Automated process: monitoring of relevant aspects of product status to support the detection of problems regarding product quality
AI	According to the latest survey conducted by the National Association of Manufacturers (NAM), approximately 78% of manufacturers anticipate a financial impact of COVID-19 and 35.5% of manufacturers are facing supply chain disruptions.[119] Because of COVID-19, enterprises, manufacturing units and factories have stopped their DX strategy, including the installation of AI at manufacturing units. As a result, AI in the manufacturing market is expected to suffer a severe impact in 2020. However, the market is anticipated to rapidly expand from 2021 with the end of COVID-19. In the new post-coronavirus manufacturing industry, automated manufacturing processes and industrial robots, both of which are already important, are expected to become highly adaptable and reprogrammable in the future through AI and software (meaning that robotized and automated cells are managed by software, loading different recipes as requires so that the production process can be easily modified).[120]

113 https://www.gtai.de/gtai-en/invest/industries/the-robots-are-coming-innovative-solutions-for-covid-19-crisis-244106
114 https://www.vision-systems.com/factory/article/14178662/vdma-german-robotics-and-automation-markets-will-drop-20-in-2020
115 https://www.grandviewresearch.com/industry-analysis/3d-printing-industry-analysis
116 https://www.marketsandmarkets.com/Market-Reports/manufacturing-execution-systems-mes-market-536.html
117 https://omm-solutions.de/2020/04/30/rpa-wird-post-covid-19-unternehmen-befahigen-alten-balast-abzuwerfen/
118 https://www.globenewswire.com/news-release/2020/07/10/2060838/0/en/Global-Blockchain-Technology-Industry.html
119 https://www.nam.org/manufacturers-survey-reveals-current-industry-impact-of-covid-19-7411/
120 https://managementevents.com/news/after-covid-19-the-new-manufacturing-normals/

New Technology	Trends of Related Markets and Impacts of COVID-19
Big Data Analytics	According to a report on the big data market in the manufacturing industry, North America is projected to account for the largest big data manufacturing industry share in the coming years among all regions. Rapid advancement in the manufacturing industry in the USA and Canada will aid the growth of the market in this region.[121]
Robotics	Post-COVID key usage scenarios for autonomous robotic systems:[122] ・ Transportation, including autonomous vehicles and other passenger vehicles ・ Automated distribution, delivery and warehousing ・ Unmanned Aerial Vehicles (UAVs) used in multiple deployment scenarios, including site and asset surveying ・ Manufacturing and production line processing robots ・ Automated operations in agriculture ・ Precision robotics in health care
On-Demand Manufacturing Technologies (3D Printer, etc.)	Impacts of COVID-19 on the 3D printing industry[123] ・ Joining together of 3D printing community to support countermeasures for COVID-19 ・ Short-term: Hardware sales are affected by restrictions imposed by a spending limit ・ Short-term: Increase of the operating rate per unit to become "participation by all" type ・ Long-Term ➢ Will responses to COVID-19 become demonstration fields for the 3D printing technology? ➢ Will enterprises employ more 3D printers as a back-up plan for supply chain disruptions?
MES	Dominance of North America of the MES market: North America has been a significant contributor to the growth of the overall MES market owing to the increasing use of manufacturing execution system (MES) in process and discrete industries in the region and the presence of players developing MES solutions are some of the driving factors for the growth of the MES market in North America.[124] While growth of the North American market for manufacturing execution systems has slowed down, it is still expected to have the largest share of the global market in 2021. There has been a significant decline of the market size from 2019 to 2020 due to the region-wide lockdown.
RPA	The use of robotic process automation (RPA) is rapidly increasing as its use has been accelerated by the impact of COVID-19. As enterprises have lost key staff members and the vulnerability manual business processes has been exposed by the COVID-19 pandemic, many enterprises have had no choice but to rely on automation to continue their business. Because of this, the share of enterprises which will have scaled up their automation technology is expected to at least double in the next two years depending on the specific technology area of low-code automation, optical character recognition (OCR), RPA or interactive AI.[125]
VR/AR	Post-COVID-19 key usage scenarios for mixed reality (MX):[126] ・ Digital twins of objects, manufacturing floors, entire factories or construction sites can be created using real-time data and imagery collected by IoT devices and mixed reality (XR) technologies. This enables such activities as remote quality assurance and monitoring.
Blockchain	In the midst of COVID-19, the blockchain technology market in the USA is estimated to be US$ 1.4 billion in 2020. The USA currently accounts for a 30.6% share of the global market.[127]

[121] https://www.globenewswire.com/news-release/2020/06/04/2043472/0/en/Big-Data-in-Manufacturing-Industry-to-Exhibit-14-CAGR-till-2026-Increasing-Number-of-Company-Mergers-Will-Provide-Impetus-to-Market-Growth-says-Fortune-Business-Insights.html

[122] https://www.iiconsortium.org/pdf/Digital_Transformation_in_Industry_Whitepaper_2020-07-23.pdf

[123] https://www.idc.com/getdoc.jsp?containerId=WC20200408

[124] https://www.marketsandmarkets.com/PressReleases/mes.asp

[125] https://www.supplychaindive.com/news/coronavirus-robots-robotics-automation-manufacturing-operations/576743/

[126] https://www.iiconsortium.org/pdf/Digital_Transformation_in_Industry_Whitepaper_2020-07-23.pdf

[127] https://www.globenewswire.com/news-release/2020/07/10/2060838/0/en/Global-Blockchain-Technology-Industry.html

(3) China

Table-21 Trends of New Technology-Related Markets and Impacts of COVID-19 in China

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	Chinese manufacturers are looking to resume their production of goods despite a labour shortage. Lenovo utilizes 5G, IoT and robotics technologies to enable intelligent manufacturing at its Wuhan manufacturing plant. High precision intelligent robots, coupled with automated processes, have enable the resumption of production with a limited human workforce (April, 2020).[128]
AI	The biggest impact of COVID-19 on the AI market in China is the increase of AI applications for robotics contributing to labor saving (unmanned operation), voice recognition to prevent human-to-human interactions and other fields.[129] IDC, an IT-related research firm, predicts that for the ICT market in China, the AI and big data markets will rapidly expand (described by the term "leapfrog" in the coming years because of COVID-19.[130]
Big Data Analytics	The Chinese government is continuing its "Made in China 2025" policy through the COVID-19 pandemic and has issued an official notice of the disbursement of a total of 700 million CNY (approximately 10,542 million yen) for research on methods to make factory production more efficient using big data and the 5G mobile communication system and other research work. Part of this spending will be allocated to weapons production. A further 500 million CNY will be made available for research on precision parts used for aerospace, automobiles, railways and nuclear power plants.[131]
Robotics	The robotics market in China is forecast to grow at a CAGR of 26.2% to reach US$ 103.6 billion in 2023. The market is primarily led by manufacturers, consumers, retails, health care providers and resource industries. The outbreak of COVID-19 is expected to have a positive impact on the use of robots in health care.[132]
On-Demand Manufacturing Technologies (3D Printer, etc.)	In 2017 before the outbreak of COVID-19, the Chinese government announced the "Additive Manufacturing Industry Development Action Plan (2017 – 2020)", calling for the creation of an additive manufacturing industry of which the turnover would reach US$ 3 billion by 2020.[133] This Action Plan forms part of the "Made in China 2025" strategic roadmap for the manufacturing sector and outlines the long-term ambition and development targets to make China a leading country in the 3D printing business. One of the highlights of this plan is to conduct 100 pilot projects across 10 key industries, including the medical, cultural, educational and Internet sectors. To achieve these targets, China fosters promising AM enterprises, supports the standardization of the country's AM industry and invests in the development of a 3D printing-related workforce. For example, China has opened the Baiyun Winbo 3D Printing Technology College, the first 3D printing college in the world, in Guangzhou. China also plans to install a 3D printer at 400,000 primary schools nationwide. It is believed that these initiatives will enable Chinese people to receive a 3D-related education from childhood and become familiar with 3D technologies, thereby bringing benefits to Chinese society in the long-term.
MES	As the world's second largest economy and a new game changer in global markets, Chinese MES market exhibits growth potential of 17.5% for the next couple of years and may add approximately US$ 2.7 billion to the market.[134]

[128] https://www.accenture.com/_acnmedia/PDF-121/Accenture-How-China-is-Using-Digital-and-Technologies-to-Combat-COVID-19.pdf
[129] https://cset.georgetown.edu/wp-content/uploads/CSET-Chinas-Use-of-AI-in-its-COVID-19-Response-1.pdf
[130] https://www.idc.com/getdoc.jsp?containerId=IDC_P40811
[131] https://www.sankeibiz.jp/macro/news/200518/mcb2005180500003-n1.htm
[132] https://www.idc.com/getdoc.jsp?containerId=us44623420
[133] https://3dprintingindustry.com/news/china-action-plan-3d-printing-3-billion-2020-126119/
[134] https://www.globenewswire.com/news-release/2020/04/04/2011787/0/en/Global-Manufacturing-Execution-Systems-MES-Industry.html

New Technology	Trends of Related Markets and Impacts of COVID-19
RPA	During pre-COVID-19 times, the IPA (RPA + AI) market size in the APAC region was expected to grow at the fastest rate among all regions and to reach US$ 3,515 million, growing at a CAGR of 14.3% during the forecast period from 2020 to 2025. This high growth rate is due to the increasing adoption of the IPA technology and the presence of several outsourcing vendors in China and India.[135]
VR/AR	According to data of IDC China, the consumption of China's AR/VR industry in 2018 was 3 billion CNY. Experts predict a rapid growth trend from 2019 to 2023. The CAGR will reach 77.8%. By 2023, consumption will be more than 65 billion CNY. China plans to lead the global VR market. In 2018, the Chinese government released a document stating how it wants to commit to VR development in China. This document is titled "Guiding Opinions of the Ministry of Industry and Information Technology on Accelerating the Development of the Virtual Reality Industry" and has been released by the Chinese Ministry of Industry and Information Technology. In 2020, China expects to have a working VR ecosystem and growing infrastructure to create VR products and services. China plans to become the world leader of the virtual reality industry in 2025. The government wants to see the growth of not only the manufacture of headsets but also such innovative technologies as chips, screens, UX, 3D modelling, motion capture, data processing and positional tracking.[136]
Blockchain	In April, 2020, the Chinese government began serving the Blockchain-Based Service Network (BSN) which is the national level common blockchain infrastructure planned for some time despite the COVID-19 pandemic.[137] The BSN is an open blockchain development platform for general use which anyone can use.[138] IDC predicts that blockchain spending by Chinese enterprises will reach US$ 2 billion in 2023. While the banking sector tops the table of blockchain spending by sector, other sectors, including manufacturing, retailing, professional services and process manufacturing, have begun applying this technology. China's trade association for metals is already developing a blockchain consortium to cover the entire steel supply chain.[139]

(4) India

Table-22 Trends of New Technology-Related Markets and Impacts of COVID-19 in India

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	IoT in India in the manufacturing market was forecast (before the start of the COVID-19 pandemic) to grow at a phenomenal speed in the forecast period from 2019 to 2025 as it would be driven by the need for automation and improvement of the operating efficiency of manufacturing units. It is now predicted that market growth will be further facilitated by 2025 due to the increased use of cloud-based solutions and connection devices. Such technological advancement as the use of big data analytics solutions and data processing offered by the relevant vendors in the market will push market growth for the next several years along with the marketing of new services and software by the main service providers. However, when the cost of the installation and actual use of IoT solutions at manufacturing units becomes high, there is a possibility that market growth will be suppressed. Moreover, a lack of understanding concerning the use of IoT solutions in various end user industries may further restrict market growth.[140]

[135] https://www.marketsandmarkets.com/Market-Reports/covid-19-impact-on-intelligent-process-automation-market-39284189.html
[136] https://daxueconsulting.com/virtual-reality-market-in-china/
[137] https://techcrunch.com/2021/02/03/bsn-china-national-blockchain/
[138] https://bsnbase.io/g/main/index
[139] https://www.ledgerinsights.com/china-blockchain-platform-for-steel-industry/
[140] https://www.techsciresearch.com/report/india-iot-in-manufacturing-market/2046.html

New Technology	Trends of Related Markets and Impacts of COVID-19
AI	According to "AI: An opportunity amidst a crisis"[141] released by PWC India in December, 2020, India has recorded the world's highest increase of the use of AI in the midst of the COVID-19 pandemic. India has the highest ratio of organizations which have increased their adoption of AI due to COVID-19 with 45%, followed by the USA with 35%, Japan with 28% and the UK with 23%. The ratio of Indian organizations replying that AI has helped to create more business opportunities was as high as 94%. The ratio of organizations which have implemented AI for some business functions was 46% in India compared to the global average of 28%. In the manufacturing sector, AI is most frequently adopted for supply chains and logistics. Those enterprises which have adopted AI replied that AI has proved highly effective. The training of current employees to use AI systems is listed as one of the top inhibitors for the adoption of AI for manufacturing.
Big Data Analytics	When India emerged from its COVID-19 lockdown in May, keeping factory workers safe from infection became an urgent priority. Artificial intelligence solutions, such as big data analysis, can help businesses to monitor social distancing and the use of protective gear and facilitate contact training in the event of a worker testing positive for COVID-19.[142]
Robotics	Data of the International Federation of Robotics shows that India ranks low in the pecking order of robotic adoption, being only 11th in terms of annual robot installation globally with less than 5,000 units installed in 2018. In comparison, China installed 154,000 robots and Japan 55,000. Auto component makers are currently expected to take the lead but a higher rate of adoption is also expected for engineering and electronic manufacturing firms. Small firms are unlikely to invest in Industry 4.0 technologies although low cost automation with the possibility of a positive financial return within a year could become popular.[143]
On-Demand Manufacturing Technologies (3D Printer, etc.)	Such industries as automotive, defence, health care and aerospace have been early adopters of 3D printing in India. On June 4, 2020, HP announced the expansion of its 3D printing services. The value of the Digital Manufacturing Network has only increased in the past few months in the wake of COVID-19.[144]
MES	The APAC region is expected to grow with the highest CAGR in the manufacturing execution system market during the forecast period from 2020 to 2025. The demand for MES is very high in the APAC region to implement the change from manual or legacy systems to automated systems. Another reason for the growth of the MES market in the APAC region is the increase of the number of manufacturing plants in various sectors, such as automotive, textiles, power and pharmaceuticals where manufacturing execution systems are in high demand. China and India are considered to be the growth engines for the MES market in the APAC region.[145]
RPA	Many manufacturing enterprises have achieved rationalization of the swift operation of entire value chains using RPA and also a cost reduction at various touch points. Because of the impact of COVID-19, these enterprises have found a strong driving force to move to RPA.[146]

[141] https://www.pwc.in/assets/pdfs/data-and-analytics/ai-an-opportunity-amidst-a-crisis.pdf

[142] https://www.weforum.org/agenda/2020/07/factory-workers-face-a-major-covid-19-risk-here-s-how-ai-can-help-keep-them-safe/

[143] https://www.livemint.com/news/india/india-inc-wakes-up-to-march-of-the-machines-11595162345268.html

[144] https://www.inventiva.co.in/stories/tamanna/covid-19-what-is-the-future-of-the-manufacturing-industry-in-india/

[145] https://www.asdreports.com/market-research-report-545904/manufacturing-execution-system-market-with-covid-impact-global-forecast

[146] https://www.livemint.com/companies/news/automation-enables-indian-organisations-to-wade-through-logistics-issues-exposed-by-covid-19-11591961477961.html

New Technology	Trends of Related Markets and Impacts of COVID-19
VR/AR	The demand for VR/AR solutions is rapidly increasing because of the COVID-19 pandemic. The main demand comes from manufacturing enterprises which need to constantly train their staff. Because it is not possible to physically receive trainers, their demand for training by VR has increased. In addition, the demand for remote trouble-shooting for high-end machinery underpins such demand. [147] Medical device manufacturers and health care organizations have a shortage of skilled workers due to COVID-19. With the use of AR, training and knowledge transfer can be achieved in a faster and smarter way. AR instructions can be easily published and viewed for a wide range of devices across an enterprise.[148]
Blockchain	The blockchain technology is expected to be increasingly used among Indian banks. Both private and public enterprises are searching for a blockchain to improve efficiency to ensure their transparency. 56% of Indian enterprises have shifted to the blockchain technology, making blockchain part of their core business. The fields in which this technology is anticipated to have the maximum effect are payments and fund transfer, settlement after trade agreement and digital ID. The state government of Andhra Pradesh planned a study on the blockchain management process with the cooperation of various emerging blockchain enterprises such as Snapper technologies and SimpleFy with a view to integrating its own e-programme and blockchain technology by 2019.[149]

(5) Indonesia

Table-23 Trends of New Technology-Related Markets and Impacts of COVID-19 in Indonesia

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	At the factory level, increased automation is expected through IoT platforms for production processes. The implementation of blockchain payments for trusted suppliers of parts, components and subsystems is also possible. AI-predictive maintenance solutions are expected to emerge. (March, 2020)[150]
AU	・ Identified future technological trends and opportunities in automotive (electric, hybrid and autonomous vehicles): Predictive maintenance for industrial operations using AI and the use of AI for decision-making in production processes ・ Identified future technological trends and opportunities in textiles, clothing and footwear: Widespread deployment of low cost AI, IoT and robotics for improved quality, productivity, waste reduction and energy efficiency (quality control and preventive maintenance, use of big data for quality verification and traceability, AI, robotics and 3D printing are mainly used for production and assembly while cloud and big data analytics are mainly used for finance). (March, 2020)[150]
Big Data Analytics	
Robotics	
On-Demand Manufacturing Technologies (Potential of Combined Use of Multiple Technologies Such as 3D Printing and IoT, etc.)	A variety of digital technologies, from 3D printing to the Internet of things (IoT), big data, robotics, e-commerce and finance technology (fintech) are expected to find transformational applications in food and beverages in the next 10 years. In the short-term, the development of new manufacturing and production processes in Indonesia based on 3D printing techniques for innovative bottle and package design, IoT-based product traceability tools for quality control across supply chains and low-cost automated food and beverage processing machines are foreseen. In the medium-term, expected innovations include the development and deployment of centralized smart production control techniques to maximize energy efficiency and minimize waste and barcode-based labelling for IoT coupled with big data analytics for product and input traceability. (March, 2020) [150]

[147] https://economictimes.indiatimes.com/tech/software/ar-vr-and-new-age-tech-companies-report-increase-in-demand-as-covid-19-grounds-workforce/articleshow/74871031.cms

[148] https://www.expresshealthcare.in/covid19-updates/covid-19-update-ar-and-vr-technologies-are-positively-impacting-healthcare-manufacturers/423257/

[149] https://www.marketwatch.com/press-release/india-blockchain-technology-market-2020-business-trends-covid-19-impact-analysis-historical-study-future-scope-and-industry-profit-growth-2020-06-01

[150] https://www.adb.org/sites/default/files/publication/575806/innovate-indonesia-unlocking-growth.pdf

New Technology	Trends of Related Markets and Impacts of COVID-19
MES	No relevant information is available.
RPA	Some enterprises replied that they had introduced RPA to improve the work efficiency of the administration department. (Based on interview results)
VR/AR	Virtual reality applications for skill development in the electronics industry: Virtual reality applications were discussed as new opportunities, including as support for various kinds of manufacturing and sales training and skills development in virtual environments. (March, 2020) [150]
Blockchain	Sectoral trends and driving factors: It is expected that the advent of new vehicles with low carbon emissions, including plug-in hybrid cars (electric vehicles and vehicles powered by biofuel, fuel cells and flexible-fuel engines) will make industries experience major short and medium-term technological changes. At the factory level, increased automation is expected through IoT platforms for production processes. The implementation of blockchain payments for trusted suppliers of parts, components and subsystems is also possible. (March, 2020) [150]

(6) Myanmar

In Myanmar, the "Software and Network Engineer Training Project" implemented from 2006 to 2011 has led to a rapid increase in the development of IT human resources, partly due to the introduction of a curriculum that can train ready-to-work engineers at all 26 computer universities across the country. However, there is no industry (demand) in country that can absorb the IT human resources, and the country is not in a position to upgrade its manufacturing industry using new technology, so it is positioned as a rare country that can supply surplus IT human resources overseas. As a result, there are hardly any new technology-related markets within Myanmar as shown in the following table.

Table-24 Trends of New Technology-Related Markets and Impacts of COVID-19 in Myanmar

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	-
AI	-
Big Data Analytics	-
Robotics	(For reference: Two locally designed and manufactured robots that may help to prevent the spread of COVID-19 have been deployed at the makeshift Pyaunggyi COVID-19 medical center on the outskirts of Yangon. These robots will be used at the medical center to transport food, medicine and trash, reducing contact between health care workers and patients and lowering the risk of spreading the coronavirus.[151]
On-Demand manufacturing Technologies (3D Printer, etc.)	-
MES	-
RPA	-
VR/AR	-
Blockchain	-

[151] https://www.irrawaddy.com/specials/myanmar-covid-19/myanmar-universities-invent-robots-prevent-spread-covid-19-hospitals.html

(7) Malaysia

Table-25 Trends of New Technology-Related Markets and Impacts of COVID-19 in Malaysia

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	With the COVID-19 crisis pushing the adoption of technology to levels previously unseen, government agencies now need to align with each other to develop a digital economic framework. Chong Kai Wooi, the MD of NEC Corp of Malaysia Sdn Bhd, said the framework should include securing all data, including biometric information, to convince the public that the transition to a digital economy will be seamless. He also said that the pace of regulatory framework updates is one of the key factors to drive the adoption of innovative digital technologies, such as biometric and artificial intelligence (AI).[152] In the government's National Fiberisation and Connectivity Plan 2 and 5G plans, there will be more cases of industry use to support and accelerate the adoption of the latest biometric and AI technologies. Going forward, the focus will be on surrounding the government's push for a digital economy where biometric and AI technologies are the key factors.
AI	-
Big Data Analytics	-
Robotics	-
On-Demand Manufacturing Technologies (3D Printer, etc.	(For reference: Rashvin Pal Singh, the CEO of Biji Biji Design Sdn Bhd Group has launched the Biji-Biji Initiative to solve the critical shortage of personal protective equipment (PPE) and is cooperating with Taylor's University and the 3D printing community, including Nurfaiz Foat and Wan from 3D Printing Malaysia and Mak Kwan Wuey from Makerzone, to help meet the demand.)[153]
MES	-
RPA	(For reference: Adaption to post-COVID business environment: A public listed real estate development company in Malaysia which had prepared for aggressive business growth engaged the RPA team of Deloitte for RPA-enabled BPI services, focusing on the digitization and automation of key processes for sales and marketing, credit administration and finance with the following objectives: (i) improvement of process efficiency, (ii) reduction of human error and (iii) scaling up and sustaining of growth.)[154]
VR/AR	-
Blockchain	(For reference: The Malaysia Palm Oil Council (MPOC) is looking to utilize the blockchain technology and traceability to raise the level of trust in its local palm oil industry by proving its commitment to transparent, sustainable and responsible supply chains. There is no prediction for the future of merchandise as "many changes are rapidly taking place in response to COVID-19").[155]

[152] https://iotbusiness-platform.com/blog/why-a-digital-economy-framework-is-vital-the-malaysian-reserve/

[153] https://www.thestar.com.my/tech/tech-news/2020/03/23/malaysian-3d-printers-produce-face-shields-to-aid-frontliners-in-the-fight-against-covid-19

[154] https://www2.deloitte.com/content/dam/Deloitte/my/Documents/risk/my-risk-thriving-business-post-covid19-cost-optimisation.pdf

[155] https://www.foodnavigator-asia.com/Article/2020/05/04/Blockchain-for-palm-oil-Malaysia-looks-to-technology-and-traceability-to-foster-industry-trust

(8) Thailand

Table-26 Trends of New Technology-Related Markets and Impacts of COVID-19 in Thailand

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	The National Electronics and Computer Technology Center (NECTEC) has developed a platform for Industrial IoT (Internet of Things) and Intelligent Data Analytics (IDA), which is based on NECTEC's intention to develop an intelligent Industry 4.0 system for Thailand. This is based on NECTEC's desire to develop an Industry 4.0 system. An important aspect of Industry 4.0 is the interconnection of factory machines. This allows the performance, energy consumption, and production capacity of individual machines to be monitored in real time, along with other factors. Factories in the post-COVID-19 economy are expected to produce only to order, with an accurate understanding of product design and related production processes[156]. In anticipation of such a future, the need for IoT training is said to be increasing from companies that are adjusting their production under COVID-19. (Based on the results of the interview survey)
AI	The NECTEC wants Thailand to begin to develop its own robots for use in factories. It is also considering the production of devices to make warehouses "smarter" and equipping factories with artificial intelligence technology to examine manufactured products, manage quality control and monitor entire production processes via cameras and sensors[156].
Big Data Analytics	-
Robotics	The NECTEC wants Thailand to begin to develop its own robots for use in factories. It is also considering the production of devices to make warehouses "smarter" and equipping factories with artificial intelligence technology to examine manufactured products, manage quality control and monitor entire production processes via cameras and sensors[156].
On-Demand Manufacturing Technologies (3D Printer, etc.)	With the need for social distance caused by COVID 19, Thai manufacturing sites are faced with the need to move to the New Normal to avoid causing productivity loss due to it. There will be an increased use of robots and automation at industrial plants, particularly blockchain, IoTs, additive manufacturing and artificial intelligence.[157]
MES	-
RPA	The use of RPA in Thailand is predicted to continually grow. As a result of the COVID-19 pandemic, there is a possibility for the RPA technology to assist various business sectors to enable the strengthening of business process engineering and the achievement of targets. Such a possibility includes process enhancement, improved customer experience, improved service provision and cost reduction. In a survey on the situation of DX by the government, many Thai enterprises expressed an interest in employing RPA for their businesses. The value of the RPA service in Thailand was predicted to more than double in 2019 and the strong market demand is expected to continue in 2020.[158]
VR/AR	Future trends for manufacturing: Japanese subsidiaries with their leading production bases in Thailand predict that they are likely to not only implement conventional work specializing in production functions on the instructions of their head office but also to increase their role in the development of new clients, markets and needs in Thailand and neighbouring countries and also in the enhancement of their business strength. ・ Implementation of the digitalization of technologies and thorough labour saving: ➢ Implementation of measures looking to the future, starting with skilled workers ➢ Using the severe labour shortage as a tail wind, thorough labour saving efforts will be made at the production floor using AI, IoT, robotics, VR and AR. Efforts will be made to convert the implicit knowledge of skilled and veteran workers into explicit knowledge.[159]

156 https://www.th.emb-japan.go.jp/itpr_ja/pr2020_09.html
157 https://assets.kpmg/content/dam/kpmg/th/pdf/2020/06/managing-in-the-new-normal-thailand.pdf
158 https://opengovasia.com/tech-industry-feels-increasing-impact-of-coronavirus-outbreak/
159 https://assets.kpmg/content/dam/kpmg/th/pdf/2020/05/presentations-live-covid-19-gjp-20200515.pdf

New Technology	Trends of Related Markets and Impacts of COVID-19
Blockchain	The manufacturing scene in Thailand is transiting to a new normal amid the uncertainty caused by COVID-19 and the concept of social distancing will be implied for production plants and workers There will be an increased use of robots and automation at industrial plants, particularly blockchain, IoTs, additive manufacturing and artificial intelligence[157].

(9) Vietnam

Table-27 Trends of New Technology-Related Markets and Impacts of COVID-19 in Vietnam

New Technology	Trends of Related Markets and Impacts of COVID-19
IoT	(For reference: FPT Software has recently collaborated with Vietnam's Ministry of Information and Communications to launch an AI-powered website application that provides real-time data on the Coronavirus (COVID-19) and at-home assessment of the infection risk. The "Corona Check" web application developed by FPT Software's flagship product akaChain provides a free and easy to use tool to detect COVID-19 infection with the assistance of artificial intelligence (AI) technology. When a user enters the locations of frequent visits, the AI algorithm automatically calculates the probability of infection based on the government's updated records of confirmed cases, travel history and highly infectious areas.)[160]
Big Data Analytics	-
Robotics	-
On-Demand Manufacturing Technologies (3D Printer, etc.)	-
MES	-
RPA	(For reference: The existing customers of FTP's featured product akaBOT were given three extra months' free use of the annual robotics process automation (RPA) license.)[161]
VR/AR	-
Blockchain	(For reference: Application of the blockchain technology could significantly streamline Vietnam's main industries, i.e. services, manufacturing and agriculture. This means that the wide scale adoption of the distribution ledger technology has the power to propel the economy far beyond its current state. While blockchain is still unregulated by the authorities, legislation is expected as it could provide a much-needed financial boost for the country.)[162]

4.2.3 Impacts of COVID-19 on Locally Operating Foreign Manufacturers and Supporting Industries

(0) Overview

Manufacturing industries around the world are affected by the COVID-19 pandemic although the degree of impact on locally operating foreign subsidiaries and supporting industries in the target countries of the Study varies from one country to another. The situation of each country is described next using the following sites as common information sources for all of the target countries.

[160] https://www.fpt-software.com/fpt-software-steps-up-covid-19-fight-with-artificial-intelligence/
[161] https://www.businesswire.com/news/home/20200421005962/en/FPT-Helps-Businesses-Automate-COVID-19-RPA-Offers
[162] https://vietnaminsider.vn/is-vietnams-hesitance-to-embrace-crypto-exchanges-hampering-economic-growth/

- JETRO: Special Issue: Impacts of Increasing New Corona Virus Infection (in Japanese)[163]
- NLI Research Institute: Prospect for Southeast Asian Economy – Slow Pace of Business Recovery Due to Lengthy Deterioration of External Demand Despite Accelerating the Opening of Economic Activities (in Japanese)[164]

(1) Germany

a) General situation of the manufacturing sector

The impact of COVID-19 on the German manufacturing industry has been very serious. In the case of the automobile industry which is a leading industry in Germany, the German Association of the Automotive Industry (VDA) has announced that the domestic production volume of passenger cars in 2020 was 3,508,500, a 24.8% decline on the previous year, recording the lowest output in the last 45 years. The number of exported passenger cars was 2,633,100, a 24.5% decline on the previous year. According to the Federal Motor Transport Authority (KBA), the number of newly registered passenger cars in Germany in 2020 was 2,917,678, a 19.1% decline on the previous year. The rate of decline was 36.3% for petrol engine vehicles and 28.9% for diesel engine vehicles. Meanwhile, battery-powered electric vehicles (BEV) and plug-in hybrid electric vehicles, both of which are low emission vehicles, enjoyed a year-on-year increase of 206.8% and 342.1% respectively.

From the viewpoint of preventing global warming, the German government announced an economic stimulus measure in June, 2021 to provide a subsidy (6,000 euros = 720,000 yen) only for those citizens prepared to buy either a BEV or PHEV of which the price is up to 40,000 euros (4.8 million yen). It is believed that this measure will lead to the increased purchase of BEVs and PHEVs.

b) Impacts on locally operating foreign manufacturers

On December 21, 2020, JETRO announced the results of the questionnaire survey with Japanese subsidiaries operating in 15 Western European countries and 8 Central and Eastern European countries (survey period: September 3 to September 24; 949 enterprises responded of which 286 are operating in Germany). The ratio of enterprises expecting a positive balance in 2020 is 48.5% which is the lowest level since 2012 when non-manufacturing enterprises were included in this survey. The main reasons pointed out for a sales decline were “restrictions on cross-border movement” and “decline of the consumption demand” caused by the spread of COVID-19 infection, posing new challenges for business operation. On the question of the timing of expected business normalization, 30%, the largest share, of respondents replied “second half of 2021”, followed by “first half of 2021” with 26.6%, indicating their hope for business

[163] https://www.jetro.go.jp/world/covid-19/
[164] https://www.nli-research.co.jp/report/detail/id=64754

normalization in 2021. As far as intended moves in 2021 onwards are concerned, many enterprises indicated cost reduction through “rationalization by personnel reduction” and “reduction of overseas personnel”. However, a challenging stance was also evident in such replies as “review of the marketed products”, “promotion of digitalization” and “review of suppliers”.

c) Impacts on supporting industries

The number of passenger cars produced in Germany in 2020 was 3,508,500, a year-on-year decline of 24.8% and the lowest figure in the last 45 years. As such, it can be reasonably inferred that the impacts on automobile-related supporting industries are equally severe.

(2) USA

a) General situation of the manufacturing sector

In the USA, the explosive increase of people infected with COVID-19 has had a serious impact on the economy, including a massive increase of the number of unemployed. Although the nationwide number of the newly infected began to fall from a peak on September 1, it increased again after hitting a low on October 24, 2021. The recent number of newly infected per day is approximately 104,000, exceeding the 100,000 market for the first time since early October. The aggregate number of infected people is approaching 49 million. The daily death count has again exceeded 1,000 with an aggregate number exceeding 780,000.

b) Impacts on locally operating foreign manufacturers

Many Japanese subsidiaries operating in the USA have expressed the opinion that their business performance has almost returned to the pre-COVID-19 level one year after the nationwide lockdown as the economic measures, including vaccination, introduced by the government and Congress have had a positive effect. In particular, personal consumption which supports the economy of the USA has rapidly recovered and, in some industries, production cannot catch up with the demand. When viewing the situation by business type, some businesses have not yet recovered from the damage caused by COVID-19, showing a picture of so-called K-shaped recovery.

As a general trend, most enterprises have just returned to their pre-COVID business situation and have not yet started to implement their post-COVID new business initiatives. Meanwhile, some have voiced the intention of making the digitalization which started during the COVID-19 pandemic lead to its integration in such existing services as retailing or new businesses.

There appear to be some post-COVID investment plans on the part of Japanese enterprises, including the construction of a new factory at a cost of 100 billion yen by Mitsubishi Chemical to

increase production of acrylic resin material and planned production increases by Shin-Etsu Chemical and Nippon Steel.[165]

c) Impacts of supporting industries

The Manufacturing Report on Business for November, 2021 released by the Institute for Supply Management (ISM) disclosed that the manufacturing index of 61.1 was a slight increase on the 60.8 for October, suggesting recovery of the manufacturing sector against the background of a robust demand for goods. The steady demand increased factory employment with the employment index hitting its highest level of 53.3 in seven months, up 1.3 points from 52.0 in October. However, it was pointed out that there is a possibility of the over-booking of orders by enterprises and increased problems with prices and supply chains due to the Omicron variant.[166]

(3) China

a) General situation of the manufacturing sector

The Chinese government is pushing its New Infrastructure Plan forward. This New Infrastructure primarily means ① 5G base stations, ② ultra-high voltage power transmission, ③ inter-city high speed rail and inner-city rail systems, ④ new energy vehicle charging stations, ⑤ big data centers, ⑥ AI and ⑦ industrial internet. This concept was proposed at the Central Economic Work Conference held in October, 2018. Because of the COVID-19 pandemic, there have been growing expectations that the Plan will have comprehensive positive effects, including the expansion of new demands and suppliers, higher employment, structural adjustment and the facilitation of innovation. Since April, 2021, policies related to the New Infrastructure have been promoted in various places and investment in individual business sectors is in progress. Concrete measures announced so far include the issue of gift vouchers to stimulate consumption and a policy of spreading the use of automobiles and household electrical appliances in rural areas.

b) Impacts of locally operating foreign manufacturers

The business reopening situation of Japanese subsidiaries as an example of the business situation of locally operating foreign subsidiaries in China shows that many have seen their businesses normalized. Although some enterprises are experiencing a slow recovery of orders received from overseas, others are enjoying their highest operating profit due to the expanding domestic demand in China and other reasons. It has been reported that the Chinese government has stated that some 40% of foreign subsidiaries are planning to boost their investment in China to counter the circulating information that foreign subsidiaries have been steadily withdrawing from China as an impact of COVID-19.[167]

[165] https://www.nikkei.com/article/DGXZQODL039620T00C21A8000000/
[166] https://jp.reuters.com/article/usa-economy-manufacturing-idJPKBN2IG4L4
[167] https://www.recordchina.co.jp/b802559-s0-c20-d0135.html

(4) India

a) General situation of the manufacturing sector

The unemployment rate for April to May, 2020 increased to the 23% level because of the impact of the lockdown but recovered to almost the pre-COVID level in July onwards. Meanwhile, the year-on-year mining and manufacturing production index fell by 57.3% in April. The decline of the manufacturing sector in particular pushed down the overall index. However, the situation recovered in May onwards.

The domestic sales volume of passenger cars and two wheel vehicles was already sluggish in 2019 and sharply dropped after lockdown. However, it began to recover in June, 2020 and the year-on-year performance turned into a plus in August. However, careful attention is required to determine whether or not this upturn is a simple reaction to the end of lockdown or a more sustainable recovery because of changing preferences among consumers (who prefer to travel by their own vehicle rather than by public transportation).

The unemployment rate tends to be higher in urban areas than rural areas. Efforts have been made to actively attract the investment of Japanese and other foreign enterprises instead of trying to achieve economic recovery solely relying on local enterprises. The COVID-19 pandemic has made “the diversification of supply chains” a common theme throughout the world. India appears to have a national drive to actively encourage inward investment so that India is perceived as a plus-one base for such diversification.

b) Impacts on locally operating foreign manufacturers

The business situation of Japanese subsidiaries as an example of the business situation of locally operating foreign subsidiaries in India shows that the local representatives and their families of these subsidiaries have temporarily returned to Japan since March, 2020 because of the spreading infection and concern regarding the local medical care system. Since the suspension of international flights (started on March 23), a total of 69 charter flights have left India for Japan (including planned flights up to the end of January, 2021). While there has been no means of travelling from Japan to India for a long time, charter flights arranged by the Japan Chamber of Commerce and Industry in India (JCCII) now operate approximately twice a month from Haneda International Airport in Tokyo which provide a limited means of travel.

Local Japanese manufacturers of four wheel and two wheel vehicles gradually restarted production in May, 2020. By mid-June, all of them had restarted production. Dealers opened for business at the same time and on-line sales commenced, making their businesses finally tangible. The sales volumes of Maruti Suzuki, etc. are increasing because of reluctance to use public transportation. Because of the reopening of factories and business operations, the period of a worsening cash position has somewhat come to an end even though it is still a matter of grave

concern. The productivity decline due to the strict observation of the standard operating procedure (SOP) to prevent the spread of infection still continues. While the total number of infected people is generally increasing, the number of infected workers has shown a rapid increase, making infection control a major task. Concern for a collapse of the health care system is increasing, particularly among Japanese expatriates. Meanwhile, the possibility of re-dispatching those expatriates who are temporarily evacuated to Japan is being explored.[168]

c) Impacts on supporting industries

On August 12, 2021, the Society of Indian Automobile Manufacturers (SIAM) released its automobile statistics (shipment base) for July. The sales volume from April to July, 2021 was 910,714 for passenger vehicles (including utility vehicles and vans), recording a year-on-year increase of 2.7 times. By segment, the sales volume more than doubled year-on-year for passenger vehicles, utility vehicles and vans. A similar impact is assumed to have taken place on supporting industries related to the automobile industry.

(5) Indonesia

a) General situation of the manufacturing sector

According to the Association of Indonesia Automobile Industry (GAIKINDO), the total automobile sales volume (based on shipment to dealers) in 2020 was 532,027, a substantial year-on-year decline of 48%[169], recording the worst performance among ASEAN countries as shown in the table below. The automobile production volume also recorded a 46% decline.

Table-28 Actual Automobile Sales in ASEAN in 2020[170]

Country	Passenger Vehicles	Commercial Vehicles	2020 Total	2019 Total	Year-on-Year Change
Brunei	12,239	266	12,505	11,909	+5%
Indonesia	388,886	143,141	532,027	1,030,126	-48%
Malaysia	474,104	48,469	522,573	604,281	-14%
Myanmar	12,867	4,840	17,707	21,916	-19%
Philippines	69,638	154,155	223,793	369,941	-40%
Singapore	46,986	9,437	56,423	90,429	-38%
Thailand	343,494	448,652	792,146	1,007,552	-21%
Vietnam	221,274	75,360	296,634	322,322	-8%
Total	**1,569,488**	**884,320**	**2,453,808**	**3,458,476**	**-29%**

[168] https://www.jetro.go.jp/ext_images/world/covid-19/asia/video/cc25b3e852c60c94/shiryo.pdf
[169] https://www.just-auto.com/news/indonesia-sales-plunge-48-in-2020_id199741.aspx
[170] http://www.asean-autofed.com/files/AAF_Statistics_2020.pdf

A leading bread making announced that it will newly start operation at two plants by the end of 2020 as it can expect a demand increase.[171] Some enterprises are said to be continuing the introduction of digital technologies to production management and operation management, and investment in equipment and systems for the purpose of automation and labour-saving in line with Making Indonesia 4.0. On its part, the government has implemented measures to relax financing regulations (extension of the repayment deadline and reduction of the loan interest rate).[172]

b) Impacts on locally operating foreign manufacturers

The business performance of Japanese subsidiaries operating in Indonesia as an example of locally operating foreign subsidiaries for April to May, 2020 showed a rapid decline of the domestic demand due to such restrictions on the retail side as the temporary closure of stores and restrictions on story entry. There was notable production adjustment except for some businesses related to food, beverages, health care, etc. Since June, production activities have gradually restarted in response to the recovery of the demand. However, the worsening situation of infection from late June has rapidly increased the number of infected workers, affecting the operating rate of some enterprises. Production has restarted in the automobile sector, mainly centering on export models.

c) Impacts on supporting industries

The massive decline of automobile sales (year-on-year decline of 48% in 2020) is assumed to have had a similar impact on the automotive component industry in Indonesia. Ayong Jeo, Chairman of the Indonesian Automotive Aftermarket Association (GATOMI) admitted that sales of spare parts were down by 80% during the lockdown period. Hadi Surjadipradja, Secretary General of the Joint Automobile and Motor Equipment Industry (GIAMM) said that such reduced scale of the economy could not sustain the industry which still relies on the import of some 80 – 90% of its raw materials.[173]

(6) Myanmar

a) General situation of the manufacturing sector

According to a survey report published by the Myanmar Trade Promotion Organization (Myantrade), an export promotion organization of the government, 30% and 40% of enterprises surveyed replied that “their business was seriously affected” and “their business was somewhat affected” by COVID-19 respectively.[174] The report point out that after tourism, the sewing

[171] https://www.jetro.go.jp/ext_images/world/covid-19/asia/matome/idn200720.pdf
[172] https://indonesien.ahk.de/en/infocenter/news/news-details/govt-extends-loan-relaxation-for-smes-as-covid-19-outbreak-continues
[173] https://www.gaikindo.or.id/industri-komponen-otomotif-ikut-terpukul-selama-pandemi/
[174] https://www.nna.jp/news/show/2073289

industry and natural rubber exporting industry were severely affected. It also reported that enterprises are requesting the government's introduction of partial exemption from rent and electricity charges in addition to tax reduction and extension of the tax payment deadline. The UN Myanmar Office has disclosed that approximately 350,000 workers, half of the some 700,000 workers of the domestic sewing industry, are facing a risk of the non-payment of their wages or even redundancy.

b) Impacts on locally operating foreign manufacturers

The results of the questionnaire survey conducted by the Japan Chamber of Commerce and Industry in Myanmar (JCCM) (survey period: May 19 to 22, 2020 with 147 active respondents and a response rate of 36%) used here as an example to show the business situation of foreign subsidiaries in Myanmar show that the operating rate between pre-COVID-19 and the present increased or did not change for 23.1% of respondents and declined for 75.4%. The forecasted operating rate for June onwards compared to the pre-COVID period is an increase or no change for 36.8% and a decline for 63.2%.

JICA also signed a loan agreement in September 2020 of up to 30 billion yen to support the Myanmar government in implementing economic measures and promoting policy and institutional improvements that will contribute to the improvement of the investment and trade environment and financial infrastructure.[175]

According to the JETRO Yangon Office, COVID-19 infections have stabilized as of November, 2021 and daily positive test results have been less than 10% for some time. In Yangon, the largest city, the traffic volume has increased and crowds have returned to the downtown area and shopping malls. Because of this situation, the return of Japanese expatriates who have completed the cycle of vaccinations in Japan to Myanmar is expected to continue.[176]

(7) Malaysia

a) General situation of the manufacturing sector

In Malaysia, the impacts of COVID-19 on its economy have been very serious. The Central Bank of Malaysia has announced that the real GDP growth rate for the third quarter of 2021 declined by 4.5% compared to the same period in 2020. This was the first negative growth for two quarters while the second quarter recorded positive growth by 16.1%. This drop is attributed to the enforcement of the Malaysian Movement Control Order (MCO) since June to combat the resurgent COVID-19. By sector, all industries recorded negative growth. The most affected was

[175] https://www.jica.go.jp/press/2020/20200901_10.html
[176] https://www.jetro.go.jp/ext_images/world/covid-19/asia/matome/mm.pdf

the construction sector with a drop of 20.6%. The manufacturing sector experienced 0.8% negative growth.[177]

It is reported that some electronics manufacturers have achieved continuous production by providing a bonus for foreign workers to maintain their motivation despite movement restrictions, indicating efforts to maintain the employment level.

b) Impacts on locally operating foreign manufacturers

As an example of the situation faced by foreign subsidiaries operating in Malaysia, local Japanese manufacturers have faced a problem of a production decline due to a shortage of labour and difficulty of procuring components. Although the worker attendance rate has almost returned to the normal level due to the relaxation of restrictions on operation by the government and an improved vaccination rate, monitoring by the government is continuing along with measures designed to prevent the spread of infection. Working from home and staying indoors in the service industry have been relaxed and the negative impacts on business are slowly coming to an end. According to the JETRO Kuala Lumpur Office, the Malaysian government has accelerated its vaccination program since around July and the vaccination rate for the adult population has reached 97.1% as of December 5, 2021. More than 2.9 million people have received a booster dose. Since August, the relaxation of restrictions on activities has been accelerating, including relaxed restrictions for individuals who are fully vaccinated, raising the upper attendance rate threshold for manufacturers, etc. where the vaccination rate exceeds a certain level and reopening of the service industry. In October, economic activities had almost normalized as the ban on inter-state movement was withdrawn. Meanwhile, border control measures are said to be heading towards becoming strict again because of the spread of infection by the Omicron variant.[178]

c) Impacts on supporting industries

As the growth rate of the manufacturing sector for the third quarter of 2021 was -0.8%, a similar decline is assumed to have hit supporting industries.

(8) Thailand

a) General situation of the manufacturing sector

The Thai economy has been gradually recovering from the negative impacts of COVID-19. The GDP growth rate for the third quarter (July – September) of 2021 was -0.3%. The negative growth started in the second quarter (-7.6%) which was the first time for the quarterly GDP growth rate to drop after two quarters. On November 30, 2021, the Office of Industrial Economics (OIE) of the Ministry of Industry announced that the manufacturing production index

[177] https://www.asiax.biz/news/59094/
[178] https://www.jetro.go.jp/ext_images/world/covid-19/asia/matome/my.pdf

(MPI; weighted with the added value; reference year 2016 = 100) in October, 2021 was 98.0, a 2.9% increase on the same month in 2020. On November 18, the Federation of Thai Industries (FTI) announced that the production volume of automobiles in October, 2021 was 154,038, a 3.3% increase on the same month of 2020. The production volume of two wheel vehicles dropped by 8.3% to 192.774 compared to the same month of 2020.[179]

According to an ASIA Times article, COVID-19 particularly affected the poor (agricultural workers and SMEs) and two years may be required for the Thai economy to recover, possibly making a review of the Thailand 4.0 policy necessary.[180]

b) Impacts of locally operating foreign manufacturers

The situation of Japanese subsidiaries is described here as an example of the situation of foreign subsidiaries operating in Thailand. According to the Survey on Business Sentiment of Japanese Corporations in Thailand for the first half of 2021 released by the Japanese Chamber of Commerce, Bangkok (JCC)[181], the business sentiment of Japanese subsidiaries in Thailand as illustrated by the DI (Diffusion Index) was +24 in the second half of 2020, recording a substantial improvement from the first half of 2020 (-64%) and the DI for the first half of 2021 of +25 maintained a similar level from the previous half year period. Although the DI forecast for the second half of 2021 is less positive (+25 → +14) due to concerns regarding the spread of COVID-19, the DI value continues to be positive. Having considered the impacts of COVID-19, most of the responding companies indicated that they expect "to continue or expand the business" (66%) while 30% are "uncertain at the moment" and 4% may "downsize the business".

One way of looking at post-COVID development is examination of whether or not the knowledge developed through industry-academia collaboration through a research project[182] aimed at achieving "region-wide management to continue projects" making the best use of the lessons learned from the flood damage in 2011 can be utilized for the rebuilding of supply chains which have been torn to pieces by COVID-19. This is an attempt to visualize the disaster risks for local communities surrounding industrial parks so that the resilience (flexible strength for recovery) can be enhanced to overcome disasters. The JICA Thai Office held a relevant webinar at the end of April, 2020.[183]

[179] https://www.jetro.go.jp/ext_images/world/covid-19/asia/matome/th.pdf
[180] https://asiatimes.com/2020/06/covid-19-drives-thailand-deeper-into-poverty/
[181] https://www.jcc.or.th/
[182] The project on regional resilience enhancement through establishment of Area-BCM at industry complexes in Thailand (FY2017 – FY2023)
[183] https://www.jica.go.jp/topics/2020/20200715_01.html

c) Impacts on supporting industries

The production volume of automobiles in October, 2021 was 154,038, a 3.3% increase on the same month of 2020, suggesting that supporting industries related to the automobile industry should also show a recovery trend.

(9) Vietnam

a) General situation of the manufacturing sector

The number of newly infected people shows an increasing trend as of November, 2021. The Vietnamese government has adopted a policy of reviewing the COVID-19 control measures and not stopping production, construction and distribution even with the infection risk to head for a new normal. Both the isolation period and health observation period after entry to Vietnam have been shortened to seven days each for those who are fully vaccinated. In some designated areas, the acceptance of tourists has restarted.[184] The Vietnamese economy in the first half of 2021 literally showed a V-shaped recovery. In 2020, Vietnam's economic growth was stagnant throughout the year because of COVID-19. However, the GDP growth in the first half of 2021 showed rapid growth as if sweeping away the stagnation of the previous year. Vietnam is the only country in Southeast Asia to record positive GDP growth in 2020. According to the General Statistics Office of Vietnam, the GDP growth rate for the first half of 2021 was 5.64% with the rate for the first quarter and second quarter being 4.48% and 6.61% respectively. Even though these figures were lower than the previous forecasts, they are still high compared to other countries in the world.[185]

b) Impacts on locally operating foreign manufacturers

There is speculation that the transfer of production bases of foreign subsidiaries to Vietnam may accelerate in the post-COVID era. In fact, the Vietnamese government achieved positive GDP growth in 2020 and has expressed optimistic targets for economic recovery.

Vietnam is the leading candidate for the relocation of production bases from China. Vietnam's membership in the TPP and the effectuation of the FTA with the EU have boosted Vietnam's attractiveness as an investment destination.[186]

Many Japanese subsidiaries are currently looking for viable post-COVID-19 investment projects. Particular attention is being paid to such fields as renewable energies, health food, health care, IT, communications, real estate and manufacturing. Many Japanese subsidiaries are actively searching for projects involving industrial or office properties and low cost rental factories.

[184] https://www.jetro.go.jp/ext_images/world/covid-19/asia/matome/vn.pdf
[185] https://estate.nikkan.co.jp/column/bdy6jtr2etp1mnax
[186] https://www.itochu-research.com/ja/uploads/em20200525_2020-024_VNM.pdf

As far as Japanese enterprises are concerned, measures to restrict the entry of Japanese nationals are continuing, delaying changes of representatives and greatly hindering the dispatch of maintenance personnel, introduction of new equipment and support for business operation from Japan. However, depending on the vaccination status, they will be quarantined for three to seven days at a designated hotel and under health observation for up to two weeks (as of January 1, 2022)[187].

c) Impacts on supporting industries

The favourable recovery of Vietnam's economy is assumed to have a similar impact on supporting industries in each industrial sector.

4.2.4 Impacts of COVID-19 on Fostering of New Technology-Related Human Resources

A survey was conducted on the fostering of human resources in administrative, educational and industrial fields in each target country of the Study. The results of a study conducted by UNESCO are also described.

(0) Overview

Table-29 Outline of the Fostering Situation of New Technology-Related Human Resources in the Target Countries of the Study

Target Country	Outline of the Survey Results
Germany	・ A policy of "accelerating Indusrie 4.0" has been formulated in response to the impacts of COVID-19 and teacher training in the ASEAN region via GIZ has been intensified. ・ Three types of qualifications relating to vocational education have been revised to increase the attractiveness and international competitiveness of vocational education. ・ E-learning materials to guide practical learning have been prepared to support continuation of the dual system.
USA	・ Relevant information on administrative and educational fields is scarce but diverse approaches to strengthening human resources (M & A and provision of free on-line tools, etc.) by private enterprises are progressing.
China	・ Strategic cooperation between three fields, i.e. the administrative, educational and industrial, can be observed. There are plans to foster advanced AT human resources as well as IT human resources for local development.
India	・ A manufacturing promotion policy led by the Prime Minister is being pursued to materialize "Self-Reliant India", one of the objectives of which is human resources development.
Indonesia	・ As part of the development of human resources capable of contributing to the ongoing trend towards IoT and Industry 4.0, the first national certification examination for CAD drawing skills has been implemented. However, there have been few other relevant activities.
Myanmar	・ The current situation is that the use of Burmese IT human resources abroad is restricted and information related to the fostering of advanced human resources is scarce.
Malaysia	・ With the support of the GTZ, upskill training has commenced for TVET trainers related to Industry 4.0. ・ Meanwhile, spread of the problem of the over-supply of advanced human resources to new graduates in the short-term is forecast.

[187] https://www.vn.emb-japan.go.jp/itpr_ja/20200731nyuukoku.html

Target Country	Outline of the Survey Results
Thailand	・ With the support of the GTZ, upskill training has commenced for TVET trainers related to Industry 4.0. ・ An advanced human resources development strategy aimed at making Thailand a hub for telework is now moving towards becoming a concrete reality. ・ As investment by Japanese subsidiaries is shifting towards high value-added options in line with Thailand 4.0, efforts to develop advanced human resources are necessary to develop their quality as required to boost Thailand 4.0.
Vietnam	・ With the support of the GTZ, upskill training has commenced for TVET trainers related to Industry 4.0. ・ Targets for 2030: 100,000 digitalized enterprises and 1.5 million digital-savvy human resources

(1) Germany

Administrative Field

- Federal Ministry of Economic Cooperation and Development (BMZ)

  To find innovative digital solutions to mitigate the effects of COVID-19, especially in low income and middle income countries, a global hackathon was organized with the GIZ acting as the executing agency supported by the BMZ on May 14 and 15, 2020. The event was also supported by the European Commission, EU member states, high-tech enterprises and partners from "Team Europe" in the civil society. Typical high-tech enterprise supporters included IBM, SAP and AIRBUS, totalling 35 enterprises. The GIZ, World Bank, UNDP, etc. also participated.[188]

- GIZ's approach to ASEAN

  The GIZ has been strategically proceeding with human resources development targeting the achievement of Industry 4.0 via the TVET (Technical and Vocational Education and Training) System. Under the training curriculum for TVET trainers, efforts are being made to develop standard teacher training programs for mechatronics, industrial electronic engineering, metal-cutting CNC and structural engineering at the college level. Meanwhile, in the scenario to establish the entire ASEAN region as a supply source for strategic labour, reconsolidation of the basic reading and writing competencies concerning digital technology is being pursued in view of the perceived necessity to innovate competitiveness to cope with changes of industries towards modernization. The relevant curriculum aims at transforming the structure of developing three types of competencies possessed by human resources: (i) calculation, reading, writing and self-learning competencies as basic capabilities, (ii) competencies to communicate, adapt to team work and deal with complicated issues as intangible competencies and (iii) basic digital competency. These reflect the human resources development strategy of the GIZ which aims at developing certain competencies throughout the ASEAN region in the future. COVID-19 has had the effect of further accelerating this trend[189].

[188] https://www.jetro.go.jp/biznews/2020/06/5e3df1f8ffaed63d.html
[189] https://asean.org/storage/2020/06/The-ASEAN-Issue-2-June-2020-dv.pdf

However, the current level of satisfaction with the TVET system on the part of industrial circles is low, making it essential to boost the new competencies among TVET trainers. Against this background, the Future ASEAN Agenda (Modernizing ASEAN TVET System) has been proposed. The most important feature o this new system is the direct involvement of the relevant industries in the planning and implementation of TVET, introducing nationwide cooperation as in the case of individual TVET institutions and vocational colleges.

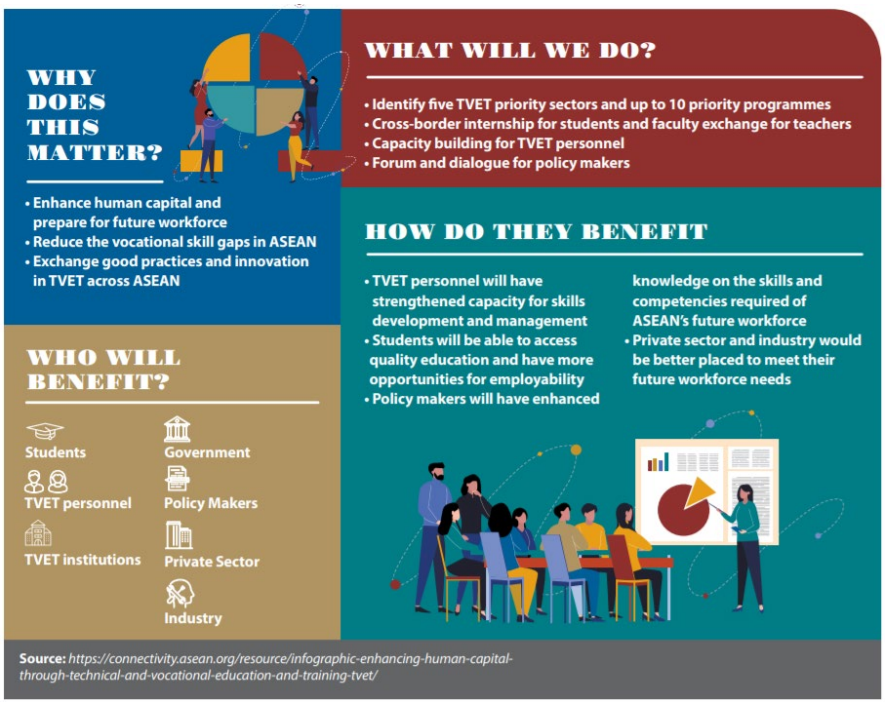

Figure-12 Enhancement of the competencies of human resources

- GIZ supporting the e-learning practice system in the dual vocational training system (Other than the ASEAN region)

  In its vocational training and education in Armenia and Serbia, the GIZ has developed and implemented various e-learning sessions in cooperation with remote e-learning organizations in these countries at a time when schools have been closed due to COVID-19. In March, an e-learning course was organized with 150 vocational teachers and trainers. Two classrooms have been turned into film studios with the support of the GIZ to provide teaching aids for e-learning using such equipment as interactive whiteboards, projectors and interactive screens. The lesson units can be downloaded via national television for the benefit of trainees who do not have access to the Internet.[190]

[190] https://www.giz.de/en/mediacenter/86352.html

Figure-13 Production site of teaching aids for e-learning for vocational training assisted by the GIZ[190]

Educational Field

- University of Passau

  On June 24, 2020, a webinar titled "Digital French-German Summer School 2020: Machine Learning, Hybrid Models, AI for Good, AI Engineering" was held, aiming at accelerating the use of research outcomes by innovators utilizing AI and big data in the environment of the COVID-19 pandemic. This webinar was jointly organized by the University of Passau (Germany), Ecole Normale Supérieure Paris-Saday (France) and Siemens AI Lab. (Germany). More than 100 people participated, including those from industrial circles, researchers, educationalists and government officials, and the webinar was held entirely in the digital environment. The presentations and subsequent discussions held during this webinar included "AI for the Good – A Corporate View" by Siemens AI Lab, "Using AI for Sustainable International Development" by the GIZ and "Machine Learning and AI in Practice" by the BMW Group. Prominent participating organizations were BMW, Siemens, GIZ, German Aerospace Center, German and French universities related to the subject issues and the Banque de France.[191]

- Federal Ministry for Education and Research

  Three higher level qualifications, namely "Bachelor Professional", "Master Professional" and "Certified Professional Specialist" have been introduced for vocational education following revision of the Vocational Training and Education Act and were enforced on January 1, 2020. Prior to this revision, various qualification titles existed for each technical field. This revision, however, intended the consolidation of qualification titles to three titles to make the level of each qualification transparent and to enhance their recognition beyond national borders. The Federal Minister of Education and Research commented that this revision would further enhance the attractiveness and international competitiveness of Germany's vocational education. The Federal

[191] http://mlmda.cmla.fr/french-german-summer-school-for-industry-2020/

Ministry of Education and Research states that even though these qualifications are not academic degrees awarded by universities, they are equivalent to such university degrees.[192]

Industrial Field

- Bosch

  Robert Bosch, a leading German manufacturer of automobile parts, has started a human resources development program for the manufacturing industry in Singapore. This program aims at fostering human resources capable of responding to the challenges posed by "Industry 4.0", a project to advance the manufacturing industry, using robotics and IT and intends to accept some 1,500 trainees from 300 enterprises in five years.[193]

- Changing use of DX by SMEs

  A German survey conducted in early May, 2020 found that approximately 81% of SMEs were moving towards more flexible dealing with clients compared to the pre-COVID situation where approximately 88% of SMEs dealt with clients face-to-face. One-third of SMEs recognize the importance of digitalization to handle clients.[194]

(2) USA

Administrative Field

(No information worth of special reporting was found for in-house human resources development by administrative organizations.)

Educational Field

Business organizations are aware of the necessity to enhance the education and upskilling of their employees to maintain their employment status in the post-COVID business environment. The changing needs of workplaces require employees to have new skills in order to stay relevant. A company's HR team can lead such an initiative and prepare training plans which target various work functions, benefiting not just employees but also the organization itself. Such educational platforms as Harvard University and LinkedIn have made many courses available for free on-line to support the learning of individuals and companies.[195]

[192] https://qaupdates.niad.ac.jp/2020/02/28/germany-berufsbildungsgesetzes/
[193] https://europe.nna.jp/news/show/2073254
[194] http://www.oecd.org/coronavirus/policy-responses/coronavirus-covid-19-sme-policy-responses-04440101/
[195] https://www.entrepreneur.com/article/350747

Industrial Field

- Oracle

  Oracle has intensified its on-line services in the light of the difficulty of providing conventional face-to-face support for its customers because of COVID-19. For example, Oracle is offering free access to on-line learning content and certifications for a broad array of users for Oracle Cloud Infrastructure and Oracle Autonomous Database. Paying start-ups for the program receive three months of credits to meet the Oracle Cloud infrastructure cost. From April 1 to June 30, 2020, credits will be automatically applied to offset the technology fees. Start-ups will still receive a usage bill but the costs will be zero.[196]

- Boston Consulting Group (BCG)

  BCG has been providing strategic consultation services for a number of global enterprises and has raised seven priority issues in terms of human resources development in the post-COVID crisis. Of these, the following two issues are closely related to the development of advanced human resources.[197]

  - Standardization of smart work

    The "accelerated introduction of smart work" has taken place during the COVID-19 crisis. Such smart work should be considered a new standard in many organizations in the post-COVID era.

  - Learning speed as a major competitive factor for enterprises

    There is a need for organizations to swiftly build up a new organizational capability to deal with an age where the speed of change is much faster than in the past and is difficult to correspond. Accordingly, the learning speed will become a major competitive factor for enterprises.

- Gartner

  Gartner analysis shows that 48% of employees will likely work remotely for at least part of the time after the COVID-19 pandemic compared to some 30% pre-pandemic. To succeed in a world of increased remote working, the hiring of managers should prioritize digital dexterity and digital collaboration skills.[198]

[196] https://www.oracle.com/corporate/covid-19.html
[197] https://image-src.bcg.com/Images/People-Priorities-for-New-Now-JP_tcm9-250926.pdf
[198] https://www.ehstoday.com/covid19/article/21131744/9-trends-impacting-the-future-of-work

(3) China

Administrative Field

In July, 2017, China's State Council released the New Generation AI Development Plan which aims at making China the world leader in AI by 2030. This was followed by announcement of the "Guidelines for National New Generation AI Innovation and Development Pilot Zone Construction Work" by the Ministry of Science and Technology in July, 2019, urging acceleration of the introduction of AI in society. The following concrete measures have been implemented based on the judgement that the impacts of the COVID-19 pandemic have made it important to accelerate infection control and R&D using AI.

- Ministry of Education/National Development and Reform Commission/Ministry of Finance

The Ministry of Education, the National Development and Reform Commission and the Ministry of Finance issued a notice on "several opinions on promoting the integration of disciplines in the construction of "double-first class" colleges and universities and accelerating the training of graduate students in the field of AI. They are implementing certain measures, including expansion of the scale of post-graduate training in the AI field, as proposed by the Ministry of Education. "Double-first class" in the AI field means first class human resources equipped with "AI+X" and aims at deepening the meaning of AI and fostering human resources with both basic theoretical understanding and "AI+X" capability so that the world's frontiers of science and technology are conquered to achieve pioneering outcomes. To expand high-end AI talent teams, leading AI enterprises are encouraged to provide experimental practice environments and to train teachers in colleges and universities according to the latest developments of industrial technologies and the latest needs for talent training.[199]

Other proposed measures include the establishment of an industry-education integration innovation platform and close school-enterprise cooperation to create a high level development platform, setting up of joint talent training projects with local governments, etc. and strengthening of international exchanges and cooperation.

Educational Field

- Ministry of Education

For the year 2020, the number of graduate school admissions has increased in such fields meeting China's national strategy and consumer needs as AI, integrated circuits, clinical medicine and public health. Once increased admissions are realized, the total quota for post-graduate admissions in 2020 is expected to be 1,106,000. For the development of AI human resources, the

[199] http://www.moe.gov.cn/srcsite/A22/moe_826/202003/t20200303_426801.html

following main points will be prioritized for the purpose of developing "double first class human resources".[200]

1. Expansion of recruitment of graduate students, mainly AI majors. The focus will be on research on basic and applied theories, promotion of the industrial transformation with research results and the creation of innovations with core technologies.
2. Expansion of the integration of knowledge of AI and basic subjects, IT, medicine, philosophy and sociology.
3. Promotion of industry-academia-government collaboration by implementing joint human resources development programs between universities and AI-related companies, industrialization bases and local governments.
4. Establishment of a forum for the exchange of opinions on priority issues related to AI technology at the national-level AI innovation platform.

Industrial Field

- Changes of Chinese industries caused by COVID-19 include ① a 16.8% decline of the need to recruit new graduates, ② strong impact felt by 58% of large and medium size enterprises and ③ focus on DX and a shift to on-line based work by 53% of large and medium size enterprises.[201]
- Baidu, a leading Internet search engine in China

  Baidu has announced its plan to foster 5 million AI human resources in the next five years for the purpose of supplying human resources for the development of a smartized Chinese economy and society. The Baidu AI Data Annotation Center established by Baidu in Shanxi Province plans to train 50,000 AI data annotators (for the work of categorizing and labelling data for machine learning) in the next five years (current capacity of around 2,000). The technological threshold for the work of annotation is relatively low and short training can enable trainees to start actual work. As such, this center can effectively facilitate the employment of local workers.[202]

(4) India

Administrative Field

On May 12, 2020, Prime Minister Modi gave a speech in which he emphasized the necessity for "Self-Reliant India" to overcome the crisis of the COVID-19 pandemic and named "Make in India" an important manufacturing promotion policy of which human resources development is one of the challenges to achieve this policy.[203]

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200 https://www.jetro.go.jp/biznews/2020/03/807038cda4258063.html
201 https://www.jetro.go.jp/ext_images/hrportal/forcompanies/covid-19/20200615_1.pdf
202 https://www.afpbb.com/articles/-/3292346
203 https://www.jetro.go.jp/biznews/2020/05/c2c134afc75cddf0.html

Educational Field

- Indian Institute of Technology Hyderabad (IIT Hyderabad)

  IIT Hyderabad (total number of students of approximately 2,500) is a public university established in 2008 with the technical and financial assistance of the Japanese government in response to a request made by the Indian government. Since 2012, JICA has been providing a scholarship program to facilitate research and the interchange of human resources between IIT Hyderabad and Japanese industries and academia and also to develop a Japan-India network in the education and research field. More than 100 IIT Hyderabad graduates have so far been invited to join the master's or doctor's courses of Japanese universities. IIT Hyderabad especially emphasizes research in such areas as natural language processing, computer vision and graphics, database and robotics. The campus is located near HITEC CITY where Microsoft, Oracle, Motorola, GE Capital and other well-known enterprises are concentrated with a success story of industry-academic collaboration. In FY2021, due to the impact of COVID-19, an online "JAPAN DAY 2021" was held on September 24 and 25, 2021 at the IIT-H campus to provide job placement assistance to Japanese IT companies.[204]

Industrial Field

- A survey titled "HR resilience planning – COVID-19 impact and preparedness" shows that around 70% of organizations believe that the single biggest concern for continued remote working is a fall of productivity. To avoid such a fall, it is said to be necessary to recalibrate their priorities, focus on managing a remote workforce, digitalize the HR function and re-imagine workforce models. Influenced by such necessity, more than 70% of organizations are now moving to virtual methods of recruitment and such emerging technologies as AI, robotic process automation and machine learning are leading this change. As new priorities emerge, the importance of technological needs concerning IT infrastructure, basic digital communication and operations support are now fading into the background.[205]

(5) Indonesia

Administrative Field

- To respond to the increasing need for human resources capable of using computers in line with the trend of manufacturing sites heading towards IoT and Industry 4.0 in recent years, a national skill certification examination for CAD drawing was conducted on February 18 and 19, 2020 in the capital, Jakarta. This was the first skill test to follow Japan's National Trade Skill Test

[204] https://www.meti.go.jp/press/2021/09/20210928005/20210928005.html
[205] https://economictimes.indiatimes.com/news/company/corporate-trends/covid-19-impact-will-be-felt-beyond-6-months-shows-ey-survey/articleshow/75084037.cms

System in Indonesia and 22 people from Japanese subsidiaries and other local enterprises took this test.[206]

Educational Field

- Indonesia particularly suffers from weak IT infrastructure in Southeast Asia. Even though communication infrastructure is generally in place, many educational institutions are unable to provide on-line teaching. Even in the case of those universities which have IT infrastructure in place, the reality is that most students participate in on-line classes using their own smartphones because they do not have a PC.[207]

Industrial Field

- If the current situation continues to the third quarter of 2021, many enterprises plan to proceed with the early retirement of their employees from October onwards without any prospect of fresh recruitment. The working environment for those in employment shows that activities using cloud and web conference are beginning to constitute the mainstream while working from home is in progress. Such major changes of employment and way of working make the introduction of measures designed to enhance the new competencies of employees necessary.[208]

(6) Myanmar

Administrative Field

(No relevant information was found within the scope of the Study.)

Educational Field

(No relevant information was found within the scope of the Study)

Industrial Field

- Myanmar Unity (the largest government approved trainee-dispatching agency in Myanmar) has announced that 54 candidates for engineering graduates of an institute of technology, who will constitute advanced human resources, are awaiting interview opportunities from Japanese enterprises and organizations as of March 6, 2020 because of the spread of COVID-19 infection.[209]

(7) Malaysia

Administrative Field

- The Regional Cooperation Programme to Improve the Quality and Labour Market Orientation of Technical and Vocational Education and Training (RECOTVET) and SEAMEO Regional Centre

[206] https://www.jetro.go.jp/biznews/2020/02/15b18dd245491cd0.html
[207] https://www.jetro.go.jp/ext_images/hrportal/forcompanies/covid-19/20200615_4.pdf
[208] https://www.jetro.go.jp/ext_images/hrportal/forcompanies/covid-19/20200615_4.pdf
[209] https://www.myanmar-news.asia/news_dLxcRwgwks_183.html

for Vocational and Technical Education and Training (SEAMEO VOCTECH) co-hosted the second batch of Training Modules of Multipliers in different locations in the ASEAN region from May to June, 2020 using the five modules listed below with the aim of enabling TVET trainers to appropriately adapt to changing industrial circles due to the impacts of Industry 4.0, etc. Of these modules, Module 2 was held in Malaysia. As Industry 4.0 is closely related to such advanced technologies as big data, cloud computing and integrated robotic systems, it is extremely important for TVET trainers to be able to adapt to changes of industrial circles through reskilling and upskilling.

The fundamental strategy for the reskilling and upskilling of TVET trainers is the development of standardized skills and knowledge based on the idea of Industry 4.0 of Germany. At present, more than 100 TVET trainers have been nurtured in the ASEAN region and the RECOTVET believes that upskilling of the remaining 600 TVET trainers can be achieved through training with five modules.[210]

Module 1: "Innovative Teaching and Learning for Industrial Changes Due to Industry 4.0" (at the Bureau of Personnel Competency Development in Bangkok and the Thai-German Institute of Chonburi, Thailand, November 23 – 27, 2020)

Module 2: "Professional Development Training for Technical Vocational Education and Training (TVET) Teachers in Industry 4.0" (at the German-Malaysia Institute (GMI) in Kuala Lumpur, Malaysia, June 1 – 10, 2020)

Module 3: "Curriculum Design for Industry 4.0 Work Process" (at the Bureau of Personnel Competency Development in Bangkok, Thailand, June 15 – 22, 2020)

Module 4: "Quality Assurance and Quality Development (Concerning Human Resources Development) at TVET Institutions" (at the Bureau of Personnel Competency Development in Bangkok, Thailand, June 15 – 22, 2020)

Module 5: "Industry and TVET Institution Linkage" (at the LILAMA2 in Ho Chi Minh City, Vietnam, May 12 – 20, 2020)

<u>Educational Field</u>

- It is predicted that there will be an over-supply of advanced human resources in Malaysia in 2020 with negative consequences, particularly on new graduates. In fact, according to the country's National Institute of Statistics, the employment rate for new graduates has decreased by 1.8% from the previous year[211]. To address this, the Ministry of Higher Education, in collaboration with the National University of Utara Malaysia, the Digital Economy Corporation (MDEC), and the Registrar General's Office (CCM), has launched GREaT (https://great.mohe.gov.my/), a job

[210] https://sea-vet.net/41-news/asean/695-launch-of-second-series-of-in-service-training-towards-fit-for-industry-4-0

[211] https://www.dosm.gov.my/v1/uploads/files/5_Gallery/2_Media/4_Stats%40media/1_General%20News/2021/8%20Ogos/24%20Ogos%20-%20General%201-covid.pdf

search portal for 2019-2021 graduates. GREaT (), a job search portal for 2019~2021 graduates, has been launched. The site provides functions such as helping students acquire necessary skills and matching them with job opportunities that match their skills.

Industrial Field

- The use ratio of digital technology among Japanese subsidiaries operating in Malaysia is 21.8% for cloud, 20.5% for robotics and 15.4% for IoT. IoT is the most promising technology to be adopted from the medium to long-term perspective of 5 – 10 years as 37.3% of these enterprises plan to use it. In the case of AI, although the actual use of AI at present is low at 1.3%, 23.2% of enterprises are considering its use. This is the second highest potential adoption after IoT. The biggest prohibitive factor for investment in the digital field is the lack of in-house engineers well familiar with the digital field (33.3%), indicating that the recruitment of suitable personnel is a bottleneck.[212]

(8) Thailand

Administrative Field

- Ministry of Higher Education, Science, Research and Innovation

  The Ministry approves a 250% special deduction for investment or expenses related to the development of human resources in the advanced technology field, a 150% special deduction for the cost of recruiting highly skilled human resources in the science and technology field and a special deduction of up to 200% for human resources development expenses in the advanced technology field for companies which have already received corporate tax exemption.[213]

- GIZ

  Hosting of Module 1 of the RECOTVET workshop[210] already mentioned for Malaysia.

- Ministry of Education

  On July 13, 2020, Narong Paewpolsong, Secretary-General of the Office of Vocational Education Commission (OVEC), disclosed a plan to train vocational personnel to work in the Special Economic Zones (SEZ) in three eastern provinces (Chonburi, Rayong and Chachoengsao) and the Eastern Economic Corridor (EEC) in the next five years. According to this plan, the EEC will require some 475,000 workers in five years, of which 253,000 should have completed a vocational education course, 213,000 should have at least a bachelor's degree and the rest should have a master's degree or a doctorate. The targeted industries are the automotive industry which should need at least 53,000 people, AI with 58,000, tourism with 17,000, robotics with 36,000, aviation with 32,000, digital business with 116,000, medical business with 11,000, high speed

[212] https://www.jetro.go.jp/biz/areareports/special/2020/0201/97a8227f1617a0b1.html
[213] https://piripiri.bigbeat.co.jp/blog/Thailand-2020

railway projects with 24,000, commercial shipping with 14,000 and logistics with 100,000. In order to meet this potential demand, the OVEC has already adjusted the curriculums of 10 vocational colleges in the three EEC provinces. The EVEC intends to further develop educational institutions capable of producing highly skilled personnel in these provinces in the coming years.[214]

- Thailand Board of Investment (BOI)

  The BOI is examining the possibility of relaxing the employment requirements for advanced human resources to make Thailand a teleworking hub in the telecommunications field as part of the measures for the post-COVID era.[215]

Educational Field

- One possible change in the post-COVID educational field is the replacement of basic teaching with on-line teaching, making a school a place for practical experience. Such a change suggests a change of school facilities from tangible ones to intangible ones and the roles of teachers will equally change. As it is conceivable that schools will outsource their basic on-line curriculums to private providers, there will be a growing need for a curriculum designed to equip teachers with skills for the progress control of learning and coaching on-line.

  The Thai-Nichi Institute of Technology has frequently been forced to adopt on-line teaching and suspension of its program to study abroad (example: suspension of overseas study at the Kanazawa Institute of Technology[216]) due to COVID-19. On the other hand, activities to "develop manufacturing human resources and a Japan-Thai co-creation platform" have started.[217] To be more precise, the enhancement of four types of competencies and cooperation with industries is proposed for the "development of manufacturing human resources" based on the basic idea of the 5-Gen learning principles (see the figure below).

[214] https://www.nationthailand.com/business/30391235
[215] https://www.murc.jp/wp-content/uploads/2020/07/cr_200722_2.pdf
[216] https://www.kanazawa-it.ac.jp/oshirase/20200406_COVID-19.html
[217] https://admission.tni.ac.th/web/upload/files/nl_19_re.pdf

Figure-14 Development of manufacturing human resources and 5-Gen principles at the Thai-Nichi Institute of Technology

As universities in Thailand are now under the jurisdiction of the Ministry of Higher Education, Science, Research and Innovation (MHESI), their role of carrying industrial advancement and innovation forward has intensified. As such, they are placing more emphasis on activities to support start-up and collaborative R & D with the cooperation of Japanese subsidiaries and also on the training of instructors who are capable of guiding the introduction of KAIZEN, IoT and robots at the production floor, targeting SMEs (see pictures below)[217].

Presentation of the results of the Smart monodzukuri support team

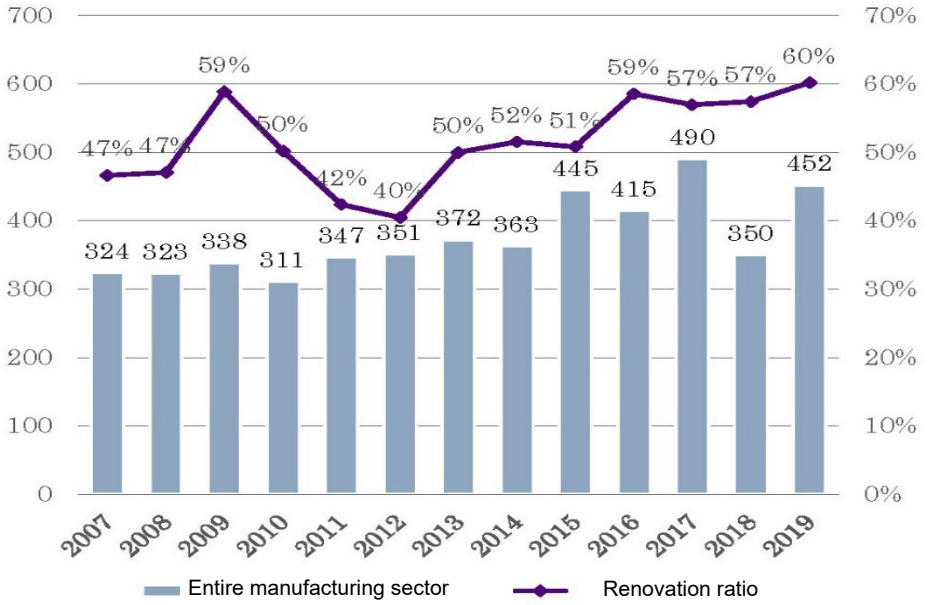
Monodzukuri (manufacturing) Research Center

Figure-15 Examples of Thailand 4.0-related activities at the Thai-Nichi Institute of Technology for 2021 – 2022

Industrial Field

- Various measures looking towards the post-COVID era are being considered. In the telecommunications field, one measure being considered is the relaxation of the employment requirements for advanced human resources with a view to making Thailand a hub for teleworking. "Non-contact" and "automatization" have become important key words in Thailand

as in other countries for the opening up of new business opportunities, suggesting that the need for advanced human resources in these areas and strengthening of the environment to foster such human resources will grow. Investment by Japanese subsidiaries in Thailand can be interpreted as moving from the type of investment observed in developing countries to investment designed to make industries highly value-added in line with Thailand 4.0 (Figure-16). This means that the conventional labour-intensive business model is shifting towards investment in automatization to secure competitiveness in the period of transition. As it can be assumed that a new strategic pattern will emerge to ensure further cost competitiveness through shifting the conventional local production involving only final assembly work to consistent production right from the upstream, high quality, advanced human resources capable of pushing Thailand forward are essential.[215]



Note: Ratio is the total of "renovation" and "rationalization" in the total investment amount
Source: JCC "Economic Survey of Japanese Companies in Thailand" for 2007 through 2019

Figure-16 Transition of number of investments in plant and equipment and transition of the renovation ratio of Japanese subsidiaries in Thailand[215]

(9) Vietnam

Administrative Field

- On June 3, 2020, the Vietnamese government approved the "National Digital Transformation (DX) Program for 2025 and Orientation to 2030". Following this, Hoang Anh Tú, Deputy Director of the Department of International Cooperation, Ministry of Information and Communications, disclosed the planned announcement of the strategy for the development of digital enterprises in September. As part of this announcement, he introduced a "development project for the application of AI to discriminate defective products on a production line".[218]

[218] https://www.jetro.go.jp/biznews/2020/08/cc6f5ecd2a26d1ae.html

- (Supplementary information) There was a plan in 2017 to increase the number of IT engineers from the then some 300,000 to 600,000 by 2020.[219] Based on this, a plan to boost the number of 1.5 million by 2030 can be anticipated.

- GIZ

  Hosting of Module 5 of the RECOTVET workshop[210] already mentioned for Malaysia.

- Ministry of Labour, Invalids and Social Affairs

  Mr. Dau Ngoc Dung, the minster responsible for Industry 4.0 in Vietnam (Chairman of the ASEAN Socio-Cultural Community Council Meeting 2020 held on June 23, 2020) proposed five issues at the 36th ASEAN Summit which illustrate the necessity for human resources development based on new knowledge, competencies and skills to respond to the changing nature of the ASEAN economic zone and society by digital technologies and automatization. The following Issues 1 and 2 are related to human resources development.

  - Issue 1: Vocational education and training concerning high quality skills matching the vocational standards in the target countries for development
  - Issue 2: Life-long education to improve and maintain competencies

  Also proposed was the capacity building of human resources capable of adapting to the Industry 4.0-related labour market and the globally fused market and contributing to productivity improvement and strengthening of Vietnam's competitiveness.[220]

<u>Educational Field</u>

- Ministry of Education and Training

  On March 31, the Ministry of Education and Training released its guidelines for on-line education and distance education for universities and other educational institutions. As of March, 2020, 92 out of 240 universities in Vietnam have adopted on-line education and the remaining universities are also preparing for the early implementation of on-line education. Moreover, the Ministry of Education and Training and the Ministry of Information and Communications have identified measures to support educational institutions, including the free broadcasting of classes approved by the Ministry of Education and Training by bodies under the jurisdiction of the Ministry of Information and Communications and making data communication for the on-line education of students free of charge.[221]

[219] https://tech.nikkeibp.co.jp/it/atcl/column/17/050200178/050200001/
[220] https://asean.org/storage/2020/06/The-ASEAN-Issue-2-June-2020-dv.pdf
[221] https://qaupdates.niad.ac.jp/2020/07/02/vietnam-covid19-highered/

Industrial Field

Examples of Vietnamese start-ups related to Industry 4.0 are MEDICI (which has built a platform which connects hospitals with enterprises and provides on-line medical services for individuals) and VEDAX (which has jointly with a Japanese subsidiary developed a system to monitor the traffic volume, etc. using image and video analysis). These enterprises are believed to be candidates to recruit advanced human resources.[222]

(10) UNESCO

The survey on the "Impacts of COVID-19 on Higher Education around the World" conducted by the International Association of Universities (IAU) backed by UNESCO reported the following summary of its findings.[223]

- The survey analysis is based on 424 replies from higher educational institutions (HEIs) in 109 countries.
- Almost all HEIs that replies to the survey have been impacted by COVID-19. 59% of them replies that all campus activities have stopped and the institution is completely closed.
- At almost all HEIs, COVID-19 has affected teaching and 67% reported that classroom teaching has been replaced by distance teaching and 24% was preparing to shift to distance teaching. Only 7% reported that teaching had been cancelled (see Figure-17 below). The shift from face-to-face distance teaching did not come without suitable teaching methods, the main ones being access to technical infrastructure, competencies and pedagogies for distance learning and the requirements of specific fields of study.

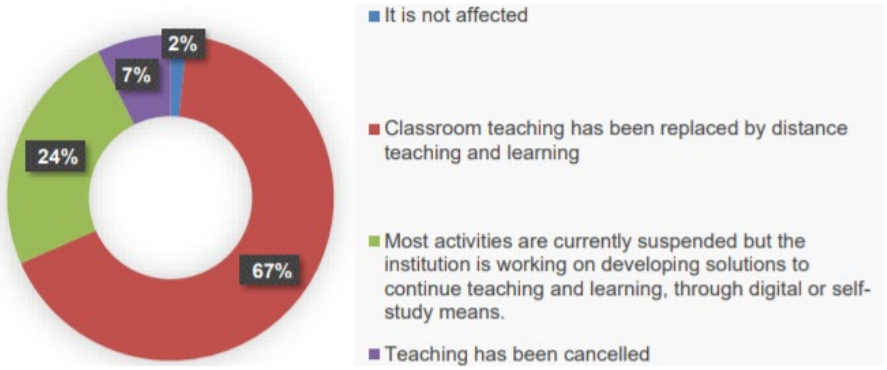


Figure-17 Impacts of COVID-19 on teaching

- COVID-19 seriously affects university partnerships (joint research, etc.) as reported by 64% of the responding HEIs. 51% said that COVID-19 had weakened partnerships while 18% said that it had strengthened them. 31% said that COVID-19 had created new opportunities

[222] https://www.jetro.go.jp/biznews/2020/08/cc6f5ecd2a26d1ae.html
[223] https://www.iau-aiu.net/IMG/pdf/iau_covid19_and_he_survey_report_final_may_2020.pdf

with partner institutions (in terms of virtual mobility and shared resources, for example) (see Figure-18 below).

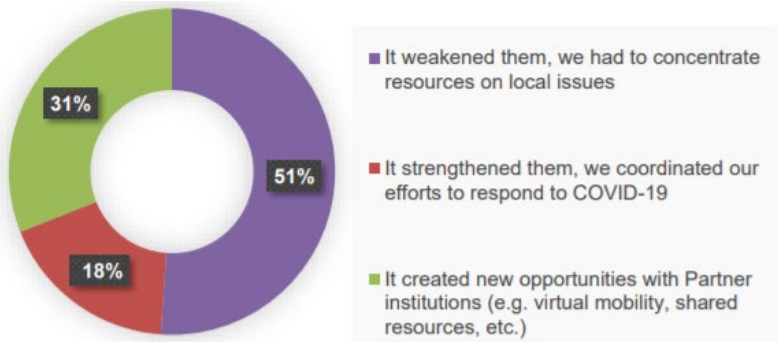


Figure-18 Impacts of COVID-19 on partnership activities

- Many of the respondents see the experience of working and teaching from a distance as an important opportunity to learn from this exceptional situation and propose more flexible learning possibilities, exploration of blended or hybrid learning and mixing of synchronous learning with asynchronous learning.
- Due to COVID-19, virtual mobility and/or collabourative on-line learning has increased at 60% of the HEIs.
- As much as 80% of the responding HEIs reported that research at their institutions has been negatively affected by the COVID-19 pandemic. The most common impacts of COVID-19 on research are the prohibition of international travel (at 83% of HEIs) and the cancellation or postponement of scientific conferences (81% of HEIs).

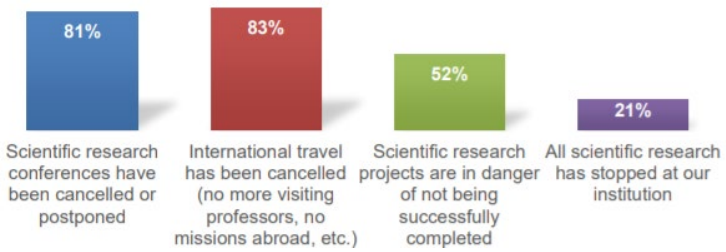


Figure-19 Impacts of COVID-19 on research activities

4.3 Interview Survey on Trends of Supply Chain Transformation of Japanese Global Manufacturers by COVID-19

4.3.1 Survey Approach

This survey was conducted in three steps, i.e. formulation of a viewpoint based on global trends, state of the ASEAN manufacturing industry observed by Japanese manufacturers and state of ASEAN manufacturers to accurately understand not only the present state but also the future direction in

relation to the impacts of COVID-19 on some of the target countries of the Study (Thailand, Indonesia and Vietnam).

In Step 1, the desk research described in Chapter 2 of this Report was conducted to obtain a global overview. In addition, further interviews were conducted with six organizations which had agreed to be interviewed for the Study before the outbreak of COVID-19. Through these activities, a viewpoint for subsequent interviews with manufacturers was formed.

In Step 2, eight global enterprises with head offices located in Japan which have a production base in the ASEAN region or receive supplies from the ASEAN region were interviewed regarding their opinions on the impacts of COVID-19 and the advancement of the manufacturing industry in the light of the said impacts so that the state of the ASEAN region viewed from Japanese manufacturers could be summarized.

In Step 3, a series of interviews was conducted with manufacturers in Thailand, Indonesia and Vietnam (four enterprises in each country, totalling 12 enterprises) based on the results of Step 1 and Step 2 so that the impacts of COVID-19 regarding the advancement of the manufacturing industry in these countries (latest situation and future direction) could be identified and summarized.

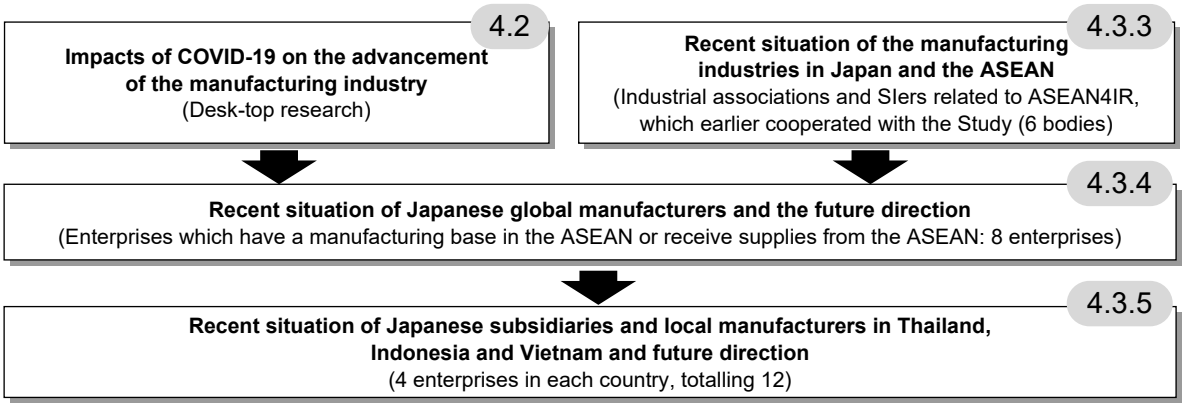


Figure-20 Approach of the interview survey

4.3.2 Survey Results

The prevailing opinion regarding the move to using digital technologies towards the advancement of the manufacturing industry is that there have generally been many changes due to COVID-19 and that the conventional approach concerning smart factories continues. Among local enterprises in the ASEAN region, some of them are conducting the trial use of various digital technologies, including trials on a minor scale.

Several areas for caution are suggested regarding the use of digital technologies. One of these is the necessity to formalize as well as standardize knowledge in the guidance provided by Japan to manufacturing floors in the ASEAN region when conventional face-to-face type guidance shifts to

remote guidance using digital technologies. Another is the difficulty of recruiting digital human resources in the ASEAN region as expressed by many locally operating enterprises along with concern regarding the vulnerability of the communication environment.

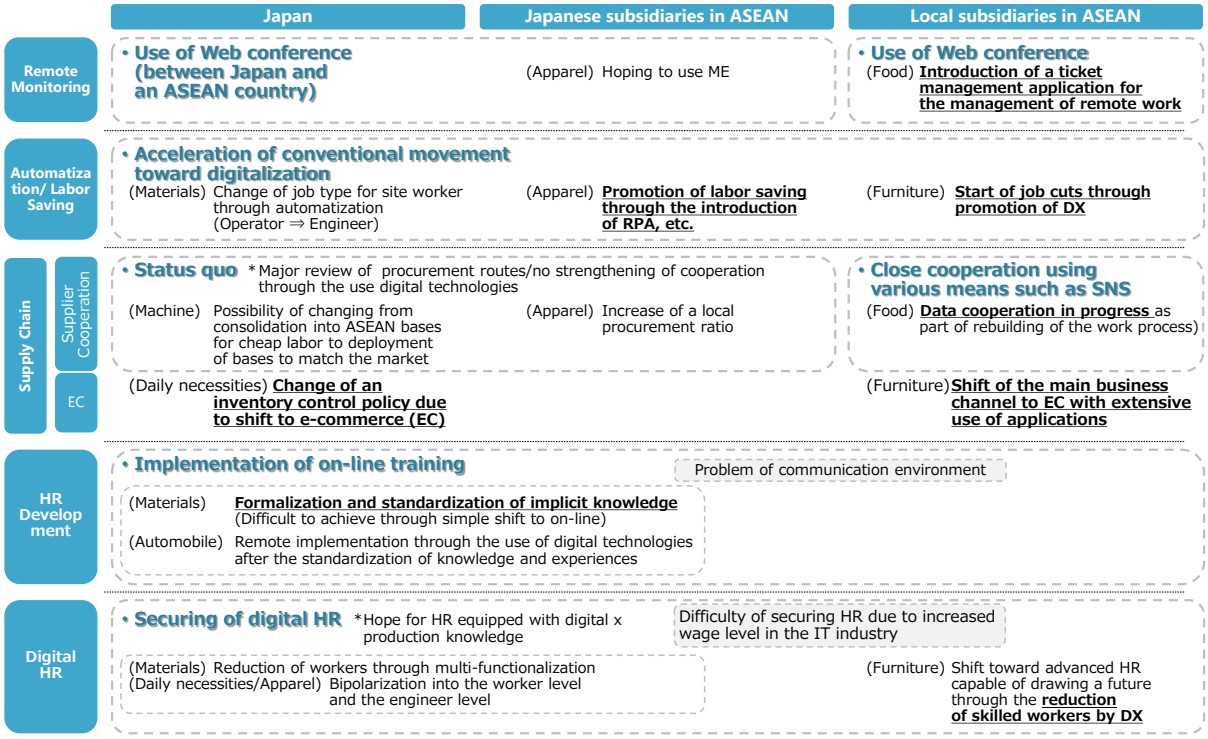


Figure-21 Summary of the interview results

4.3.3 Re-Interview Survey with Existing Contacts

A hypothesis was made regarding the possible impacts of COVID-19 in terms of two aspects (four survey items) based on the desk research results. A series of interviews was conducted in advanced with industrial associations and SIers (total of six interviewees) with a close relationship to the ASEAN 4IR initiative on changes experienced by Japanese subsidiaries and local manufacturers due to COVID-19. These interviewees had cooperated with the Study before and had an understanding of such changes. For this interview, the aspect of "impacts on conventional digitalization approaches" was used to constitute a third point of interest for ensuring interviews.

Figure-22 Areas most severely affected by COVID-19 in the manufacturing industry (hypothesis)

In addition to the hypothesis formed through a series of interviews, the needs for remote monitoring and human resources development were added to the list of interview items in the subsequent step in view of the changes observed with these items.

Viewpoints	Principal Opinions and Views
Efforts to ensure peace of mind and safety	■ Special efforts in response to COVID-19 are limited (One concrete example was observed with a local enterprise which has created a system where the body temperature is checked at the factory entrance and the pilot lump is lighted when detecting the temperature above the designated threshold value. (Thailand))
Review of supply chains	■ **There has been no major changes**, including a comprehensive review. The actual situation is that intended reviews following China +1 and trade frictions between the US and China are difficult to implement due to the worsening of business environment. ■ The supplier side may be required to certain responses in terms of order placement and inspection due to the shift of work to on-line. There is a possibility of selection criteria to be changed.
Impact on conventional effort of digitalization	■ As far as the conventional needs for smartification are concerned, **there have been few changes of direct themes** due to COVID-19. ■ **Acceleration or stagnation of conventional efforts** are observed depending specific industries. (Acceleration is observed with such special procurement industries as medical care and food while the trend of stagnation is observed with the automobile industry, etc. where the demand has fallen.) ■ A shift to digitalization of on-site maintenance, witness inspection, start-up of a production line, etc. may occur due to travel restrictions.
Others	■ **Needs for remote monitoring** are being strongly felt among owners of local enterprises sue to their inability to the production floors. ■ The hurdle for the installation of cameras in a factory due to strong resistance by workers has lowered because of the rising needs tor remote inspection and study visits to the factory. ■ A major redundancy of full-time employees is difficult. **There is a strong interest in upskilling and development of digital HR**, including the use of surplus manpower. ■ Thai government has started **digital training** of new graduates who can not find a job due to declined employment opportunities. **A request for cooperation is made to Japanese subsidiaries. (**As Japanese manufacturers in Thailand enjoy certain popularity among young Thai as places of employment, it is relatively easier for these subsidiaries to recruit IT HR compared in Japan.)

Figure-23 Results of the re-interview survey with existing contacts

4.3.4 Interview Survey with Eight Global Manufacturers Based in Japan

Eight enterprises based in Japan which have a manufacturing base in the ASEAN region or receive supplies from the ASEAN region were interviewed primarily on the question of "what transformation are they considering as Tier 1 manufacturers?" The general reply to this question is that the company-wide understanding of the use of digital technologies has progressed in general. Meanwhile, the opinion on the future direction of human resources involved in manufacturing varies from one enterprise to another, suggesting possible dispersion in their future approaches.

Viewpoints		Principal Opinions and Views
Promotion of digitalization (Automatization, labor saving, remote monitoring, etc.)		■ **Understanding of digitalization has progressed throughout the enterprise**, creating an environment where it is easier to promote DX. (The conception of DX among those lagging industries in terms of DX in the past is changing.) ■ There is an observable change in needs from in-factory monitoring to **general visualization capable of overlooking multiple factories or workplaces.** ■ It has become clear that **many types of work can be remotely handled** once the IT environment is established together with the presence of certain personnel in a country of operation. (Witness inspection, equipment maintenance, etc.)
Supply chain	Review of sales channels	■ There has been a move to examine a possible change from concentration of production bases to local production for local consumption as COVID-19 impacts are smaller when production bases are nearer to the market. (However, the conventional production mode is expected to continue for small production volumes of small products.) ■ As a short-term response to COVID-19, several enterprises **have absorbed demand fluctuations by revising an inventory strategy.** ■ Some enterprises are forced to revise their inventory strategy as the main sales channel has changed **from shops to EC** du to COVID-19.
	Management of and cooperation with suppliers	■ In general, there have been **few new movements due to COVID-19**. ■ With some suppliers, electric communication has advanced using the standard format, etc. (However, there are suppliers who can only deal with Fax or paper documents in Japan.)
Human resources	Remote development of HR	■ As group training has become impossible in Japan or ASEAN countries, there has been as shift to **on-line type training** such as Webinar, Web conference use of iPhone, etc. ■ The pending issue is **how to respond to the needs for interactive sessions and skill transfer. Standardization of knowledge and experiences** must be promoted in advance. (Switch from the conventional training incorporating gestures to on-line means only verbal communication with reduced amount of information, making it more difficult to convey information properly. Common understanding between the Japanese side and the local side is necessary.) ■ The communication aspect tends to deteriorate. (Decrease of opportunities to inherit knowledge and know-how through casual conversations.)
	Requirements of HR towards digitalization	■ There will be divided views: **one towards the necessity of general bottom-raising and another towards advancement of polarization.** ■ With the former, not only the engineering but also **digital-related knowledge** is required for the instructing side. **Through knowledge of work, product, equipment, etc**. is required for the production floor side. ■ With the latter, separation between the **expert HR** capable of managing and instructing from the head office across production bases and **operating HR** executing instructions received. ■ **The sensitivity to digitalization is high** among highly capable local youth. (Thailand)

Figure-24 Interview survey with global manufacturers based in Japan

4.3.5 Interview Survey with Japanese and Local Manufacturers in Thailand, Indonesia and Vietnam

An interview survey was conducted with a total of 12 manufacturers (four manufacturers in each country). Compared to Japanese subsidiaries, local manufacturers are more active in the use of digital tools, including simple applications, with a tendency to try various things, such as supplier collaboration, etc. In the so-called daily necessities sector, including food, review of the supply chain is not mentioned. In the clothing sector and others which are affected by the business climate, voices are heard regarding a switch to e-commerce and small quantity production to meet the demand. In regard to human resources, many enterprises are facing a difficulty of recruiting and keeping suitable IT personnel because of it being a seller's market in these countries.

Viewpoints		Principal Opinions and Views
Promotion of digitalization	General trend	■ There is **a general trend towards** digitalization. **Changing awareness among the top management** is a major factor, constituting **a tail wind for investment in digital technologies.** ■ At factories, the main infection control measures are physical ones because of the difficulty to do it remotely and there have been few changes of efforts towards **visualization and automatization. (The conventional efforts are the mainstay.)**
	Special matters	■ Some enterprises significantly affected by COVID-19 have mentioned **the review of the entire work process and intention to reduce the workforce** using the crisis as an opportunity. ■ With Japanese subsidiaries, there appears a tendency to shift the work (check of the manufacturing method, handling of problems encountered, etc.) conventionally done by personnel on business trip to remote work from the head office. At present, conventional means (on-line meeting, image sharing by e-mail, etc.) are the main methods, some enterprises has mentioned **accelerated introduction of MR, etc. in the future**. ■ A voice is heard that labor saving is progressing through the introduction of **RPA** (Robotic Process Automation) to the back-office sections. ■ An enterprise is attempting **progress monitoring through the introduction of a ticket management application** to the remote work.
Supply chain	Review of sales channels	■ Because of a limited impact on the supply chain among the surveyed enterprises, **the main reaction is to maintain the status quo**. Some enterprises intend to **increase the domestic procurement ratio and dispersion of procurement sources**. ■ The principal reaction to deal with a short-term impact is **increased inventory**. Some enterprises mentioned **a shift to e-commerce** and **departure from the mass production for mass consumption model** by the entire industry in the future.
	Management of and cooperation with suppliers	■ As many enterprises are already attempted the introduction of basic tools (e-mail and chat tool) and diversification of suppliers, **new moves have been limited.** ■ Except some local enterprises, hardly any enterprises conduct electronic sharing of data with suppliers and no intention to do so in the future is expressed. ■ Enterprises without basic tools or Japanese subsidiaries for which the authority to select suppliers rests with the head office in Japan are aware that they struggled because of **their inability to flexibly to respond to rapidly changing demands.**
Human Resources	Remote development of HR	■ In general, raining is progressively generally **shifting towards on-line** using a Web conference tool, etc. ■ The shift to on-line training (mostly classroom learning) for **the back-office sections** is progressing smoothly in general although there are some problems, including how to maintain concentration of trainees. ■ **Technology-related on-line training** (mostly featuring practical exercise) requiring the teaching with use of images, etc. faces **such issues as immediacy, transmissivity, quality, etc. of communication.**
	Requirements of HR towards digitalization	■ **Knowledge of ITC is not sufficient** to carry DX forward. The required HR are those who possess knowledge of work an production management and are capable of drawing a vision, overlooking the entire picture. ■ The mainstream view concerning the use of digital technologies is that there will be no problem as **many local employees have relevant knowledge** and their interest in and adaptability to advanced technologies are high. (Development and introduction of advanced technologies are different matters.) ■ It is **difficult to recruit and ensure long service** of IT human resources as it is a seller's market with a high wage level in every country. (Employment at a start-up, etc. has recently become popular.) ■ **In-house training is imperative** for IT HR in the manufacturing industry as they are required knowledge of production floors and work processes but **leaving their jobs after being trained** has become a matter of concern.

Figure-25 Interview survey with Japanese and local manufacturers in Thailand, Indonesia and Vietnam

5. Invitation Program Implementation

5.1 First Invitation Program

(1) Program Background and Objective

The main objectives of the survey were to learn about Japan's policy for upgrading manufacturing industries related to Industry 4.0 and examples of field-based initiatives, to share and collaborate with similar initiatives in other countries, and to share knowledge and strengthen networks with key persons from governments, institutions and organizations in important countries as cooperation targets and resources for JICA to promote cooperation in the field of

industrial development using new technologies. The main purpose of the survey was to share knowledge and strengthen networks with key persons in governments, institutions, and organizations in countries that are important as cooperation targets and resources for JICA to promote cooperation in the field of industrial development using new technologies. The first training course (that was scheduled in FY2019) was planned and implemented as a trial version of the new issue-specific training program that JICA plans to launch in 2020 to promote understanding of new technologies and strengthen networks among related parties, which will contribute to the advancement of technology-based industries. The subject-specific training program will start in FY2021 as "Business Innovation in the Fourth Industrial Revolution Utilizing IoT and AI.

(2) Training Schedule (February 16 - 22, 2020)

Date	Time	Place to Visit	Training Contents
Feb.16 (Sun.)			Arrival in Japan
17 (Mon.)	10:00-11:00	JICA Head Office	Program Orientation
	11:00-12:00		Courtesy Meeting with the Director of Industrial Development and Public Policy Dept., JICA HQ. (At the time)
	13:30-15:00		Lecture "The Role and Expectation of Digital Policy for Industrial Development in Asia"
	15:30-17:00	JETRO Head Office	Lecture: "Overseas Development of Industrial Advancement Technologies of Japanese Companies"
	18:30-20:30		Welcome Dinner by JICA
18 (Tue.)	09:30-11:30	Robot Revolution & Industrial IoT Initiative (RRI)	Lecture: "Latest Technological Trends of IoT and Robots in Manufacturing"
	15:00-15:30	National Institute of Advanced Industrial Science and Technology (AIST)	Visit to observe AIST initiatives and "Science Square TSUKUBA"
	15:30-16:00		
19 (Wed.)	10:00-12:00	Yasukawa Solution Factory	Study visit to a Smart Factory
	14:30-15:30	JICA Head Office	Lecture: "Examples of Solutions Suitable for Asia for Advancement of the Manufacturing Industry"
	17:40-19:10	Move to Hiroshima	Take flight to Hiroshima
20 (Thu.)	09:00-15:00	MAZDA Hiroshima Plant	"Case Study of the Advancement of the Manufacturing Site of an Automobile Factory by IoT & Industry-Academia-Government Collaboration"
	15:20-16:30	Visit Hiroshima Peace Memorial Museum	Hiroshima Peace Memorial Museum
	18:25-19:45	Move to Tokyo	Take flight to Tokyo Haneda
21 (Fri.)	09:30-12:00	JICA Takebashi Building	Keynote Speech: "Attractiveness of the smart manufacturing market in Southeast Asia viewed from the strength of the Japanese manufacturing industry"
	12:30-14:00		Exchange Lunch Meeting with invitees
	15:30-16:00		Wrap-up Meeting
22 (Sat.)			Departure from Japan

(3) Invitees: 9 persons

No.	Country	Organization	Position
1	Indonesia	Ministry of Industry National Research and Innovation Agency	Director
2	Indonesia	Ministry of Communication and Information Technology (KOMINFO) Directorate General of Informatics Applications	Acting Director
3	Malaysia	Malaysia Productivity Corporation (MPC) Quality & Excellence Development	Director
4	Thailand	Department of Industrial Promotion (DIP) of the Ministry of Industry	Deputy Director General
5	Thailand	Digital Economy Promotion Agency (DEPA)	Executive Vice President
6	Thailand	National Innovation Agency (NIA)	Deputy Director General
7	Vietnam	Ministry of Planning and Investment (MPI) National Innovation Center (NIC)	Director
8	Vietnam	Ministry of Industry and Trade (MOIT) Department of Science and Technology (DST)	Vice Head
9	Vietnam	Ministry of Information and Communication (MIC) Department of Information Technology (DIT)	Director General

(4) Contents (Summary)

1) Lecture

- "The Role and Expectations of Digital Policy for Industrial Development in Asia"

> Introducing private sector-led actions implemented so far concerning Society 5.0 which is an approach of the Japanese government in response to 4IR and future prospect of the relevant actions

- "Overseas Development of Industrial Advancement Technologies of Japan"

> Introducing Denso's approach to lean automation and the LASI Initiative aimed at fostering relevant SIers in Thailand

- "Latest Technological Trends of IoT and Robots in Manufacturing"

> Introducing a road map for 4IR and efforts to promote 4IR through the use of industrial IoT and robots in the manufacturing industry.

- "Examples of Solutions Suitable for Asia for Advancement of the Manufacturing Industry"

> Introducing actual cases of solutions aimed at advancing the manufacturing industry in Japan and ASEAN countries

- "Attractiveness of the smart manufacturing market in Southeast Asia viewed from the strength of the Japanese manufacturing industry"

> Introducing an "inclusive" way of manufacturing which makes the best use of "advanced coordinated architecture products" as a strong point of Japanese manufacturing

(monodzukuri) to benefit people of Southeast Asia unlike the Western style of a top-down approach using ICT.

2) Observation Visits

- National Institute of Advanced Industrial Science and Technology (AIST): Science Square TSUKUBA"

> Visit to observe research results relating to industrial advancement, including the manufacturing industry, at the AIST, summary introduction of the AIST's work in the field of industrial advancement and exchange of opinions

- Yasukawa Solution Factory

> Visit to observe equipment and systems of a factory which has realized production based on Industry 4.0 by introducing the latest IoT and AI technologies

- MAZDA Hiroshima Plant

> Visit to observe a plant which has realized the advancement of manufacturing work and improvement of productivity by introducing, AI, etc. at automobile production lines

3) Other

- Exchange Meeting

> At the exchange meeting held during the lunch time of the final day, lecturers and people from the target places for observation visits were primarily invited to exchange opinions on the efforts of Japanese subsidiaries in the target countries and other topics.

> During the exchange of opinions, the participants were interested in the Director General of the Ministry of Information and Communications of Vietnam's efforts to strengthen information security in line with the shift to IoT in Vietnam as well as the IoT strategy of the Ministry of Industry and Trade of Vietnam. They also expressed interest in the Malaysian government's desire for close collaboration with Japanese companies for the advancement of manufacturing.

5.2 Program Replacing the Invitation Program to Japan

(1) Program Background and Objectives

Based on the findings of the Study so far, the current situation of advancement of the manufacturing industry towards 4IR in the target countries except Myanmar (Indonesia, Malaysia, Thailand and Viet Nam) can be summarized as follows.

- Large enterprises can proceed without external assistance as they have sufficient financial strength and understanding of an ongoing trend of advancement of the manufacturing industry.
- Training of SIer (System Integrator: actor to provide solutions using IoT technology, system development, etc.) to respond to advancement of the manufacturing industry is being conducted to a certain extent. (For example, LASI in Thailand)
- In contrast, response of SMEs to advancement tends to be slow in not only target countries but also in Japan. Although a subsidy (or grant) system and other supporting measures are somewhat available in every country, there is a common lack of understanding among SMEs, regarding why advancement is necessary and what are the merits of advancement for their own production floors and business management. As such, it is a pending task to motivate them to aim at advancing their business.

In view of the current situation described above, a new program was implemented for the purpose of clarifying how to proceed with the change of awareness towards the advancement of mid-sized enterprises as well as SMEs and making the participants learn as many precedents of advancement of the manufacturing industry in Japan as possible as references for a desirable change of awareness. The invitation program planned for FY 2021 was replaced by an on-line exchange program because of COVID-19.

(2) Schedule (November 8 – 12, 2021)

Day	Time	Contents	Lecturer, etc.
November 8 (Mon.) (Future of Advancement of the Manufacturing Industry)	15:00-15:30	・ Opening address by JICA ・ Self-introduction of the trainees ・ Explanation of the training contents by the Study Team: How to view case studies on YouTube, etc. ・ Explanation of the future image of the manufacturing industry to be realized by Industry 4.0 by the Study Team	JICA; Study Team
	15:30-17:00	Lecture: "Manufacturing in Asia and Japan in the era of sustainability, digitization and globalization"	Manufacturing Management Research Center, Tokyo University
November 9 (Tue.) (On-Line Lecture of Precedents in Japan)	15:00-15:50	Lecture: "Manufacturing as the foundation of all industries"	Robot Revolution & Industrial IoT Initiative
	15:50-16:00	Break	
	16:00-16:50	Lecture: "Digital Eyes into the field"	Factory Scientist Association
	16:50-17:00	Break	
	17:00-17:50	Lecture: "ASEAN-Japan Cooperation in the field of DX for manufacturing"	Ministry of Economy, Trade and Industry (METI); AMEICC

Day	Time	Contents	Lecturer, etc.
November 10 (Wed.) (Presentation of Efforts of Each Country and Discussions)	15:00-16:20	Sharing of the situation of efforts towards advancement of the manufacturing industry in each country (including responses to COVID-19) (20 minutes x 4 countries)	Participant from each country
	16:20-17:00	Discussions ・ Way to change awareness towards the advancement of mid-sized and small manufacturers ・ Cooperation of Japanese enterprises (manufacturers and SIers) ・ Framework for future cooperation for the advancement of Japanese and ASEAN manufacturing industries ・ Request for JICA's assistance, etc.	Participant from each country; Study Team members; JICA personnel; others
November 11 (Thurs.) (Rounding Up of Training and Preparations for Final Day)	15:00-16:00	Rounding up of the training (discussion) Preparations for the open webinar on the final day	Participant from each country; Study Team members; JICA personnel; others
November 12 (Fri.) (Open Webinar)	10:30-10:45	Keynote Address: "DX in Manufacturing and ASEAN-Japan Cooperation"	METI
	10:45-12:25	Panel discussion ・ Presentation by each country (approximately 10 minutes each) ・ Prospects for future cooperation for advancement of Japanese and ASEAN manufacturing industries ・ Current efforts and future cooperation policy, etc. of JICA	Speaker from each country; METI; JICA
	12:25-12:30	Webinar closing address	JICA

(3) Invitees: 8 persons (November 8 – 11, 2021)

No.	Country	Organization	Position
1	Indonesia	Industrial Services Standardization and Policy Agency (BSKJI), Ministry of Industry	Policy Analyst
2	Malaysia	Industry Development Division, Ministry of International Trade and Industry (MITI)	Senior Principle Assistant Director
3	Malaysia	Industry Development Division, Ministry of International Trade and Industry (MITI)	Senior Assistant Director
4	Malaysia	Industry Development Division, Ministry of International Trade and Industry (MITI)	Senior Assistant Director
5	Malaysia	Industry Development Division, Ministry of International Trade and Industry (MITI)	Assistant Director
6	Malaysia	Malaysia Productivity Corporation (MPC)	Manager
7	Thailand	Digital Economy Promotion Agency (DEPA)	Executive Vice President
8	Vietnam	Ministry of Planning and Investment (MPI) National Innovation Center (NIC)	Acting Head

(4) Speakers at the Open Webinar: 5 persons (November 12, 2021)

No.	Name		Country	Organization	Position
1	Mr.	Heru Kustanto	Indonesia	Industrial Services Standardization and Policy Agency (BSKJI), Ministry of Industry	Head
2	Mr.	Joshua Tan Pang Yoong	Malaysia	Industry Development Division, Ministry of International Trade and Industry (MITI)	Senior Principle Assistant Director
3	Ms.	Saliza Saari	Malaysia	Malaysia Productivity Corporation (MPC) Organization Excellence Development	Director
4	Mr.	Supakorn Siddhichai	Thailand	Digital Economy Promotion Agency (DEPA)	Executive Vice President
5	Mr.	Vu Quoc Huy	Vietnam	Ministry of Planning and Investment (MPI) National Innovation Center (NIC)	Director

265 people from mid-sized Japanese enterprises (in the manufacturing industry), solution or equipment providers related to the digitalization of the manufacturing industry and others registered to attend the Open Webinar and some 150 people actually participated.

(5) Contents (Summary)

1) Lectures

- "Manufacturing in Asia and Japan in the Era of Sustainability, Digitization and Globalization"

> Introduction of the strength of the Japanese manufacturing industry and what post-COVID smart manufacturing should be in Southeast Asia

- "Manufacturing as the foundation of all industries"

> Introduction of examples of a digital platform in the manufacturing industry

- "Digital Eyes into the field"

> Introduction of a case to provide training designed to support the smartification of manufacturing SMEs in Japan through their self-help efforts

- "ASEAN-Japan Cooperation in the field of DX for manufacturing"

> Introduction of a RDX demonstration project and a LIPE program

- Keynote Address: "DX in Manufacturing and ASEAN-Japan Cooperation"

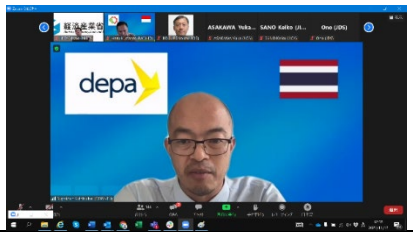
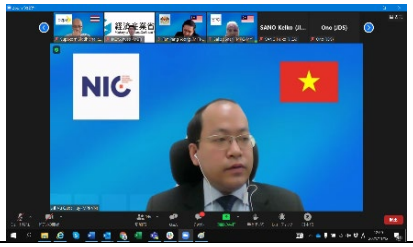
> Introduction of DX and Japan-ASEAN cooperation in the manufacturing industry

2) Presentation by the representative of each country (Summary)

Country and Title	Summary of Presentation
Indonesia (Industry 4.0 Implementation in Indonesia)	Manufacturing is the largest sector in Indonesian economy. Making Indonesia 4.0 started in August, 2018 and aims at leading economic growth and achieving Global Top 10 status by 2030. Priority areas are identified and the Indonesia Industry 4.0 Readiness Index (INDI 4.0) is used as the relevant index. One pending issue is the shortage of human resources carrying DX, IoT, etc. forward. The infrastructure and finance to develop such human resources are also insufficient. Cooperation with Japan (JICA) is hoped for to achieve Industry 4.0.
Malaysia: MITI (Collaboration for Smart Manufacturing in the DX Era)	The acceleration of digitalization is intended based on the Malaysian Digital Economy Blueprint, National 4IR Policy Framework. Digitalization of the manufacturing industry has been promoted since 2018 under the Industry 4WRD policy. As SMEs need guidance on DX, there is a program for this. SMEs can also receive the necessary funding. Matching with SIers is in place. Capacity building is in progress through cooperation with universities. Many SMEs lack sufficient funds while facing such problems as a shortage of usable platforms and necessary human resources and inability to collect real-time data. Meanwhile, cooperation with Japanese enterprises is progressing even though there is a problem of insufficient skills on the SME side.
Malaysia: MPC (Industry 4WRD Malaysia Productivity Corporation)	Productivity Report 2021 is published and various issues are analysed. Even though there are some difficulties to achieve DX, measures to deal with them are introduced. Cooperation with Japan is hoped for to share actual business cases involving SMEs.
Thailand (Advancement of Manufacturing industry in Thailand)	Activities at the ITC, TGI, Automation Park, SIMTEC, SMC, etc. are promoted as development centers for Industry 4.0. The DEPA has been constructing Digital Valley since 2019. Thailand aims at becoming a leader in the field as this Digital Valley will be equipped with a digital manufacturing ecosystem. A digital hub is being constructed to the east of Bangkok as a smart city. Cooperation with Japan is hoped for.
Vietnam (Digital Transformation in Manufacturing Sector in Vietnam)	In 2020, the National Digital Transformation Program was launched with the aim of digitalizing 20% of the national economy by 2025. SMEs are currently facing problems, including a high cost of introducing security measures and solutions. A lack of suitable human resources is another problem. Cooperation with Japan is hoped for in terms of the exchange of knowledge, networking with experts, capacity building of human resources and support for technology transfer.

3) Panel Discussion

At the Open Webinar held on November 12, 2021, the representatives of four countries replied to the questions asked by the moderator, explaining the problems and measures to be sought by each country.

Key Question:	What is the biggest prohibiting factor for SMEs from applying digital technologies in their manufacturing and what would be the solution for it.
Mr. Heru Kustanto Ministry of Industry, Indonesia: 	I think that the shortage of the necessary human resources is the one, particularly digital-savvy human resources. The infrastructure and finance to train such human resources are also problems.
Mr. Joshua Tan Pang Yoong Ministry of International Trade and Industry, Malaysia: 	As a nation, Malaysia is strengthening the engagement between enterprises concerning DX and there is a need for the government to support such engagement. It is important to show successful cases.
Ms. Saliza Saari Malaysia Productivity Corporation: 	Pending issues include the lack of a comprehensive plan and the absence of business assessment. MPC has prepared a program to solve these issues. It is important for vendor enterprises to understand SMEs via supply chains as they need to think about what kind of support SMEs require of them. The introduction of successful cases to SMEs is making their initiatives change.
Mr. Supakorn Siddhichai Digital Economy Promotion Agency, Thailand: 	The cost appears to be too high. As SMEs are unable to understand the merits of DX, it is difficult for them to make a judgement on investment. We would like to proceed with financial support in addition to showing successful cases of DX to SMEs. Once they understand the merits of DX, they will judge the investment need themselves to proceed.
Mr.Vu Quoc Huy Ministry of Planning and Investment, Vietnam: 	There is a lack of sufficient understanding of the importance of DX. Enlightenment by the government is important. What is critical is to make SMEs understand the importance of DX before promoting DX among them.

6. Detailed study and implementation of the pilot in collaboration with Japanese affiliated companies

Based on the results of the desk survey and the first field survey, the manufacturing processes and target company groups that can be expected to become more advanced through the use of new technologies were extracted (see 7.1), and the steps, issues, and proposed measures for smart manufacturing through the use of new technologies were listed (see 7.2). Based on this list of proposed measures, we identified the issues and needs of Japanese companies that are operating or considering operation in the region, as well as the issues and needs for industrial human resource development in the target countries, and developed nine proposals for the implementation of pilot programs that would contribute to solving these issues. Two of them were selected through consultations among the parties concerned, and were implemented together with an open innovation event on smart manufacturing that was to be held separately. The remaining seven proposals, which were not selected, have been included in JICA's medium to long-term cooperation programs (see 7.3) after the details were elaborated.

6.1 Smart Manufacturing Ideathon Seminar in Vietnam

As shown in the table below, events were held in Hanoi and Ho Chi Minh City for Japanese and local manufacturers and system integrators in Vietnam to discuss and match ideas on how to make their workplaces smarter for the 4IR.

Table-30 Summary of the Smart Manufacturing Ideathon Seminar

Areas of Cooperation	Promoting collaboration between Japanese and local companies
Target country	Vietnam
Implementation period	1 day x 2 times (1 time each in Hanoi and Ho Chi Minh City)
Target group	・ Managers of local subsidiaries of Japanese small and medium-sized manufacturing companies and local Japanese companies, and persons in charge of production and kaizen. ・ Officers in charge of 4IR-related policies at ministries and departments
Cooperated organizations	・ MPI-AED (Agency for Enterprise Development, Ministry of Planning and Investment) Announcement of support policy ・ HAPI (Hanoi Authority for Planning and Investment -SME Support Center) Company selection and observer ・ DOIT-HCMC (Department of Industry and Trade, Ho Chi Minh City) Company selection and observer ・ Japan Center (Hanoi and Ho Chi Minh City)
Place of implementation	Japan Center (Hanoi and Ho Chi Minh City)
External resources	・ Facilitator during brainstorming (Lecturers of Hanoi University of Science and Technology – HUST / Ho Chi Minh City University of Technology -HCMUT)
Issues and needs of participating Japanese companies	・ Interested in smart factories, but don't know where to start. ・ Want to know the examples of smart manufacturing in Japan and around the world.
Objectives to fulfill	・ Share the correct understanding of 4IR and consider measures that SMEs should take to achieve the future vision of the 4IR. ・ Examine specific measures that can be taken locally with reference to the case study.

Activities and Process	1. Each participant will be asked to enter their own manufacturing site issues and needs in advance (at the time of pre-registration) using the web-based registration system. 2. Before the event, tally the issues, needs, and ideals of all participants and organize them to eliminate duplication. 3. The overall picture of the upgrading of the manufacturing industry, including Industry 4.0, will be explained by clearly dividing it into important core parts (including the upgrading roadmap) and peripheral/derived parts, and many specific examples will be introduced. (Summary by the survey team, exhibition by companies if possible) 4. Present the pre-aggregated issues, needs, and ideals to everyone online. 5. Discuss and generate ideas by brainstorming (in groups according to the number of participants) on what is needed to solve each problem, need, or ideal. Try to come up with multiple ideas for solutions from different perspectives, such as policy, code of conduct, technology, and education. 6. All participants will discuss the applicability of feasible solutions, including new technologies, to the discussed results. 7. Introduction of support measures for manufacturing innovation by the local government. 8. Summarize the results of the discussion and share them with everyone.
Important point	Solution providers for smart manufacturing will not participate in discussions. This is because such companies may be obsessed only with selling their solutions. Instead, they are given time to introduce their solutions after the report of discussion result.

6.1.1 Seminar in Hanoi

Date and time : Wednesday, November 6th, 2019, 9:00-17:00

Location : Vietnam -Japan Institute for Human Resource Development (VJCC), Hanoi

Participants ･･ :

Vietnamese SMEs	13 companies (20 persons)
Japanese medium and small companies	5 companies (6 persons)
Solution provider companies	Vietnamese 4 companies (7 persons) / Japanese 5 companies (9 persons)
Vietnamese Administrative Organization	MPI (2 persons) / MOIT (1 person) / HAPI (3 persons)
Lecturers of HUST	3 persons
Other observers	2 organizations (3 persons)
JICA	2 persons
JDS	4 persons
	Total 60 persons

Preparatory steps

- As for the participating SMEs, we contacted and invited SMEs introduced by the TAC of MPI-AED, companies participating in the Industrial Innovation Project of MOIT, and SMEs introduced by the HAPI SME Support Center. We also asked Vietnam office of the Japan Chamber of Commerce and Industry to share the information to its member medium and small manufacturing companies.
- As for the solution provider companies, we contacted AED-TAC, MOIT, HAPI, and the companies introduced by companies that we visited during the survey, and also asked the Vietnam office of the Japan Chamber of Commerce and Industry to share the information with their member companies.

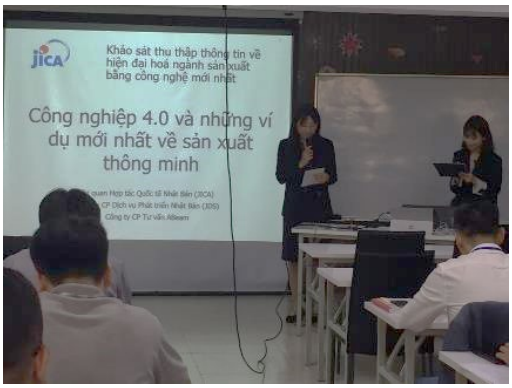
Details of the seminar

(1) Opening remarks Industrial Development and Public Policy Department, JICA Headquarters (at that time)

4IR is a hot topic right now, and JICA will be focusing on it. Following this ideathon, a hands-on seminar is planned. Participants of this seminar will be given priority to attend.

(2) Industry 4.0 and the latest examples of smart manufacturing (Survey team)

Understanding of Industry 4.0 and explanation of the latest case studies. It is considered better to promote digitalization (bottom-up method) based on KAIZEN as a Japanese style of Industry 4.0.



(3) Brainstorming Each facilitator (HUST lecturers and JDS consultants)

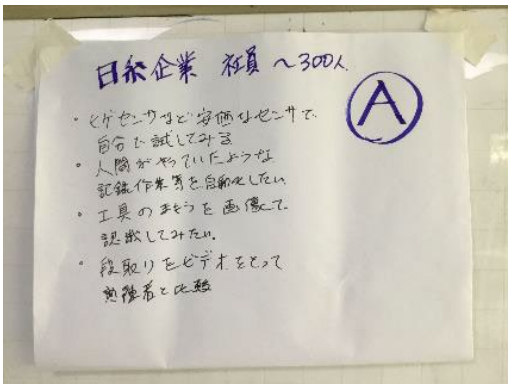
Divided into five teams and did brainstorming in each group.

The presentations of the group work results are as follows.

Team A) Small-scale Japanese manufacturing companies (less than 100 employees)

Future smartification policies of participating companies:

- It is risky to introduce an expensive system right away.
- Would like to start with something like counting the number of products made.
- Would like to develop a method of checking lathe wear with data, such as taking videos and comparing them with the procedures of skilled workers.



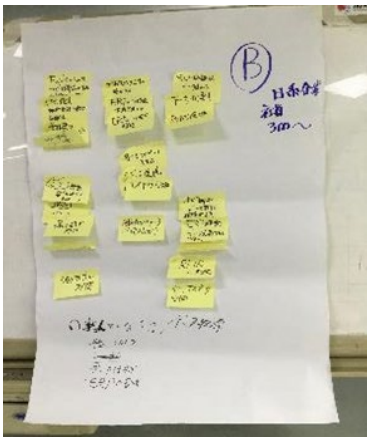
Team B) Large-scale Japanese manufacturing companies (more than 300 employees)

Current issues faced by participating companies:

- IT introduction and 5S are quite advanced.
- It's hard to import paper data into ERP.
- It's hard to make everyone familiar with 5S, especially IoT technology.
- Even if employees are trained, they will quit.

Future smartification policies of participating companies:

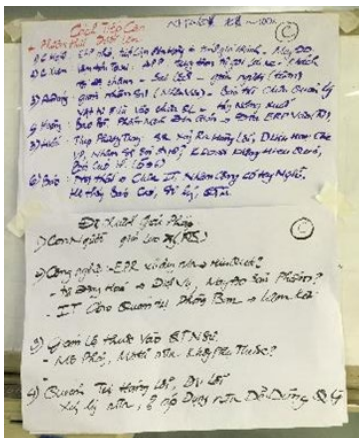
- Would like to start with something small.
- Would like to consider utilizing analyzed sensor data and environmental data together.
- Would like to spread the top-down policy to all employees.
- Would like to take security into consideration when implementing ERP.



Team C) Vietnamese companies (less than 100 employees)

Future smartification policies of participating companies:

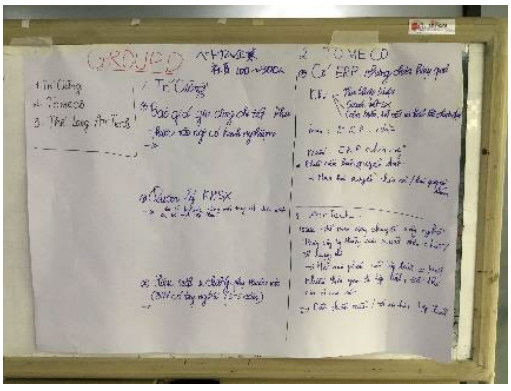
- Human resource management, automation of all processes, and quality control are issues. Would like to propose workforce reduction (efficiency improvement), data-driven decision-making, and reduction of defect rate.
- Seeking proposals for bottom-up promotion, sensor implementation, and ERP implementation solutions.



Team D) Vietnamese companies (100 to 300 employees)

Future smartification policies of participating companies:

- Facing challenge of making quotations and would like to proceed with the solution in case study.
- Have an issue that ERP implementation is difficult, and would like to consider bottom-up implementation instead of top-down implementation.
- Want to create KPIs and evaluate them. For this purpose, would like to introduce video cameras and take videos of skilled workers to compare their work.
- Even if the production line is small, it takes the same amount of time and effort to set up the system, so we need a solution to solve this problem.



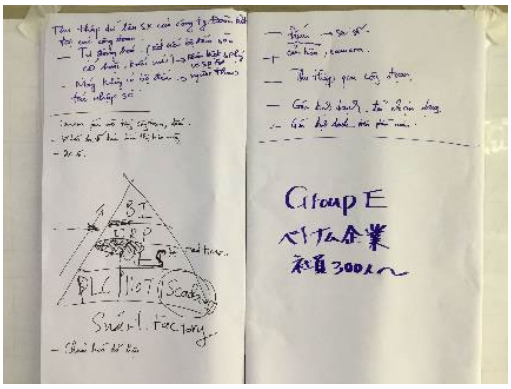
Team E) Vietnamese companies (more than 300 employees)

Current issues faced by participating companies

- Printed materials are counted by hand, which leads to errors.
- No IoT has been introduced to the press process, and no data has been obtained.
- There are a large number of machines (40), and it is difficult to control defective products and grasp the operation volume of each machine.
- Control of the number of remaining parts in the case of defective parts in the production of circuit boards.
- Necessity of automating the labeling process.

Future smartification policies of participating companies:

- The participants discussed what a smart factory should look like, summarizing it in a diagram.
- Would like to promote the use of cameras.
- Would like to promote the conversion of analog work into digital data.



(4) Presentation by Solution Provider

Solution Provider A

A company that provides solutions for the construction equipment industry (150 Japanese, 6 Vietnamese, 57 years in business). As a solution, would like to propose EMS (under development), ECO Power FIT (intermittent operation system), and DiAS (AI-based energy saving control) for SMEs.

Solution Provider B

A small company that develops IoT/AI solutions. Can propose system for warehousing, logistics, and others. It has a system called AI-OCR that can streamline data entry.

Solution Provider C

The group is supported by 300,000 people worldwide and 12,000 people in Asia. The company provides services to the manufacturing services industry (Data Center/WAN Network/Server Systems). Currently operating a data center in a joint venture with Vietnam. The company also provides solutions for warehouse management, supply chain management, ERP, etc. Would like to propose RPA to streamline our business.

Solution Provider D

The company deals with equipment solutions, robots, etc. for the plastics industry.

Solution Provider E

The company deals with automation solutions, machining, etc.

Solution Provider F

The company offers ERP/Cloud/DMS/RPA, etc. Offers cheap ERP, not expensive ERP like Oracle/SAP.

(5) Support measures by MPI-Agency for Enterprise Development (AED) for SME manufacturers in the field of smartification

For Industry 4.0, we are trying to revise the laws and regulations and support it with a special system. It may take some time to develop the laws and regulations.

(6) Introduction of MOIT Priorities and Programs to support digital transformation in manufacturing

Shared the result of Industry 4.0 Readiness Assessment of Vietnamese manufacturing industry. The application rate of Industry 4.0 is still 2-3%. The Vietnamese government is preparing an action plan to proactively support Industry 4.0 in the future.

As for MOIT, it provides a program to support enterprises and help them adopt IoT. Hope to realize Industry 4.0 in Vietnam soon.

(7) Creativity support project of SME support center, Department of Planning and Investment, Hanoi

There are 275,000 companies in Hanoi. Programs are in place to promote entrepreneurship. Currently cooperating with Hanoi University of Technology. If you want to start a business, please register. Hanoi Innovation Start Center will be established to strengthen support.

(8) Introduction of human resource development course at VJCC Hanoi (VJCC)

VJCC is preparing a seminar for SMEs (Data-Driven Management: 3-day course, fee-based), to be held in March 2020, which should help SMEs solve their issues. Participants of today's session will be notified by e-mail later.

(9) Introduction of IoT hands-on training program for SMEs (Survey Team)

For those who attended the VJCC's Data-Driven Management seminar, we are planning a training course for companies that want to create their own systems.

(10) Ideathon Summary and Closing Remarks

(11) Sending seminar materials and participant list to participants after implementation

After the seminar, the materials used in the seminar and the contact list of the participants will be shared with all the participants in the hope that it will help them to collect information and build a network for future promotion of smartfication.

6.1.2 Meeting in Ho Chi Minh City

Date and time : Friday, November 8th, 2019 ····· 9:00-16:00

Location : Vietnam -Japan Institute for Human Resource Development (VJCC), HCMC

Participants :

Vietnamese SMEs	5 companies (7 persons)
Japanese medium and small companies	5 companies (6 persons)
Solution provider companies	Vietnamese 2 companies (2 persons) / Japanese 4 companies (7 persons)
Vietnamese Administrative Organization	MOIT (1 person) / DOIT (4 persons)
Lecturers of HCMUT	3 persons
Other observers	9 organizations (11 persons)
JICA	2 persons
JDS	4 persons
	Total 47 persons

Preparatory steps

- As for the participating SMEs, we recruit appropriate companies for participation from recommended companies by MOIT's Industrial Innovation Project and SME organizations affiliated with the DOIT SME Support Center. We also asked Vietnam office and HCM branch office of the Japan Chamber of Commerce and Industry to share information to its member medium and small manufacturing companies.
- As for solution provider companies, we contacted companies introduced by MOIT, DOIT and companies that we visited during the survey, and also asked the Vietnam office and its HCM branch of the Japan Chamber of Commerce and Industry to share the information with their member companies.

Details of the seminar

(1) Opening remarks (JICA Vietnam Office, Ho Chi Minh branch)

The 4IR is still on the way, but it is said that digital technology will transform the manufacturing industry, and JICA will continue to focus on it. In this survey, we found that small and medium-sized companies are not even prepared for it and have a different understanding of it. In this ideathon, we want to deepen its understanding. We are also planning to hold a hands-on seminar in March to follow. Participants of this seminar will be given priority to attend.

(2) Industry 4.0 and the latest examples of smart manufacturing (Survey team)

Understanding of Industry 4.0 and explanation of the latest case studies. It is considered better to promote digitalization (bottom-up method) based on KAIZEN as a Japanese style of Industry 4.0.

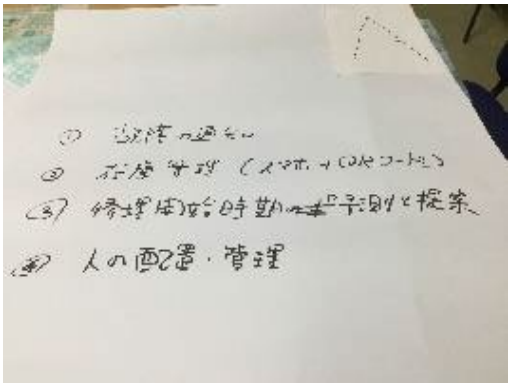
(3) Brainstorming Each facilitator (HUST lecturers and JDS consultants)

Divided into three teams and did brainstorming in each group.
The presentations of the group work results are as follows.

Team A) Japanese manufacturing companies

Future smartification policies of participating companies:

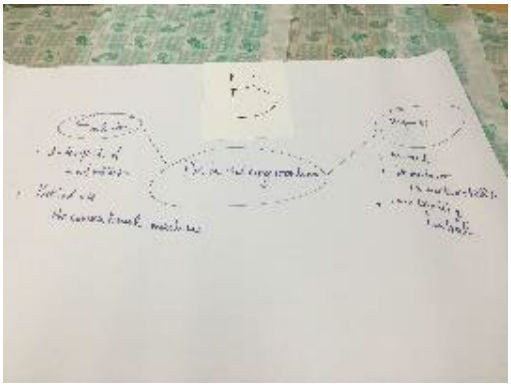
- Improve the efficiency of notifications when a machine breaks down (e.g., monitoring with cameras and send notifications).
- Inventory management using smartphones and QR codes.
- A system that predicts and suggests when to start repairing equipment (based on equipment noise, temperature, etc.). In companies where it is difficult to automate, would like to use a system that understands the characteristics and abilities of people in order to allocate and manage people (when someone is absent, when a new employee is hired, etc.).
- In employee management, in particular, employees do not like the use of cameras to measure their abilities, so it is necessary to use cameras only for limited purposes, or to use them for praise (awards) rather than for management purposes.
- As AI has advanced, data can be easily used for analysis if it is available.



Team B) Vietnamese companies

Future smartification policies of participating companies:

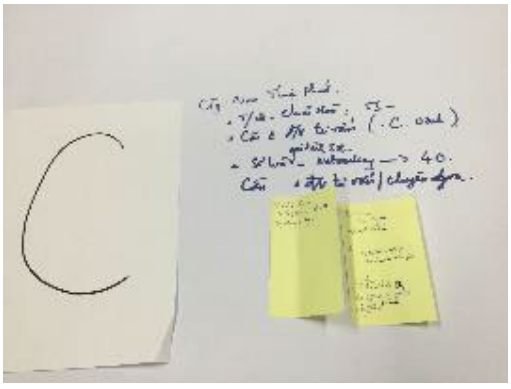
- The first company is a company that has yet to automate. They discussed the need to automate simple tasks to improve productivity and maintain quality.
- They thought it is possible to automate the work by using the sensors already in the machines and creating a control system without installing new machines.
- The second company wants to install sensors on their machines to manage the raw materials they purchase. They discussed the importance of capturing data to understand the operating rate.
- The third company is a factory with a lot of automation. Since they have already installed robots, they want to introduce low-cost IoT. They would like to introduce a new system for quality control, defect rate management, and production control, but they would like to create their own system using smartphones and inexpensive sensors, and would like to introduce AI in the next step.



Team C) Vietnamese companies

Future smartification policies of participating companies:

- Three manufacturing companies. The machining company is facing the issue of human resources and is unable to recruit talented people. Therefore, they are interested in automation and want to improve efficiency through smart technology. They are looking for a provider for this.
- They think it is important to improve the efficiency of work for 5S activities and production efficiency, and would like to do human resources management.
- A company that manufacture products that cannot all be mechanized wants to create replacements for people through smart technology.
- The third company is in agriculture. The company receives agricultural products from farmers, packages them, and ships them. Production management is not yet in place. Standardization of the production process is important, and they would like to promote it.
- They wished to visit the companies mentioned in the case studies in the distributed material.
- There was an opinion that efficiency improvement cannot be achieved only by reducing the number of people.



(4) Presentation by Solution Provider

Solution Provider A

Headquarter in Vietnam is in Ho Chi Minh City, has about 120 people doing business in Vietnam. Deals with more than 500 customers in Vietnam. Deals with applications, systems, and data centers. The systems to propose include a face recognition entry/exit system and a security system using CCD cameras. Would also like to provide consultation on the differences in awareness between management and front-line workers, which is an issue when introducing systems.

Solution Provider B

The company handles the world's fourth largest cloud system. They are good at customer management, sales management, etc. They have 40 employees in Vietnam, and currently have no business with non-Japanese companies. The system can be configured to include agents and customers.

Solution Provider C

As a trading company, the company is involved in a variety of systems, and is also involved in the system described in the case study. Currently involved in energy-related proposals for EMS, distributed power supplies, and AGV (Automatic Guided Vehicle). Proposals can be made in a variety of fields. Industry 4.0 is a big goal, but they think it should start small at the beginning.

(5) Introduction of MOIT Priorities and Programs to support digital transformation in manufacturing

Shared the result of Industry 4.0 Readiness Assessment of Vietnamese manufacturing industry (survey of 2,500 companies). The application rate of Industry 4.0 is still low. There is a lack of understanding of how to implement it. The Vietnamese government is preparing an action plan to proactively support Industry 4.0 in the future.

As for MOIT, it provides a program to support enterprises and help them adopt IoT. Hope to realize Industry 4.0 in Vietnam soon.

In addition to the presentation of a specific support program, the presentation was given by a young staff member, which led to an active question and answer session from the participating companies. Details are as follows.

Question and answer session

- What support programs to implement?
  → Published the plan on the web and is asking for application from companies.

- How much is the burden of companies side?
  → About 40%.

- What are the criteria of selecting companies?
  → Select companies whose objectives match the project, and evaluate them by the evaluation committee.

- Does the government pay 60% for consulting only? Cannot it be really necessary equipment?
  ⇒ Machinery and equipment is the property of the company, so it is borne by the company. Consulting costs can be borne by us.

- If the government were to bear only the consulting fees, it would be meaningless because the amount is low. We would like to see a fund created to help lend money for capital investment.
  ⇒ It is difficult to do so immediately because the Ministry of Finance is governing the budget.

(6) Introduction of human resource development course at VJCC (VJCC)

Introduction of VJCC. VJCC is preparing a seminar for SMEs (Data-Driven Management: 3-day course, fee-based), to be held in March 2020, which should help SMEs solve their issues. Participants of today's session will be notified by e-mail later. There will also be a consultation service after participation in the training.

(7) Introduction of IoT hands-on training program for SMEs (Survey Team)

We are planning a training course for companies who attended the VJCC's Data-Driven Management seminar and want to create their own systems.

(8) Wrap-up of the Ideathon and Closing Statement (Survey Team)

(9) Sending seminar materials and participant list to participants after implementation

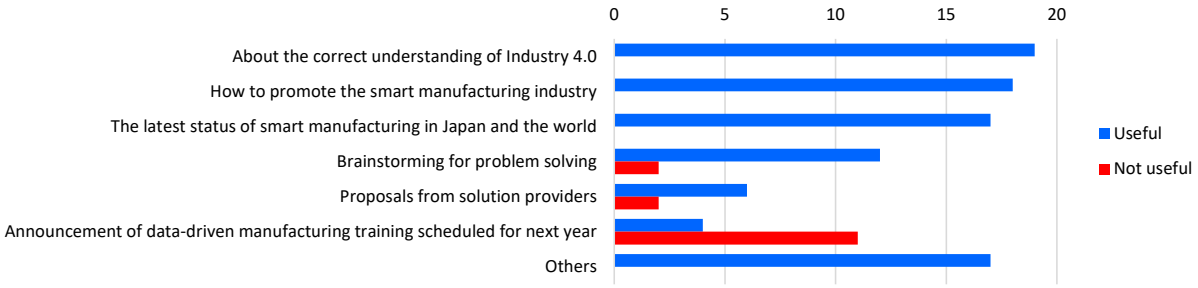
After the seminar, the materials used in the seminar and the contact list of the participants will be shared with all the participants in the hope that it will help them to collect information and build a network for future promotion of smartification.

6.1.3 Results of a post-seminar survey of participating companies

(1) Number of Survey Respondents

City	Japanese companies		Vietnamese companies		Total
	Manufacturing	SIer	Manufacturing	SIer	
Hanoi	2	1	5	3	11
Ho Chi Minh City	3	1	4	2	10

(2) Did you find the seminar useful?



(3) Opinions and comments about the seminar content (excerpt)

	Japanese companies	Vietnamese companies
Manufacturing	・I am glad that I was able to understand and organize IoT and 4IR. I think I'll start with what I can do, little by little. ・I had thought that IoT was something that our company had nothing to do with, but after attending the seminar, I realized that it can be done easily and inexpensively. It was very informative. ・I felt that the efforts of the solution providers were aimed at large companies and were not in line with what we SME companies should be working on. All the contents of the seminar were very informative.	・It was a very useful seminar for us to develop our business. ・I am grateful to have been able to attend this seminar. I was able to understand the true meaning of 4IR in Vietnam. I hope that Vietnamese companies, especially those doing business with Japanese companies, will be able to apply the 4IR in line with the actual situation in Vietnam. ・This seminar has given me a better understanding of manufacturing management methods and the steps to smart manufacturing for 4IR.
SIer	・If the solution companies could present to the entire audience, we could have prepared the appropriate materials. The seminar information was short notice, so it was difficult to prepare in a short period of time. ・There are more than 100 Japanese IT companies in HCMC alone, but I felt that there were few Japanese providers participating. This may be because the Japanese IT companies in the region are mainly engaged in offshore development for Japan, or because the time from the announcement of the recruitment to the holding of the seminar was too short.	・I think the discussion would have been more effective if we could have had a three-minute introduction of each participating company's business before the brainstorming session. ・It was a very enjoyable seminar. I would like to continue to cooperate and collaborate in Vietnam and abroad, as I have made proposals to many factories.

(4) If JICA were to provide support for smart manufacturing in the future, what kind of support would you like them to provide?

	Japanese companies	Vietnamese companies
Manufacturing	・I would like to visit companies that are actually implementing smart technologies. I would also like to have my staff participate in the hands-on training scheduled for next year. ・Information sharing on new IoT products. Seminar on making your own IoT kit.	1. Training. 2. Visit the company's site and give advice on the application of digitization. 3. Guidance on demonstration experiments at the company ・Training support to the manufacturing department of the factory. ・Initial and overall support to achieve optimal operational efficiency. ・Visit successful businesses in Japan and Vietnam that have applied the 4IR model to their manufacturing operations. ・Consultation on 5S and smart steps in our factories ・Help us improve our manufacturing management so that we can apply 4IR technology in the field. ・I would like to receive consultation and training by experts that will lead to practical application.

	Japanese companies	Vietnamese companies
SIer	・ I would like to see a similar seminar, but with clearer information on how solution companies can be involved in advance. ・ As a vendor, it would be great if you could provide opportunities for employee training (business knowledge) and matching with local companies for sales support.	・ Visits to companies and solutions that have automated their manufacturing processes ・ Implement projects in Vietnam in cooperation and collaboration with JICA. ・ More solution support for industries that cannot be replaced by machines

6.2 Hands-on training on IoT implementation for SME in Vietnam

A hands-on training program on smart manufacturing sites was conducted for the companies that participated in the seminar in 6.1. The training was originally scheduled to be held onsite in April 2020, but due to the COVID-19 pandemic, it was held remotely online. The outline of the training is as follows.

Table-31 Overview of hands-on training for SME IoT implementation in Vietnam

Target	People in charge of site improvement and production management in small and medium-sized manufacturing companies who want to start upgrading and smartening their manufacturing sites with inexpensive demonstration experiments
Training period	・ Online distribution period: Thursday, January 7, 2021 to Thursday, January 28, 2021 ・ Orientation and Q&A sessions: January 7 (Thursday), 14 (Thursday), and 21 (Thursday), 2021 ・ Presentation of IoT implementation experiment results: Late April ・ Endline survey: Late November
Training format / Delivery media	・ Online ・ E-learning using Moodle and question and answer session using Zoom
Language	Japanese / Vietnamese
Equipment used in the exercise	Each participant will purchase the followings from online shopping sites in Vietnam, Japan, and China. M5Stack FIRE and three types of sensors M5 GO IoT kit, two types of sensors, and a platform for fixing
Overview of system to create	Information (environment/light/distance) is acquired by sensors from the production line and sent to the cloud via the network to accumulate data, which is then analyzed and visualized.
Curriculum	1. Knowledge required for smart manufacturing (Part 1) Lecture approx. 30 min. 2. Knowledge required for smart manufacturing (Part 2) Lecture approx. 40 min. 3. IoT creating exercise: Arduino basics and practice Lecture and practice: approx. 1 hour 30 min. 4. IoT creating exercise: M5Stack and IoT system development Lecture and practice: approx.1 hour 50 min. 5. Points to note when installing the created IoT equipment in a factory Lecture: approx. 5 min. 6. Cautions and applications when manufacturing IoT systems for manufacturing sites Lecture: approx. 20 min.
Number of participating companies/people	8 companies, 13 persons (8 Vietnamese, 5 Japanese)

Since this training was mainly based on practical training and it was difficult to constantly monitor the training participants' practical training online, all the teaching materials used were video recordings of the actual creation of IoT devices to be installed at the manufacturing site, and the participants created the same devices while watching the video. In this way, the participants were able to create the same device while watching the video. Basically, the online training focused only on the practical points and question-and-answer sessions, and the training was conducted once a week for 4 weeks. Therefore, the participants were supposed to complete the creation of the IoT devices to be installed at the factory site during the 4 weeks. However, in reality, none of the participating companies were able to complete the project. Many of the reasons for this were that they were not able to devote time to the creation of the devices while conducting their normal business.

A presentation of the results of the experiment of introducing IoT to the manufacturing site was scheduled to be held around 2 months after the completion of the online training. Prior to the implementation of the training, we checked the progress of each company and found that no company had actually introduced IoT devices to their factories, despite having received the training. The main reasons for not introducing the devices were that they were too busy and did not have time to do so, and that they did not have internal approval. Therefore, we decided to conduct individual interviews with the participating companies instead of a presentation. The results of the interviews with the 4 companies that responded to the post-interview survey are shown in the table below.

Interviewee company	Manufacturing A	Solution Provider B	Manufacturing C	Manufacturing D
Business Description	NC automatic lathe machining (Resin and metal processing parts)	Provide custom solutions using Salesforce.com platform	Development and manufacture of industrial sewing machines, etc.	Contract manufacturing and sales of innerwear products
[About the training content]				
Q. Due to the impact of COVID-19, the hands-on training at the site that was originally planned was cancelled and replaced with online training, what do you think?	Online training has many limitations. For example, it was difficult to ask questions right away.	It was at the same level as regular training. I think the employees agreed with me.	If possible, face-to-face training would be better, but I understand that this time we have no choice due to the COVID-19 disaster. I had no problems with the many materials and videos provided online.	The training content was clear and sufficient.
[About the teaching materials (videos)]				
Q. How was the amount of content, ease of understanding, and difficulty level set?	It was easy to understand.	It was appropriate.	No problem. It was easy to understand.	It is detailed and appropriate. Not too long.
Q. Do you have any requests for the content of training that you would like to receive if you have the opportunity in the future?	Training on how to apply sensors.	I would like to know the case studies of IoT commercialization from a business perspective. Small and medium-sized companies have limited budgets for IoT investments, and there is a limit to how much they can spend on IoT on an individual basis, both on the vendor side and on the factory side. I think it would be desirable to provide common IoT services to many companies from a general-purpose infrastructure.	Since we were not able to purchase the equipment this time, we would like to continue to receive training on how to visualize information from temperature sensors and measurement time if there is ongoing training in the future.	I am in charge of kaizen and other activities in manufacturing (so contents related to that).
[Future plans to apply]				
Q. Are you considering introducing visualization of the manufacturing sites as discussed in the training?	It is currently under consideration. We are now in the process of creating it and plan to introduce it by the end of this month.	Management of goods in the factory, anti-theft measures, and recording of people's entry, exit, and movement. Also, management of factory equipment (e.g., judging the air condition of a compressor based on its flow rate). In reality, however, it is often difficult for SMEs to respond to each of these requests, given their financial strength.	Due to the COVID-19 disaster, there are no concrete plans yet at this time.	No concrete plans yet, we will consider which content is appropriate to introduce. We tested the M5 and the results were the same as shown in the training video.

Interviewee company	Manufacturing A	Solution Provider B	Manufacturing C	Manufacturing D
Q. If you are thinking of introducing the system, what do you think about the need for training of the staff required for it, consultants etc. to get proper advice?	We have 1 staff with expertise inside.		It depends on the content of the system to be introduced. For example, a human resource management system requires external personnel, but a management system for a factory or cafeteria can be implemented by internal personnel. With the content of this training, I think we can implement the system by ourselves.	We are strong in electronic components and circuits, but we feel that we are weak in programming to upload collected information to the cloud. We need people who can do analysis and data analysis.
Q. Based on Corona's experience, how do you think IT and other advanced technologies may be useful in the future in the manufacturing industry?	I think it will be useful.		In the manufacturing industry, it is impossible to go 100% online and remote, so we are using IT to smarten up, quantify, and visualize information in our daily work.	I had thought that IoT and IT were important before Corona, but Corona made me feel their importance even more.
Q. Has the Corona experience created any room for improvement in the flow of personnel to and from the headquarters in Japan, or in the supply chain for raw materials and supplies? How do you think this should be resolved?	Room for improvement was recognized.	As far as I know, I have not heard of any major impact. This is probably because the company's customers, SMEs at the end of the supply chain, are less affected. (These companies are the starting point of the supply chain, and there is no chain before them.)	The factory produces sewing machines and imports parts from China. Imports of these parts stopped due to the Corona disaster, and the company switched to in-house production and domestic procurement. Shipments were also affected, and the number of customers decreased, which affected sales, so the company is working to develop new customers. The parent company is working on IT and has a company-wide level inventory management system. The manufacturing and production management divisions are also considering expanding their supply chain to Southeast Asian countries.	The lead time for procurement of raw materials has become longer. Procurement comes from Japan, overseas, and within Vietnam.

Interviewee company	Manufacturing A	Solution Provider B	Manufacturing C	Manufacturing D
[About the IoT creation exercise]				
Q. What do you think about M5Stack, the IoT terminal introduced here? (What kind of IoT terminal do you think is appropriate for an IoT system for the Vietnamese manufacturing industry?)	It was easy to use.	Specific devices will be discussed in the future, so at this point, we don't know the details yet.	I had never heard of M5Stack before. As for other small IoT terminals, I have heard explanations of Lenovo and Microsoft products at seminars, but this was the first time I saw a real IoT terminal.	It is not used much in Vietnam. Raspberry Pi and ESP32 are used.
Q. What do you think about the environmental, distance, and light sensors introduced here? (What kind of sensors are needed for IoT system for Vietnamese manufacturing industry and in what situations?)	The problem with distance sensors is that they often have errors (they cannot measure the exact distance). The optical sensor is fine.		We need sensors for humidity and for counting number of products for smart and automated production	Sensors for temperature, humidity, light intensity, and CO_2 concentration are often used.
Q. What do you think of the cloud services introduced in this project for IoT data collection, Ambient, Google Apps Script, and LINE? (What data collection service or app do you think is appropriate for IoT system for Vietnamese manufacturing industry?)	All the company's data is managed in the cloud, and using cloud services is not a problem.		At my company, we store data in the cloud environment and on PCs, and I believe that storing and managing large amounts of data in the cloud will become more important in the future.	Google's cloud is the most common.
Q. What do you think about Excel and Power BI that we introduced for the IoT data visualization we collected? (What kind of analysis service or application do you think is appropriate for IoT data visualization for Vietnamese manufacturing industry? Also, what kind of IoT data analysis do you think is important?)	I have not used this kind of service in my business yet, so I am not sure.	I think there is a need for IoT data visualization. Salesforce is also a platformer and has an IoT interface. We are currently working on a system that solves the inventory management of refrigerators using Salesforce and IoT interface as a challenge for our in-house engineers.	The company is using Excel to create graph of production volume for visualization. A full-fledged data visualization using the cloud is under consideration, but first the company needs to consider the cost of implementation and information security management measures.	I don't know much about information analysis, and usually use Excel and other tools for analysis.

Interviewee company	Manufacturing A	Solution Provider B	Manufacturing C	Manufacturing D
Q. Was the programming for this creation exercise difficult?	It was no problem.		There were no problems. I didn't have the equipment this time, but I think I can program without problems if I get the equipment.	It was difficult because I had no experience in sending or receiving information to the Web.
[Future support from the Japanese government such as JICA]				
Q. Is there anything you would like to see from the Japanese government, such as JICA or JETRO, in terms of smart and sophisticated manufacturing sites?	I would like to see what other companies are doing.	The commercialization of 5G has started in Vietnam, and the infrastructure business will probably be taken over by Vietnamese telecom carriers, but I think there is a chance to win on the IoT edge side, i.e., the application and service side, if we are creative. I think it is important to train human resources who can develop these applications and services with innovative (sharp) ideas. In my company, we hire employees from excellent universities, but here, employment is generally fluid and there are cases where people do not have a high sense of purpose in finding a job.	I can't think of anything specific right now, but I am interested in technical training on IoT, such as smart and digitalization to strengthen the competitiveness of factories. Also, since we are from the technical department, I think IoT training for managers from the perspective of the company's overall vision and business direction is also necessary.	I can't immediately come up with a concrete plan.

6.3 PoC Project for Smartification of Factories by Digital KAIZEN in Thailand

The survey results regarding support for upgrading the manufacturing industry identified that local government agencies in all subject countries to the survey had selected SMEs as their targets. The reason was that while many large enterprises understood the necessity of upgrading and had the resources capable of upgrading themselves, SMEs lacked both the resources and awareness of such necessity. Even if they were aware of such needs, the situation was that they were unclear of what needed to be done. Those views were found out in each country during the first field survey, and thus it was summarized that the change management (awareness reform) of SMEs regarding the utilization of digital technology would be an important factor in the advancement of the manufacturing industry (Figure-26).

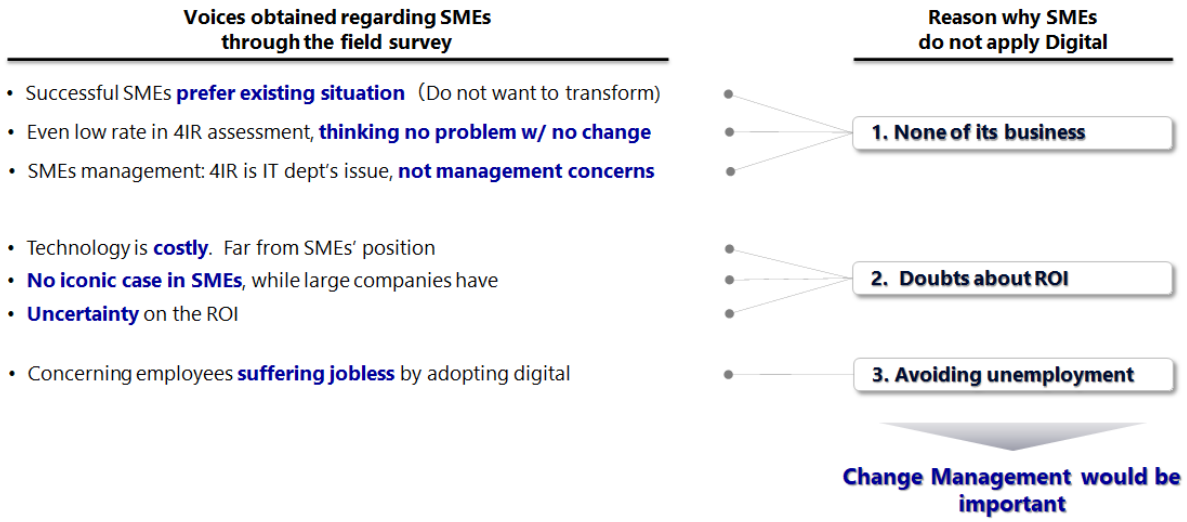


Figure-26 Voices obtained through the field survey

Therefore, based on the hypothesis that activities contributing to SMEs' awareness reform will be highly effective as JICA's cooperation in the future, it was decided to conduct a factory smartification experiment project (hereinafter referred to as the "PoC") targeting local SMEs as one of the pilot activities. Based on the results of this experiment, the usefulness of the smartification of SMEs is verified along with the wide introduction of relevant educational contents as examples to SMEs, thereby making them recognize the importance of advancement which would be considered to be their own agenda.

Although generally referred to in one word as SME, a wide range of companies of various levels are grouped as SMEs. In determining targets for smartification, companies with experience of already having engaged in KAIZEN activities were judged to be the most suitable targets. Among such companies, eligible companies were those that had already attempted to collect on-site data through KAIZEN activities, but had found difficulties in continuing such activities because of the enormous work required to be performed manually by frontline workers. Even if they were able to continue their

activities, these companies experienced problems such as poor accuracy in their data. These companies are considered to be eligible for a smartification attempt based on the belief that utilization of digital technology will lead to the presentation of a roadmap to achieve 4IR in the future because such smartification attempt will enable the continuous implementation of KIAZEN activities (digital KAIZEN) at relative ease and the resulting establishment of a prospect of achieving productivity improve. (Figure-27)

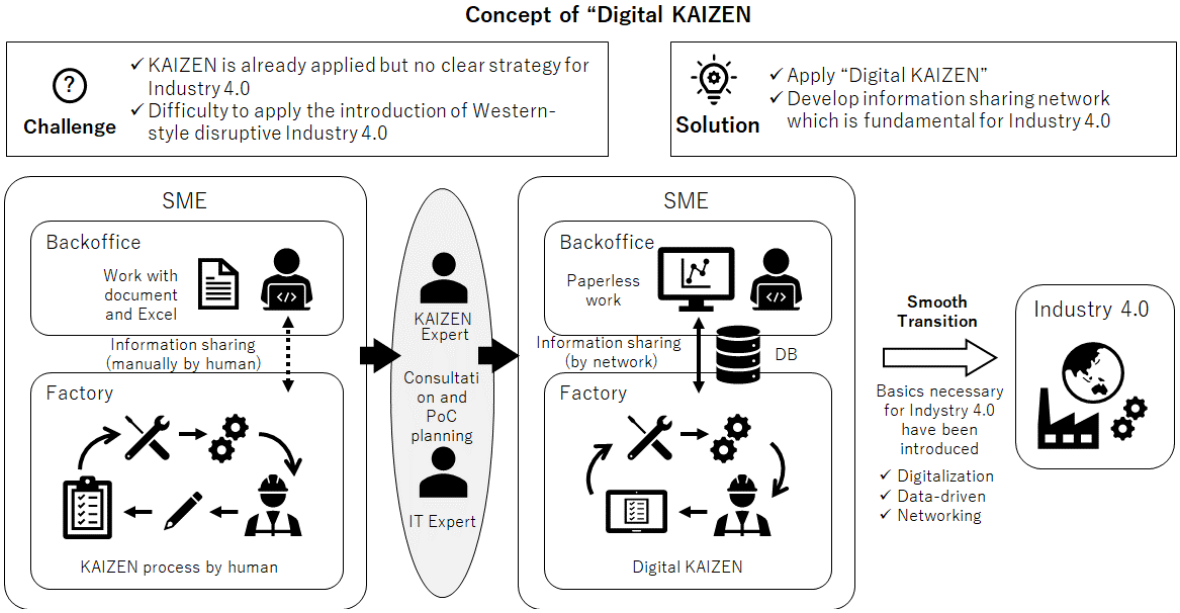
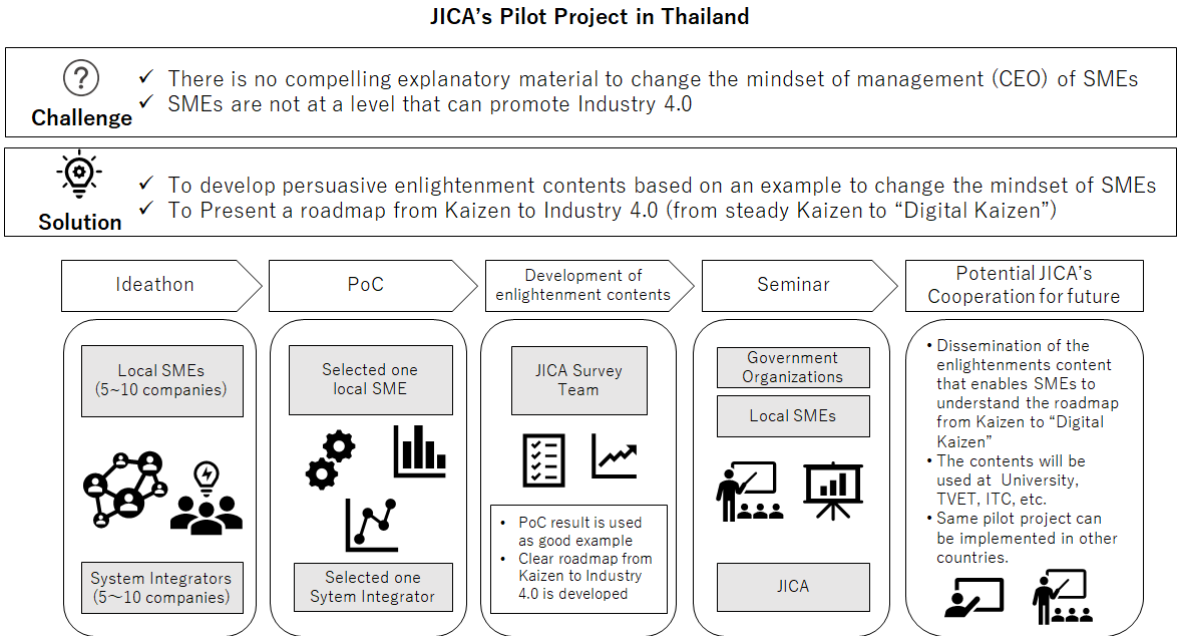


Figure-27 Conceptual Diagram of Digital KAIZEN

Hence, Thailand, where KAIZEN activities among small-and-medium manufacturers are relatively advanced among the countries surveyed, was selected as the country to implement this pilot project. Figure-28 is an overview of this pilot project. This project is structured in two layers where the effectiveness of KAIZEN is to be recognized at the concept level, followed by actual experience of the effects using real equipment. A concrete approach is the organization of an Ideathon and PoC at plants. The Ideathon adopts a format where multiple SMEs and solution providers (hereinafter referred to as "Sler (s)") achieve matching through mutual discussions on the day, having in mind the need to enable participating SMEs to become spontaneously aware of their own problems and possible solutions through the listing of various problems and ideas to solve them.



[Step 1]

1. Selection of candidate local companies which can provide sites for the PoC experiment (to be nominated by the FTPI)
2. Selection of candidate SIers (public advertisement by JICA)
3. Holding of an Ideathon involving candidate local companies, candidate SIers and the Survey Team
   - ✓ Selection of ideas which constitute the first step towards Industry 4.0 while being aware of a roadmap from KAIZEN to Industry 4.0
   - ✓ Preparation of a scenario for assessment, consultation and PoC for each target company

[Step 2]

4. Preparation for (arrangement of equipment, consolidation of cloud environment, etc.) and implementation of PoC
   - ✓ Continuous collection and accumulation of data throughout the PoC implementation period
   - ✓ Change of settings, if necessary, based on the collected data (trial implementation of KAIZEN)
5. Verification of the effects of the experiment and extraction of the necessary issues for the use of the data
6. Creation of contents to facilitate education
7. Presentation of the results at the final seminar
   - ✓ Explanation of the results in connection with the entire picture of the roadmap from KAIZEN to Industry 4.0.

Figure-28 Overview of PoC Project for Smartification of Factories by Digital KAIZEN in Thailand

6.3.1 Implementation of Ideathon

In regard to the participating SMEs, a request was made to FTPI (a governmental agency under the Ministry of Industry, which is in charge of measures to improve the productivity of local SMEs. The number of member companies is approximately 5000) to recruit participants. The main requirements for selecting participants were that the companies are local companies in Thailand (local capital ratio of 51% or more) and already experienced in the KAIZEN process. SIers were solicited on the JICA Thai office website, and also a request for public advertisement was made to FTPI. In addition, to stimulate discussion and promote mutual understanding between SMEs and SIers, requests were made to several academic institutions to send instructors specializing in this field to act as facilitators.

The pilot project started with the survey team's presentation of the Japanese style industry 4.0. It indicated a roadmap leading to the 4IR, starting from digitization of KAIZEN and appealed its significance and effects to the management of the participating companies. SMEs were then requested to discuss and present their problems and possible solutions among themselves and also with other companies. This was followed by the matching with SIers and final presentation materials were produced based on the joint proposals of matched SMEs and Siers. The Government of Thailand was requested to explain the available subsidy scheme in Thailand so that it would be easier for the participating SMEs to actually implement the contents examined in the Ideathon.

These arrangements were made to avoid a situation where problems and the proposals to solve them were simply based on existing solutions offered by SIers and also to enhance the feasibility of implementing likely solutions from the financial aspect. As such, they constituted key elements in guiding the Ideathon to success. Table-33 summarized the problems and solutions given by the final presentations by the SME+SIer groups. Besides, since the purpose of the Ideathon was to provide SMEs with awareness, appropriateness of the applicable technologies (so-called solutions) was not discussed in the event.

After the Ideathon, each matched group was requested to submit a proposal for a demonstration experiment. The budget for this experiment was primarily based on the amount offered by the afore-mentioned subsidy scheme (equivalent to approximately several million yen) with added spending elements to cover the cost of trial and error and the cost of compiling a report in view of the nature of the PoC.

In the end, proposals were made by three groups. Each proposal was evaluated based on the pre-arranged evaluation criteria (shown below) and it was decided to conduct the PoC based on the highest scored proposal made by Group F (Peace Canning (1958) Co., Ltd. (hereinafter referred to as "Company PC") and NEC Corporation (Thailand), Ltd.[224]

[Evaluation Criteria]

Technology Aspect : Three evaluation points as follows.

Feasibility) Can a certain level of results be achieved within a certain period of time?
Commonality) Are the issues common to a wide range of manufacturing SMEs ?
Implementation System) Is the implementation system ready on both side: SME and SIer ?

Price Aspect : Points are allocated according to the degree of deviation from the standard price.

This Ideathon is outlined below together with photographs taken on the day of the Ideathon.

[224] More detailed contents of the Ideathon, the name of the selected company, etc. are publicly available on the JICA Home Page. http://www.go.jp/thailand/english/office/topics/200731.html

Table-32 Outline of the Ideathon

Date and time	Friday, November 29, 2019
Venue	DEPA event room (Thailand, Bangkok)
Participants	・ SME: 6 companies (12 persons) ・ SIer: 3 companies (15 persons) ・ Local agencies: MoI (2 persons), DEPA (11 persons), NSTDA (4 persons), FTPI (4 persons) ・ Academic institutions: TGI (3 persons), Thai-Nichi Institute of Technology (1 person), KMITL (2 persons) ・ JICA (3 persons)
Purpose	・ To select a candidate company by matching SMEs with SIers for implementation of PoC project for smartification of factories ・ To promote education to the management of SMEs by introducing Japanese-style Industry4 0 and smartification cases of the manufacturing industry (digital KAIZEN) ・ To introduce the local government agencies' support system for smartification of the manufacturing industry
Program Overview	1. Opening address Chief Representative, JICA Thailand Office Senior Executive Vice President ,DEPA 2. Introduction of Industry 4.0 and the latest examples of smartification of the manufacturing industry 3. Internal discussions (SME companies and facilitators to examine problems and solutions) 4. Group work (exchange of opinions with other SMEs + facilitators) 5. Each SME to hold further internal discussions and sharing of results through presentations 6. Each SIer to introduce themselves through presentations 7. Matching of each SME and SIer 8. Final presentation by matched SMEs+ SIers 9. Introduction of subsidy system by Thai government agencies (DEPA, MoI) 10. Closing address FTPI, Deputy Executive Director JICA,Deputy Director General, and Group Director for Private Sector Group, Industrial Development and Public Policy Department (at that time)

Group work session

Group work session

Table-33 Summary of Ideathon's Final Presentation

Group (Industry[*1])	Problems and Improvements Desired	Solutions + Technologies that can be Utilized
A (Printing)	・In the factory printing line for forms/ledgers, data of the line status is acquired manually, and therefore, data reliability is low. ・When printing forms/ledgers in multiple colors, considerable time is required to set up the line.	・IoT sensors can automatically acquire data of the manufacturing status, enabling accumulation and analysis of data. ・Time required to set up the line can be reduced with IoT sensors, by measuring the remaining amount of ink in the printing press.
B (Metal Plating)	・In the plating process, the cause of the defective product could not be identified among factors such as the temperature, humidity and concentration of water and chemicals. ・Quality inspection involves a lot of effort and time. ・Difference is observed in the skills of experienced and young employees.	・The top priority factor can be clarified by obtaining data on factors such as the temperature, humidity and concentration of water and chemicals with sensors and data can be analyzed (however, it is difficult to do so for SMEs that do not have sufficient funding capacity). ・Time required for quality inspection can be reduced by articulating the skills of experienced and young employees as explicit knowledge.
C (Resin molding)	・Would like to constantly monitor about 20 kinds of parameters during the manufacturing process, but currently, data is obtained only once every hour. ・Since it is noisy in the factory, the buzzer notifying parameter abnormality cannot be heard. ・Difference is observed in the skills of experienced and young employees.	・By extracting parameter data acquired by machines and visualizing it as real time data, experienced workers will be able to give advice even from outside the factory. ・In the future, more data is expected to be obtained, and by analyzing such big data, preventive equipment maintenance can be conducted.
D (Resin molding)	・By utilizing subsidy from NSTDA, sensors have already been installed to acquire critical parameters (four types) in the manufacturing line. However, such data is not being utilized since it is not possible to correlate the data obtained and check time-series changes ・If a defect is found after the product has been shipped, there is no way of checking if the same defect exists in other products manufactured at the same time. ・Since data is not being utilized, maintenance plan cannot be formulated.	・A 2 million Baht project can be planned in three years. In the first phase, the data will be acquired by IoT sensors (since the sensors already in use are not acquiring the desired data). ・In the second phase, data analysis will be carried out so that the cause of product defects can be elucidated.
E (Electric Equipment)	・Managers cannot grasp what is happening on-site in real time, resulting in too much time to notice delay in delivery. ・On-site workers are not able to input real-time data. ・It would be desirable to monitor the movement of the entire line from beginning to end.	・IoT sensors can be used to obtain the necessary data in real time, and to make it available for everyone to see on the dashboard. ・In the future, operation rate and capacity can be analyzed, and workers will also be equipped with sensors so that the optimum positioning of workers can be assembled automatically.

F (Food Processing)	・ Data is acquired manually, and therefore, data reliability is low. ・ Work-flow requires work done by hand such as cutting foodstuffs and sprinkling salt. Therefore, it is difficult to accurately standardize such procedures in a manual. ・ Though the experienced workers rely on their senses in work, such skills cannot be articulated as explicit knowledge. ・ It would be desirable to automatically determine the product quality based on KPI's degree of achievement set for each operation. ・ It would be desirable to apply data for cleaning and disposal KAIZEN in the future.	・ Data which is easy to obtain as numerical values, such as amount of salt and pressing weight for making pickles, can be measured with sensors so that managers can check such values in real time (however, it will be difficult to quantify work of cutting foodstuffs). ・ Correlation between data fluctuation and product quality can be analyzed to determine what factors affect quality.

*1: SME businesses that have the issues raised in this ideathon

6.3.2 Implementation of PoC

Based on the results outlined in the previous section, the PoC was implemented at Company PC located in Chiang Mai. The overview, purpose, and results of the PoC are described below.

Company PC is a medium-scale food manufacturer (with around 1,000 employees), mainly producing canned pickles, vegetables and fruits at four factories in Thailand. As shown in Table-33, this company has a history of KAIZEN activities to improve as well as stabilize its productivity but has been unable to produce sufficient results because of the low reliability of data due to manual data collection and the difficulty of using data in a timely manner due to the lengthy tabulation process. Although its production processes greatly depend on manual work, there is a lack of explicit knowledge of the work and skills, resulting in a problem where large variations in terms of quality and work speed between factory workers with different skill levels have led to high reworking and defect rates.

Under these circumstances, three policies were set by the PoC to solve each of three problems faced by Company PC by means of achieving data collection, timely visualization and utilization by the use of digital technologies, thereby aiming at achieving an increase of the production output as the highest goal. The first is the early identification of points for improvement by automating the manual measurement of production volume at random timings using proximity sensors. The second is visualization of the productivity of each worker, which has not been quantified before, through automatic data acquisition using digital measuring instruments and their data analysis. The third is monitoring of the production line stoppage situation through recording it by push-buttons installed at the site, in view of the fact that the frequent temporary stoppages of production lines greatly affect the production output although this problem was not presented in the Ideathon.

Figure-29 shows the problems faced by Company PC, their solutions in the PoC and their effects.

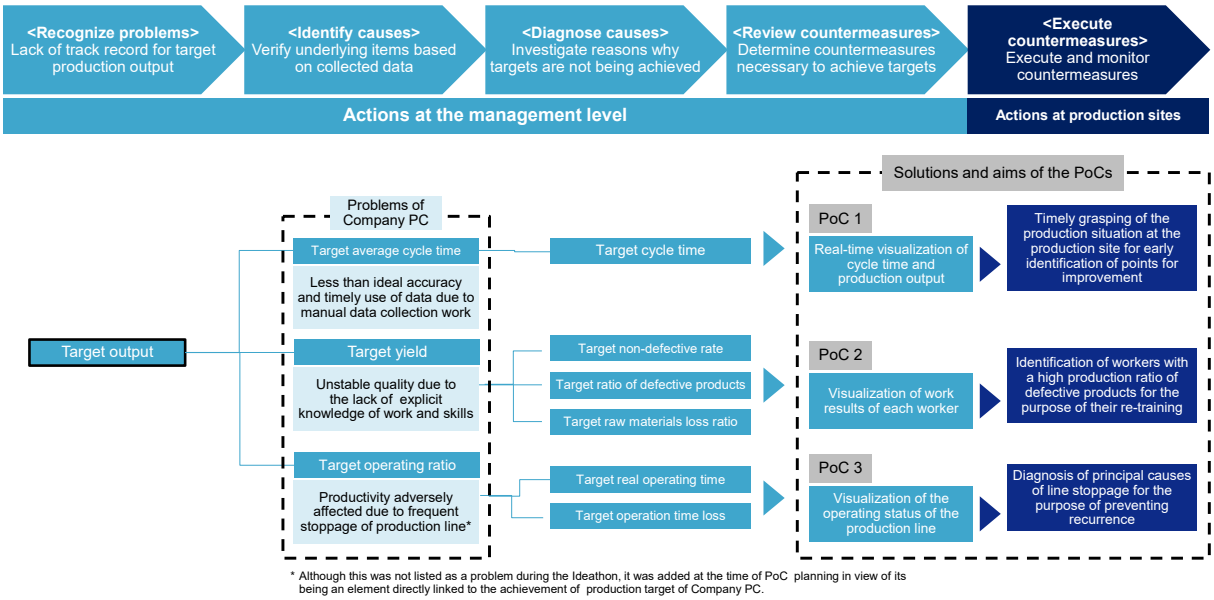


Figure-29 Issues Faced by Company PC and Expected Effects of Measures Taken by PoC

An solution designed to quantitively assess the production status using digital data was introduced with procuring all the equipment in Thailand, targeting the product filling process (especially the process of filling vegetables, etc. in cans) and the weighing process (process to measure the weight of a can to check that the weight is within the standard weight range for the relevant product with a view to adjusting the weight), both of which were major factors for the identified problems.

Collecting and analyzing the data for a certain period of time made it possible to identify a cycle time and the number of products produced per unit-time, the number of defective products (products outside the standard weight range,) and the staff in charge of production. It also made possible the timely grasping of line shutdowns, their causes and the time required to solve the problems, confirming the feasibility of clarifying the necessary KAIZEN activities. Figure-30 shows the schematic diagram of the factory layout of Company PC and the solutions to be introduced while Table-34 describes each policy in detail.

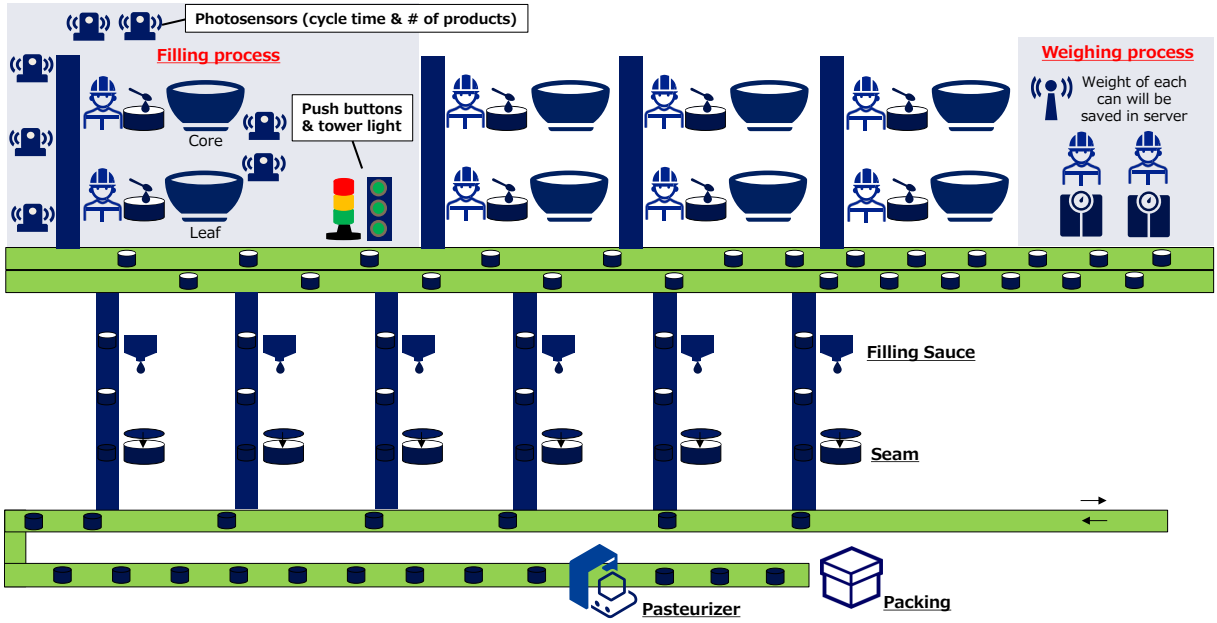
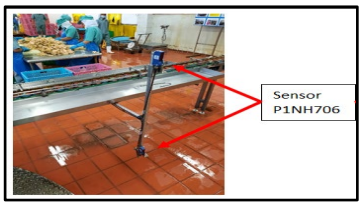
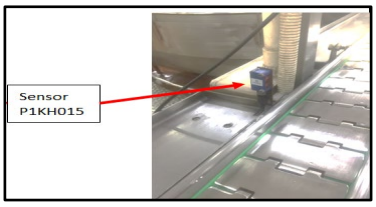
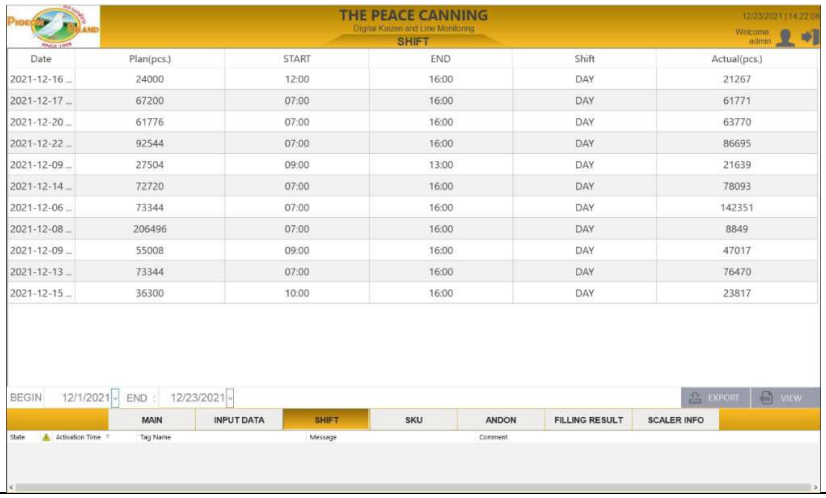
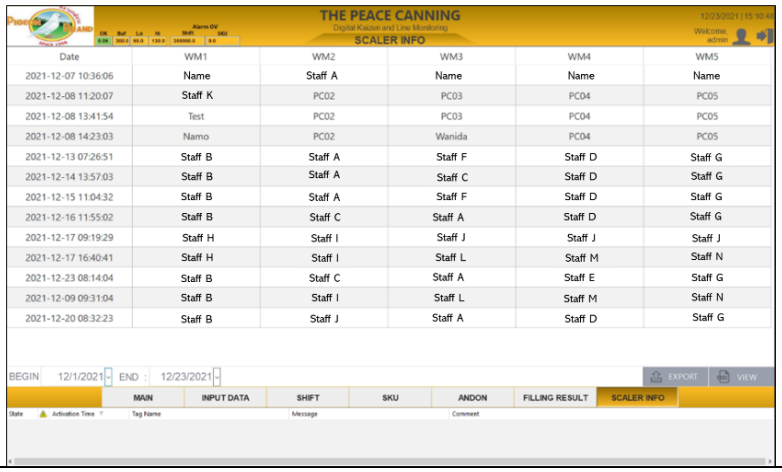
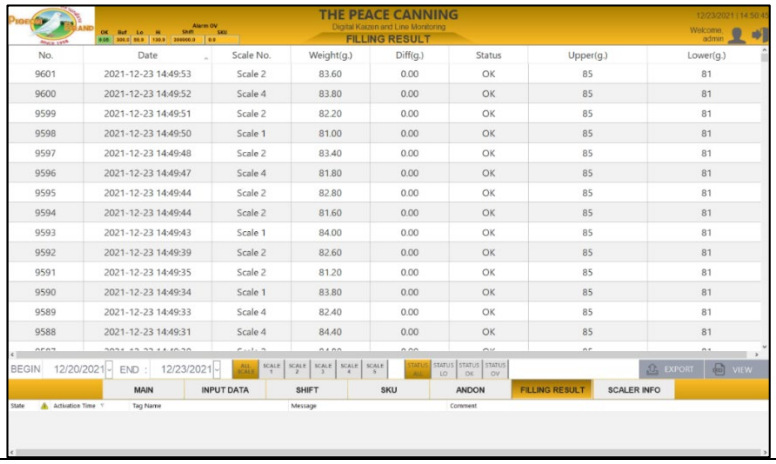
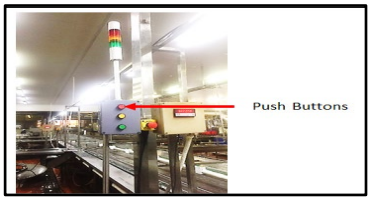
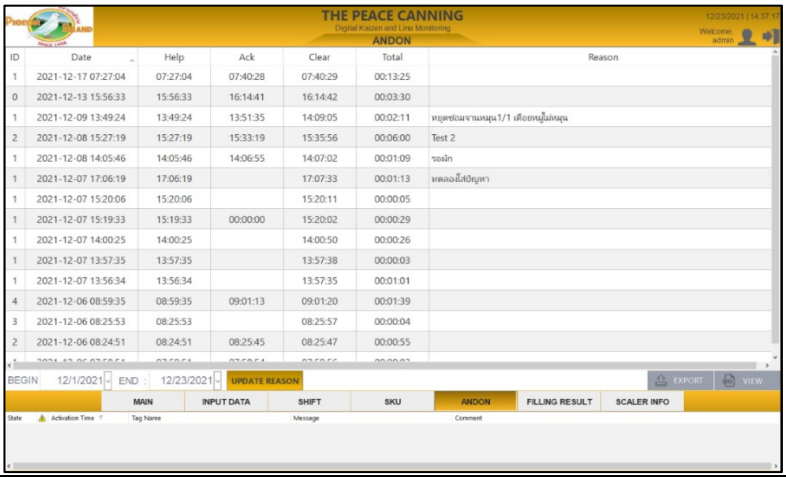


Figure-30 Schematic Diagram of Factory Layout of Company PC

Table-34 Three Policies by the PoC

PoC 1: Automatic Measurement of Production Volume	
Problem	Various information related to productivity (cycle time, unit time, and number of products produced per shift/product, etc.) is not obtained accurately and timely.
Solution introduced	Multiple photo sensors are installed for a single filling line so that the product cycle time, number of input products and number of finished products can be measured. The line manager now inputs the target production output per shift as well as type of product in advance so that the difference between the planned and actual outputs can be checked in real time on the monitor. ■ Sensors installed on the line   ■ Production status monitoring screen shown on the monitor situated at the side of the line 

	■ Performance verification screen (the planned and actual production outputs per shift are shown on the screen below) 
Purpose of KAIZEN activity	The accurate collection of productivity-related information and the timely verification/analysis of such data enable a precise understanding of the production status and identification of problems, leading to the achievement of the improvement and stabilization of the productivity.
PoC 2: Quantifying the productivity of each worker	
Problem	In the weighing process, products of which the weight is outside the standard weight range are identified and the weight is adjusted. However, many products are sent to the next process with an incorrect weight (especially excess eight) even after this adjustment process. Although insufficient skill on the part of workers is recognized as the main cause, workers with skill problems have not been identified.
Solution introduced	Arrangements are made to record the weight measurement result of each can by means of collecting weight data from a digital scale used for weighing. Moreover, the user of each scale by each hour and the standard weight range of each product can now be registered in advance so that data analysis can identify those workers producing products outside the standard weight range. ■ Screen to register the use of a digital scale 

	■ Screen to verify the weight measurement results by scale 
Purpose of KAIZEN activity	The identification of workers who produce non-standard weight range products can establish the cause of such products and enables improvement of the work sequence and retraining of the identified workers, leading to a reduction of the reworking and defective product ratios.
PoC 3: Recording of temporary line stoppage situation	
Problem	Temporary line stoppage associated with line problems frequently occurs. As a lot of time is used to detect such a stoppage, to identify the cause and to solve the problem, productivity is adversely affected. There is a lack of analysis of the principal causes of such stoppages and of the reasons for the lengthy time required for problem-solving, resulting in a response of simply dealing with a problem on an occasion basis.
Solution introduced	An andon system consisting of a tower light and three push buttons is installed so that the person discovering a line stoppage can push a button to light the tower light to alert the line manager. A mechanism is also created by which the time stamp for the time of occurrence of line stoppage, time spent by the relevant person to reach the site of the stoppage and time spent to complete an appropriate response can be registered along with the causes of the stoppage. ■ Tower light and push buttons installed for the line  ■ Screen to verify the registered information on the andon system 
Purpose of KAIZEN activity	An andon system not only enables quick finding of a line stoppage but also specifies the principal causes, time spent to first notice a stoppage, time spent to solve the problem, etc., leading to the discovery of the root causes and examination of measures.

In addition to the above-mentioned factory smartification activities, this PoC also created video contents explaining the significance and effect of digital KAIZEN by generalizing the overview, results, and results of this PoC that would be utilized in the following cases.

- Final seminar of this survey
- Awareness-raising activities for SME management after the survey

The outline of the video is described in Table-35 below.

Table-35 Outline of Video Contents

Session	Speaker	Contents Outline	Length (13 minutes in total)
Opening	Narrator	Challenges faced by the manufacturing industry, including the impact of COVID-19. Potential and importance of digital technology to solve problems and the current status of SMEs (lack of awareness and understanding)	1 minute
Interview 1	Site manager of the plant where PoC was implemented	Introducing our company Explanation of situations and challenges prior to PoC implementation (unstable productivity due to high percentage of manual operations, high rates of rework and defective products)	1.5 minutes
Interlude	Narrator	Difficulty of KAIZEN activities involving work performed manually. Introduction of digital KAIZEN as the first step in 4IR Introduction of JICA pilot projects (Ideathon, PoC)	1 minute
Interview 2	SIer (person responsible for introducing solutions)	Overview of the solutions introduced Explanation that the solutions introduced contributes to productivity improvement	1.5 minutes
Interview 3	President of the company implementing PoC	Outcome of this pilot project (Ideathon and PoC) Prospects and expectations regarding future approaches Messages to other SMEs (significance and recommendation of digital KAIZEN)	2 minutes
Interview 4	Survey team	Introduction of future 4IR image Explanation of approaches with high feasibility (starting with small start and recommending gradual scale-up)	2.5 minutes
Interview 5	Thai government agency (FTPI) officials	Efforts by the Thai government aiming to achieve Thailand 4.0 Message to SMEs (significance and recommendation of digital KAIZEN) Comments on the pilot project	2.5 minutes
Closing	Narrator	Significance of digital KAIZEN as the first step in 4IR	1 minute

6.4 Assessment of PoC

6.4.1 Conducting End-Line Surveys

Each solution introduced in the PoC was actually used by suitable users of Company PC for a certain period of time. The collected and accumulated data was then analyzed. The effects of each of the three policies listed in 6.3.2 are described next.

PoC1

Below is the screen of the real-time monitoring of the production status by the line manager of Company PC using a monitor installed at the production site. The availability of a system which is capable of checking the production output and cycle time in real-time promises that this system can lead to the examination of possible measures to be adopted by the line manager to improve the productivity and also to improve the awareness of workers.

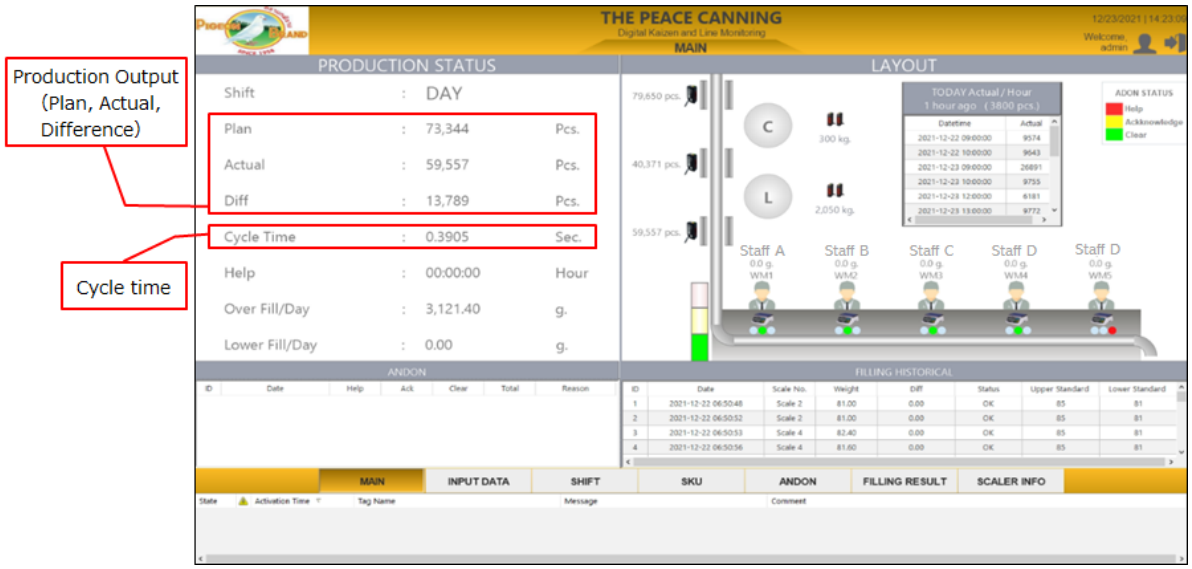


Figure-31 Production Status Verification Screen Introduced by the PoC

PoC 2

Figure-32 below is a list of measured data which is outside the standard weight range based on the data collected by digital scales. It was possible to identify those workers who had produced many products outside the standard weight range by means of comparing the said measured data with hourly scale user data which was input in advance. Company PC now plans to make these workers undergo training designed to improve their work skills.

Example table of data to be analyzed				
Date	Scale No.	Diff (g.)	Status	
12/23/2021 08:58:18	Scale 1	0	OK	
12/23/2021 08:58:18	Scale 3	0	OK	
12/23/2021 08:58:18	Scale 2	0	OK	
12/23/2021 08:58:18	Scale 3	0	OK	
12/23/2021 08:58:15	Scale 2	0	OK	
12/23/2021 08:58:12	Scale 1	0	OK	
12/23/2021 08:58:11	Scale 4	0	OK	
12/23/2021 08:58:08	Scale 1	0	OK	
12/23/2021 08:58:07	Scale 1	0	OK	
12/23/2021 08:58:07	Scale 2	0	OK	
12/23/2021 08:58:07	Scale 4	0	OK	
12/23/2021 08:58:05	Scale 4	0	OK	
12/23/2021 08:58:04	Scale 4	0	OK	
12/23/2021 08:58:03	Scale 3	0	OK	
12/23/2021 08:58:03	Scale 4	1	OV	OV (= Over filling) – Dec 23, 2021, Scale 4
12/23/2021 08:58:01	Scale 2	0	OK	
12/23/2021 08:58:01	Scale 3	0	OK	
12/23/2021 08:58:00	Scale 2	0	OK	
12/23/2021 08:58:00	Scale 4	39	OV	OV (= Over filling) – Dec 23, 2021, Scale 4
12/23/2021 08:57:59	Scale 2	0	OK	
12/23/2021 08:57:58	Scale 3	0	OK	

Figure-32 Digital Scale Measurement Data in the PoC

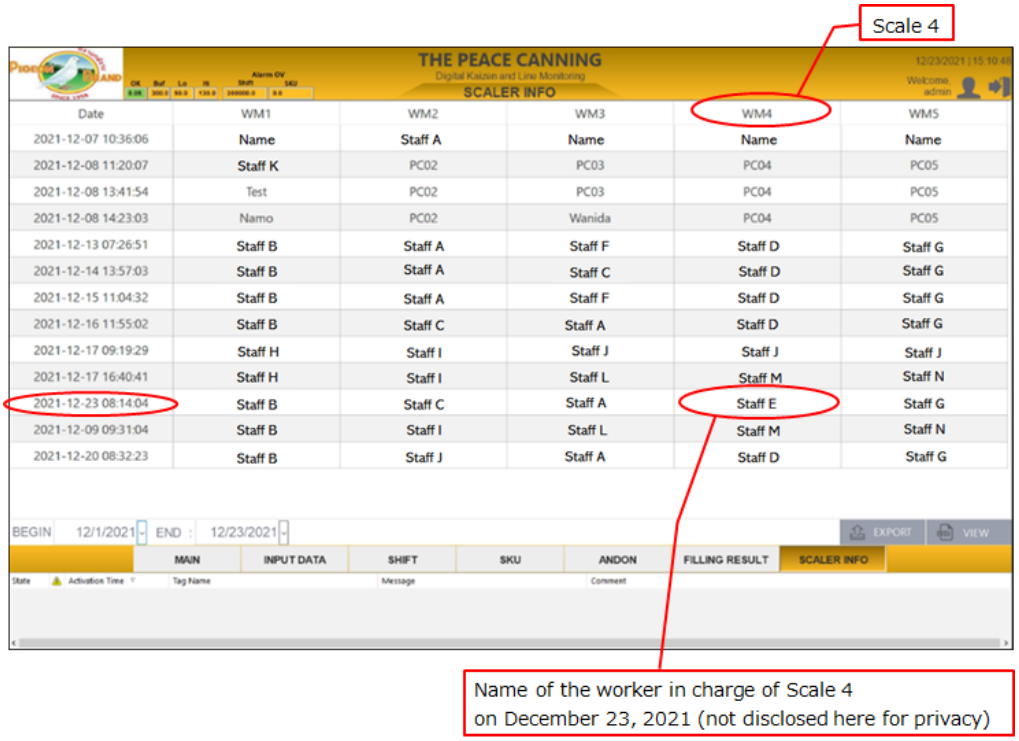


Figure-33 Digital Scale User Verification Screen Introduced by the PoC

PoC 3

Figure-34 below compiles the causes of line stoppage which occurred during the data collection period and the total downtime until the stoppage was solved. In the past, Company PC was unable to analyze the causes of stoppages and downtime duration and also to understand the frequency of stoppages by cause. The visualization of line stoppages through the introduction of suitable solution is now expected to clearly identify the principal causes of line stoppages and help to prepare the planning of permanent measures.

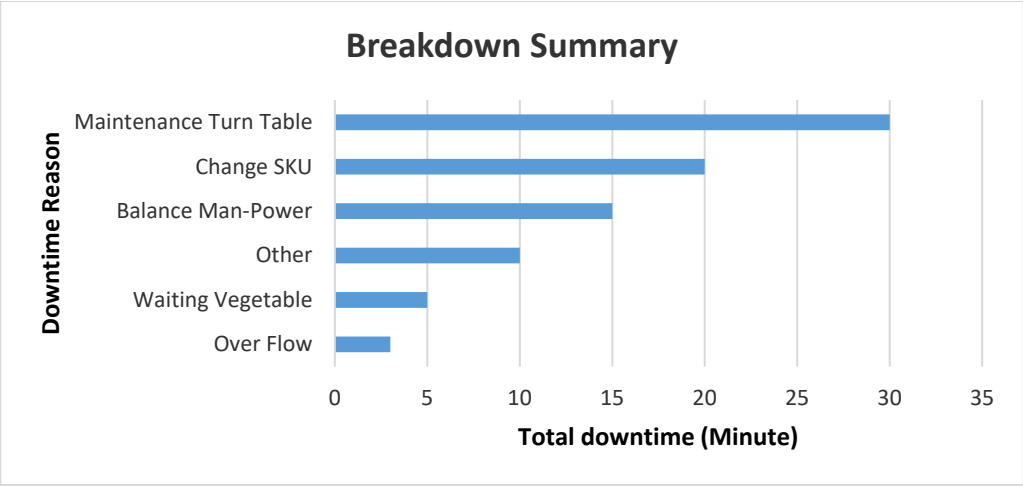


Figure-34 Summary of Downtime and Reasons Based on Collected Data in the PoC

As a method for confirming the results of this PoC, the President of Company PC where PoC was implemented was interviewed regarding the impression and challenges identified through the company's involvement with digital KAIZEN, along with future prospects. The following is a summary of the comments.

> Even before implementing this PoC, I was aware that our challenge was to improve productivity. However, the KAIZEN activities we had been conducting manually had not provided sufficient information, and despite the labor-consuming steps, the outcome was limited since we could not clarify any solution.
>
> Through this PoC approach, we learned the significance and effects of digital KAIZEN by first attending the Ideathon. Then, through the subsequent PoC activities, we were able to clearly visualize and quantify our problems of high rework and product defect rates and their reasons. This also made it easier for us to determine the points and actions of the KAIZEN activities that are truly necessary to rectify our problems. In addition, after receiving consultations from the JICA survey team, we were able to fully understand that improvements in our KAIZEN activities would directly lead to higher productivity and hence higher profitability for the company.
>
> For our company, the momentum for digitalization is rising. After completing the PoC, we hope to continue our approach to lead us to smartification and company-wide DX efforts. Specifically, by installing sensors on all lines and all processes, we intend to identify bottleneck processes through comparison between different lines as well as between different processes.

As can be seen from the above message, it is essential for the management to first visualize and clearly recognize their problems and then investigate their causes. Speedy and accurate measures can be taken if this can be realized, connecting to appropriate on-site KAIZEN activities. Even though only a part of the problem was clarified, this PoC was meaningful in that the management understood the significance and effect of continuing this activity.

6.4.2 Final Evaluation of PoC

As described in the interview comments in the previous section, the company to which the factory smartification system was introduced in this PoC gave a highly positive evaluation. We believe that the target company understood the significance and effects of the digital KAIZEN system. FTPI, a local governmental organization, also voiced high praise and thanks to this PoC, which combines the Ideathon Seminar with the Factory Smartification PoC. This doesn't only imply that the video contents based on the results of the Ideathon Seminar and PoC was in line with the Thai government's efforts to support digitalization awareness among the management of local SMEs, but the PoC also led to specific digital kaizen initiatives and clearly demonstrated the importance of such initiatives.

The cost of this PoC project is based on the level of the local government's subsidy program, and similar content can be adequately covered by resources in the home country. Therefore, we believe that we will be able to conduct more effective educational activities to convey the importance of digitalization to the management of local SMEs by using the video content produced through this PoC project.

In addition, it is also important to draw a roadmap for the future 4IR world, which lies ahead of these continuing efforts. Specifically, as shown in the previous section, what needs to be done is to expand data collection and analysis targets throughout the entire organization and to visualize and share such data in a timely manner. Such efforts will lead to discovering potential issues and the reduction of lead time for decision-making, as shown in Figure-35. For this purpose, the shared data must be utilized appropriately by the entire company, from the management to on-site staff, to enable them to take necessary actions. The company must also provide employee training for such purposes.

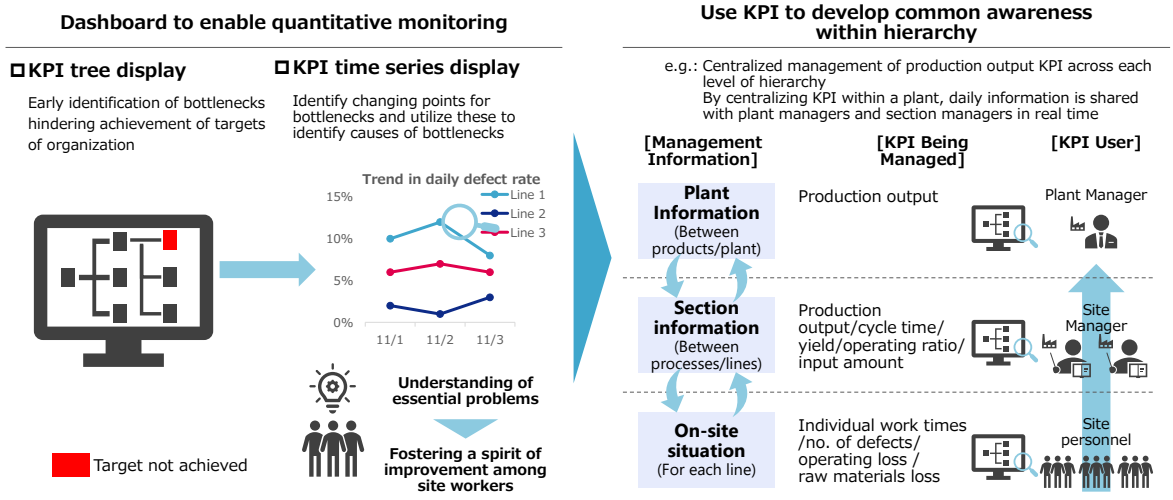


Figure-35 Image 1 of Measures Toward 4IR: Discovering Potential Issues and Reducing Decision-making Lead Time through Visualization and Sharing of Company-wide Data

Should further advances in data collection and utilization of technology become possible by applying AI, as shown in Figure-36, it will become possible for an AI system to automatically propose improvement measures and to detect risks by simulating their effects before actually deciding and executing such measures and also by accumulating information on measures implemented in the past to analyze them together with other information. Although this kind of a digital world may still be a distant future for the SMEs of the countries surveyed, it is crucial to maintain a vision for the entire company's future and an image of the roadmap toward 4IR for the purpose of determining the next step of digitalization.

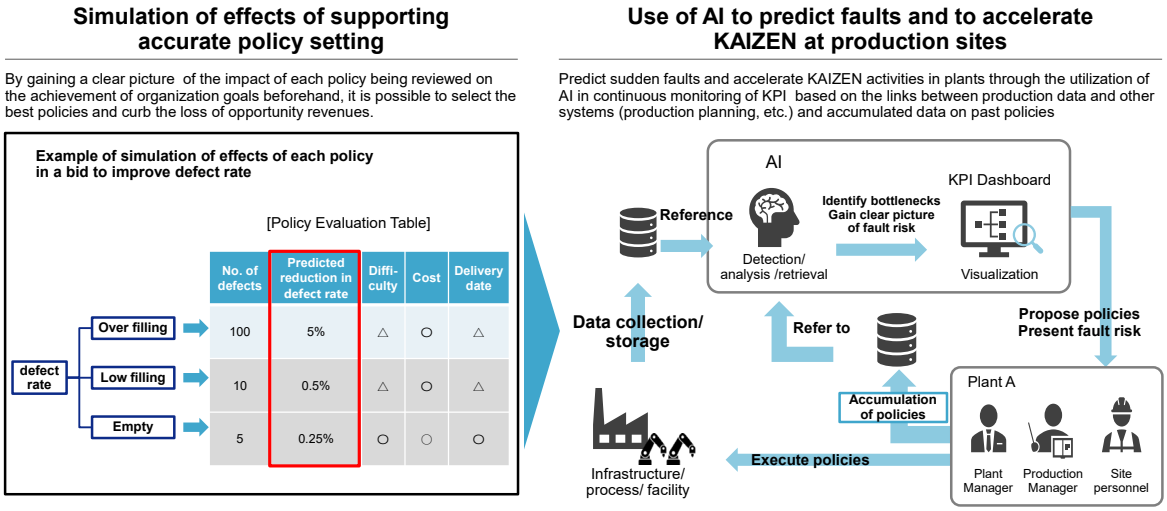


Figure-36 Image 2 of Policies Toward 4IR: Simulation of the Effectiveness of Policies and Policy Proposal by AI

6.5 Implementation of the final seminar

An “Open Webinar on the Result of Survey on Smart Manufacturing in the DX Era” was held as the last event of the study as shown in the table below, focusing on the presentation of the final results of the study to a wide range of stakeholders in the field study countries and especially on the presentation of the results of the PoC pilot program, which was implemented for a long period of time until the end of the study period.

Table-36 Outline of the Final Results Presentation Seminar

Date & Time	Wednesday, January 19, 2022, 15:00-16:30 (Japan standard time)
Format	Zoom Webinar
Target audience	Government officials in charge of 4IR-related policies and promotion of smart manufacturing in Asian countries
Participants	Total of 62 participants (see below for detailed composition)
Program	1. Opening remarks 2. Presentation of the overall result of the survey ・ Results of the literature survey and field survey in ASEAN countries ・ Results of the survey on the impact of COVID-19 on smart manufacturing ・ Results of PoC pilot programs in Thailand and Vietnam 3. Q&A 4. Closing remarks

(1) Composition of the participants

The composition of the seminar participants is shown in the table below. Basically, the participants were government officials from Indonesia, Malaysia, Thailand, and Vietnam, but there were also participants from universities and industry organizations visited during the survey, as well as from private companies that participated in the pilot program.

Table-37 Composition of Participants to the Final Results Presentation Seminar

Country	Government Organizations	Educational Institutions	Private Companies			Total
			Industrial Organization	Manu-facturing	SIer	
Indonesia	MOI (3)		Gaikindo (1)			4
Malaysia	MITI (2) MIDA (2) MIGHT (1) MPC (1) SIRIM (1)	GMI (2)				9
Thailand	DEPA (1) DIP (3)	TGI (1)		5	4	14
Vietnam	MOST (1) MPI (1) SHTP (1)	HCMUT (2)			2	7
Germany	GIZ* (4)	University of Bremen (1)				5
Japan	METI (1) JETRO* (16) AMEICC (2) SMRJ (1) JICA* (3)					23
Total	44	6	1	5	6	62

* … Including participation from offices and projects in ASEAN countries

(2) Content of Presentation

The content of the presentation was basically a summary of the contents of this report. As mentioned above, a separate public seminar was held in November 2021 to discuss the issues and measures to be taken to promote smart technologies in SME manufacturing companies, so this final seminar has focused on the presentation of the results of the PoC pilot programs in Thailand and Vietnam, and a video summarizing the results of the PoC in Thailand was also introduced.

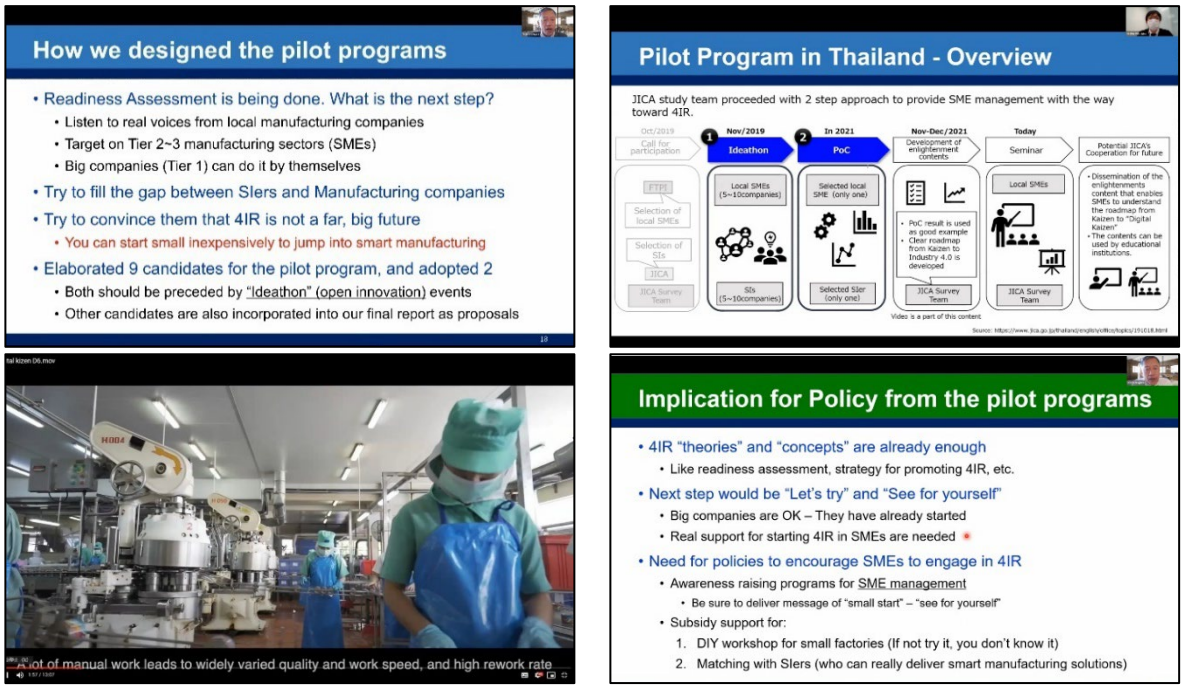


Figure-37 Contents of the Final Results Presentation Seminar

(3) Q&A

After the presentation, many questions were raised by the participants and there was a lively question and answer session. The main questions are listed in the table below. There were questions especially about the effectiveness and cost of the PoC pilot program.

Table-38 Q&A at the Final Results Presentation Seminar (Main Contents)

Question	Answer
In Vietnam, how did you explain the benefit of introducing IoT device such as cost optimization? I do not think the training done by online is the reason for them not to implement the equipment on the site if IoT device really works to grow their business.	The official answer from them were "no time to implement". But we think they may be a bit too large companies than we initially targeted, and they may already have some sort of automation, and may feel difficult to find the place to install DIY sensors.
I assume NEC IoT equipment introduced in the pilot program in Thailand is relatively expensive. In this PoC, how local company was convinced to purchase it? Or did you give the equipment for free as it is a PoC implemented as a part of JICA survey?	JICA awarded the budget for the 1st prize of matching competition, and encouraged Thai government agencies to support other matching companies by their subsidy programs.
Smart manufacturing might lead to unemployment due to automation of the work. In this context, how government is justifying the subsidy to accelerate implementation of smart manufacturing? Are there any condition such as keeping the local employment workers number in Thailand and Vietnam?	Possible unemployment due to the smart manufacturing is inevitable, so it must go together with measures for reeducating workers to upgrade their skill to be used in the smart manufacturing.
What is the reasonable period of ROI* (before the profit exceeds the investment) for PoC investment on industry 4.0 adoption?	If you start small, then ROI would soon be big because the cost is very inexpensive and is suitable for SMEs.
What is the priority elements for the PoC? process, technology , skills etc.?	Process was the highest priority element, and technology must also the latest such as IoT and AI. But skill was not the priority element in PoC.

* … Return of Investment

(4) Upon completion of this survey

With this final results presentation seminar, practically all the activities of this survey were completed. Throughout the survey, the trend of upgrading the manufacturing industry with the latest technologies such as IoT has been progressing since the start of the survey, mainly among large companies in the countries surveyed in the field, and this trend is about to be further accelerated by the COVID-19 pandemic. However, the results of the survey highlight that awareness and penetration of smart manufacturing among SMEs are still lacking. This is not because of technical or financial difficulties, but rather because there is a lack of information on good examples of small starting that can be done inexpensively and are expected to be effective, as well as concrete ways to implement them. This suggests that the enlightenment and dissemination of smart manufacturing sophistication, especially to SMEs, will be required for the manufacturing-related policies of each country as well as for the international cooperation in the future.

7. Proposals for smartification of manufacturing industry through the use of the latest technology

7.1 Determination of Production Processes and Target Company Groups of Which Advancement Can be Expected with the Utilization of New Technologies

7.1.1 Narrowing-down of Target Processes and Companies

In order to propose a future cooperation policy for JICA, the industries and companies for which JICA's cooperation will be most effective are examined for each country.

(1) Target Countries and Industries of Which Advancement Can be Expected

The priority in terms of the target company groups and processes for which the utilization of new technologies is necessary (beneficial) has been narrowed down by country and industry, taking such outputs of Task 2 as the industrial promotion policy, situation of industrial agglomeration, current situation of smartification, ICT dissemination status, level of industrial human resources, etc. in each target country of the survey into consideration.

Table-39 Industrial sectors of which advancement can be expected in the subject countries of the field survey

	Myanmar	Vietnam	Indonesia	Thailand	Malaysia
Transport		?	✓	✓✓	✓✓
Electric/ Electronic		✓	✓	✓	✓
Medical				?	✓
Food Processing	✓	✓	✓	✓	
Textile	?	?	?		
Agriculture	✓	✓✓	✓	✓	
Other			Chemical	Bio/ Chemical	Chemical/ Aviation

[Legend]
- ✓✓ : Advancement of manufacturing is relatively easy compared to other sectors and a significant positive effect can be expected.
- ✓ : Advancement of manufacturing is possible and a certain positive effect can be expected.
- ? : Advancement of manufacturing is relatively difficult compared to other sectors or a positive effect cannot be expected.
- Blank: The development level of the sector is low and it is difficult to visualize the possibility of advancement at present.

The above table ranks those industries of which advancement can be expected by the introduction of latest technologies in individual countries and does not intend the comparison across countries.

The general situation of each country, including the grounds for assessment of the industries listed in the table above, is described next.

Myanmar

The main industries in Myanmar are food processing, textiles and machine parts. In general, the manufacturing industry is still in the process of development due to slow improvement of the power supply network and communication infrastructure. (For example, in regard to machine parts, these are entirely imported for a local Suzuki factory).

In fact, several government officials expressed the opinion that “it is too soon for Myanmar to introduce Industry 4.0”. If we dare to state a type of industry for which there is a strong hope for future advancement, it is the food processing industry in which many foreign companies have invested or moved into (for example, Capital Diamond (wheat flour, etc.) invested in by Mitsubishi and Acecook in the Thilawa Special Economic Zone) and SMEs are the majority of companies operating in this industry (even though there is a bread factory which has introduced FA). Nevertheless, the number of companies which have invested in a large-scale production line and moved to full-scale production in Myanmar is very limited. Meanwhile, agriculture is another main industry outside manufacturing where the utilization of the latest technologies is feasible to a certain extent. As many people are engaged in agriculture, its advancement will directly benefit the public. Its supply chain and peripheral industries such as farm products, organic agricultural products, etc. can also be subjects for the utilization of new technologies.

Vietnam

As far as the development level of the manufacturing industry is concerned, Vietnam lags behind Indonesia, Thailand and Malaysia. Even though Vietnam has VinFast, a domestic automobile manufacturer, this does not mean that the transportation equipment industry in Vietnam is superior to that of the three said countries. VinFast has made the production of complete cars possible by bringing in scores of German engineers and importing the entire range of production equipment. Southern Vietnam has a huge smartphone factory of Samsung which is said to earn 20% of the GDP and a semiconductor factory of Intel, illustrating the rise of the electrical and electronic industry in which large foreign companies have invested. Meanwhile, during the interviews for the survey, many of those interviewed expressed their expectations of "Agriculture 4.0" which involves the application of IT to agriculture. Examples of the application of new technologies, such as IoT, to agriculture (smart agriculture) include the indoor aquaculture of prawns using IT for operational control and the remote control of watering at banana plantations in the south. However, the scale of individual farmers is too small, so it is necessary to target cooperation with smart agriculture companies that are relatively large in scale that target overseas markets, etc., with large added value that can be sufficiently profitable even with investments in IoT, etc. At present, the food processing industry, including companies producing dairy products, is rapidly growing and VinaMilk, a former national company, has commenced the operation of a large-scale factory employing the latest technologies.

Indonesia

The Making Indonesia 4.0 identifies such prioritized model industries for adaption to Industry 4.0 as ① food and beverages, ② textiles and apparel, ③ automobiles, ④ chemicals and ⑤ electrical appliances. Although the automobile industry is the principal industry in Indonesia, the application of IoT to white goods may be possible because households which cannot purchase an automobile are able to replace large household electrical appliances and also because Panasonic, Mitsubishi, Hitachi, etc. have been operating in the country for a long time. Recent years have seen the inward investment of Japanese food companies (Yamazaki Baking Co., Ltd., Marugame Udon, etc.) and, therefore, technological advancement of the food processing industry may be possible. Another possible field for the utilization of IoT, etc. is agriculture where IoT, etc. may be used for the cultivation of highly value-added crops. Every industry in Indonesia has some Japanese factories with a relatively long history of local operation. Because of the sharp rise of the personnel cost linked to the GDP growth rate, there is a possibility of the growth of automation and the adoption of IT at production sites if the necessary funding capacity is available.

Thailand

The transportation equipment industry in Thailand which has been developed with inward investment by Japanese automobile manufacturers has grown to the level of being called the Detroit of Asia. Although the transportation equipment industry is a leader in the use of the latest technologies such as IoT and AI, many companies in Thailand's supporting industries have yet to adopt the latest technologies and thereby curb labor costs. Since increasing labor costs in Thailand is forcing companies to upgrade their industries, the upgrading of the transportation equipment industry (especially the industries Tier 2 and below) is considered to have the greatest potential. Other prioritized industries for Thailand 4.0 are ① next generation automobiles, ② smart electronics, ③ medical and health tourism, ④ agriculture and bio-technology and ⑤ future foods as subject industries for the first S-curve and ⑥ robotics, ⑦ aviation and logistics, ⑧ bio-fuel and bio-chemistry, ⑨ digital and ⑩ medical-hub as subject industries for the secondary (New) S-curve. As such, there is a sufficient prospect of the advancement of these industries with the introduction of the latest technologies. (The medical equipment industry alone is classified as "?" in Thailand as this is a subject industry for the secondary S-curve and the production of advanced equipment utilizing IT has hardly started. Medical equipment currently manufactured in Thailand consists of motorized beds, small general-purpose measuring instruments, etc. which do not require much advanced technology.)

Malaysia

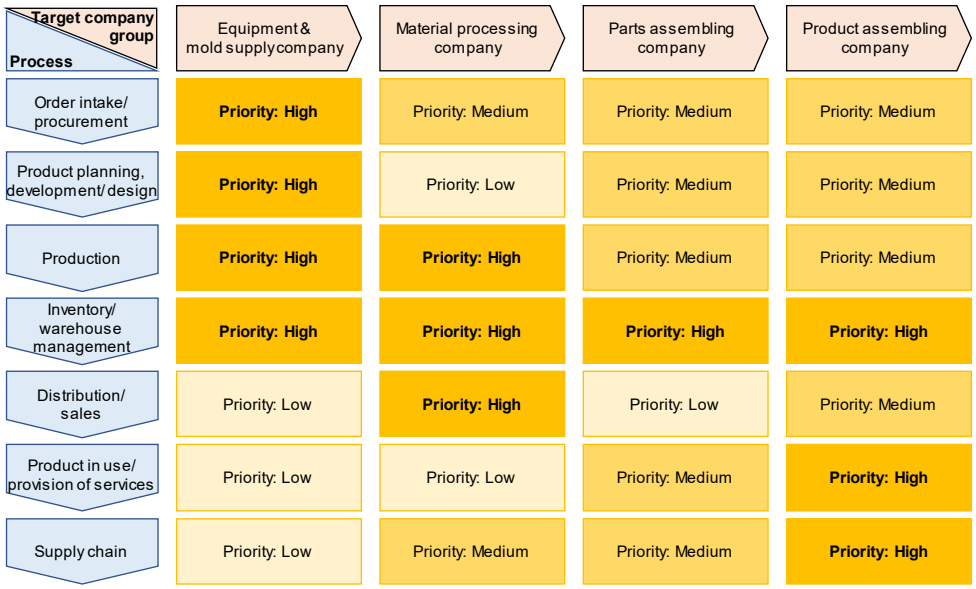
In Malaysia which has two domestic automobile manufacturers (Proton and Perodua), the introduction of FA has much advanced at large companies and, therefore, there appears to be a strong possibility of the advancement of manufacturing. The industrial fields prioritized by Industry 4.0 are electrical/electronics, mechanical devices, chemicals, medical devices, aerospace and others (including the automobile industry). In each of these fields, advancement through the introduction of the latest technologies can be expected to be achieved provided that advanced industrial human resources are steadily secured.

(2) Manufacturing Processes of Which Advancement Can be Expected

In order to examine company groups and processes of which advancement can be expected, the business process (axis of ordinates) within individual companies and company groups (axis of abscissa) in the manufacturing field are tabulated, referring to the framework proposed in the IoT/robot adoption promotion survey in the 4th Industrial Revolution era "Smartification of Manufacturing Roadmap Survey" of the Ministry of Economy, Trade and Industry.

At the start of this survey, analysis "by country, by industry and then by process" was planned to narrow down the fields in which Japan's technological strength and solutions would be particularly effective (for example, Japanese technology D matches process C of industry B of

country A). Through past studies, however, it was found that many SMEs in each industrial field of each target country had neither achieved safety assurance at production sites nor simple work efficiency through KAIZEN, etc. and had not therefore reached the stage of examining which of the latest technologies should be introduced (see Chapter 5 for more details). Because of this, the actual analysis featured only the degree of manifestation of the industrial advancement effect of utilizing the latest technologies (degree of improved work efficiency and creation of high added value) by comparing individual areas composed of the combination of a specific target company group and a specific process so that the general tendencies commonly observed with the target countries were revealed instead of the initially envisaged more in-depth analysis.



Target company group / Process	Equipment & mold supply company	Material processing company	Parts assembling company	Product assembling company
Order intake/ procurement	**Priority: High**	Priority: Medium	Priority: Medium	Priority: Medium
Product planning, development/ design	**Priority: High**	Priority: Low	Priority: Medium	Priority: Medium
Production	**Priority: High**	**Priority: High**	Priority: Medium	Priority: Medium
Inventory/ warehouse management	**Priority: High**	**Priority: High**	**Priority: High**	**Priority: High**
Distribution/ sales	Priority: Low	**Priority: High**	Priority: Low	Priority: Medium
Product in use/ provision of services	Priority: Low	Priority: Low	Priority: Medium	**Priority: High**
Supply chain	Priority: Low	Priority: Medium	Priority: Medium	**Priority: High**

Figure-38 Manufacturing processes which can be expected to be advanced

To start with, production line equipment and molds can be said to be good matches to the concept of Industry 4.0 to enable mass customization in an effective manner as they are characterized by large variety/ single product production based on order (the reason for low priority in the processes of distribution/ sale, product in use/provision of services and supply chain of equipment of a mold supply company is that the products of such a company are not for mass sale).

In the case of a material processing company, as production is based on a design received from the upstream, there is strong potential for the utilization of technology in “production” (for example, in the processing of precision injection molded parts, the production parameters are set based on the weather on a particular day and accumulated weather data as well as the temperature, humidity, etc. of the day as measured by sensors to enable reduction of the fraction defective). As this type of company produces a variety of parts for many customers, efficiency improvement can be expected with “inventory/ warehouse management” and “distribution/sales” through the utilization of technology.

In the case of a parts assembly company and product assembly company, prevention of the stoppage of a production line and bad stock is important and, therefore, inventory management (securing of the minimum level of inventory with appropriate timing) is the key to achieving this. Inventory/ warehouse management is a process where Industry 4.0 which enables the input of parts at the best time through networking of the supply chain from the upstream to the downstream can prove its positive effects. In contrast, "the production process" relies on manual work because of the cheaper labor cost than in Japan. Although the advancement of "production" may be feasible from the technological point of view, its priority is judged to be only medium in these company groups in the target countries.

Finally, in the case of a product assembly company, as the company ships products used by end users, the effects of utilizing the latest technologies are high in the "product in use/ provision of services" and "supply chain" processes (for example, the situation of operation is checked for heavy machinery and household electrical appliances equipped with IoT sensors so that repair or the provision of supply products can be conducted at an appropriate time).

7.1.2 Establishment of Purposes of Smartification and Selection of Technologies to Apply

For those fields of which the priority is high in 4.1.2 above, the purpose of utilization of latest technologies was clarified based on the study results of "competitive factors and added value created by the use of IoT and robots" as classified in the "IoT/robot adoption promotion survey in the 4th Industrial Revolution era" by the Ministry of Economy, Trade and Industry. This study examined the elements of competitiveness and added value created by the utilization of the latest technologies (expressed as "smartification" in the study), analyzing the relationship between various purposes of utilizing the latest technologies and individual target company groups/processes. Using the results of this analysis, the purpose of utilizing the latest technologies is plotted in individual areas composed of the combination of a specific target company group and a specific process as shown in Table-40. (Table-41 lists the primary purposes of smartification while Table-42 shows a more detailed picture, including the secondary purposes.)

Table-40 Primary and secondary purposes of smartification

No.	Primary Purpose of Smartification	Secondary Purpose of Smartification
1	Quality improvement	Reduction of the fraction defective
		Standardization of quality and reduction of quality variation
		Improvement of the design quality
2	Cost reduction	Reduction of the usage amount of materials
		Reduction of production resources
		Inventory reduction
		Labor-saving of equipment management and monitoring
3	Productivity improvement	Improvement of the operating rate of equipment and workers
		Improvement of the work efficiency, work duration and work load of workers
		Reduction of equipment stoppages caused by breakdowns

No.	Primary Purpose of Smartification	Secondary Purpose of Smartification
4	Shortening of product development and mass production times	Automation of product development and design
		Rapid response to specification changes
		Shortening of the design and construction time of a production line
5	Response to shortage of human resources and fostering of such resources	Utilization of diverse human resources
		Inheritance of skills
6	Provision of new added value and improvement of the added value provided	Improvement of the capacity to respond to diverse needs
		Expansion of the available processing technologies to be offered
		Provision of new products and services
		Improvement of the performance and functions of products
7	Other	Strengthening of risk management

Source: IoT/robot adoption promotion survey in the 4th Industrial Revolution era "Smartification of Manufacturing Roadmap Survey".

The observation of high priority areas (those cells with an orange background in 4.1.2) finds a general tendency for such areas to be located in downstream processes for companies located in the downstream of production. The applicable technologies to achieve smartification in the high priority areas are compiled in the following two tables in line with this tendency.

Table-41 Combination of company groups and processes which can be expected to be advanced and purposes of smartification

Target company group / Process	Equipment & mold supply company	Material processing company	Parts assembling company	Product assembling company
Order intake/ procurement	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement
Product planning, development/ design	1. Quality improvement 2. Cost reduction 4. Shortening of product development and mass production 6. Provision of new added values and improvement of provided values	2. Cost reduction 4. Shortening of product development and mass production	1. Quality improvement 2. Cost reduction 4. Shortening of product development and mass production 6. Provision of new added values and improvement of provided values	1. Quality improvement 2. Cost reduction 4. Shortening of product development and mass production 6. Provision of new added values and improvement of provided values
Production	1. Quality improvement 2. Cost reduction 3. Productivity improvement 4. Shortening of product development and mass production 5. Responses to shortage of human resources and required fostering	1. Quality improvement 2. Cost reduction 3. Productivity improvement 4. Shortening of product development and mass production 5. Responses to shortage of human resources and required fostering 6. Provision of new added values and improvement of provided values	1. Quality improvement 2. Cost reduction 3. Productivity improvement 4. Shortening of product development and mass production 5. Responses to shortage of human resources and required fostering 6. Provision of new added values and improvement of provided values	1. Quality improvement 2. Cost reduction 3. Productivity improvement 4. Shortening of product development and mass production 5. Responses to shortage of human resources and required fostering 6. Provision of new added values and improvement of provided values
Inventory/ warehouse management	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement
Distribution/ sales	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement	2. Cost reduction 3. Productivity improvement
Product in use/ provision of services	1. Quality improvement 6. Provision of new added values and improvement of provided values 7. Other (strengthening of risk management)	7. Other (strengthening of risk management)	1. Quality improvement 6. Provision of new added values and improvement of provided values 7. Other (strengthening of risk management)	1. Quality improvement 6. Provision of new added values and improvement of provided values 7. Other (strengthening of risk management)

Table-42 Combination of company groups and processes which can be expected to be advanced and purposes of smartification (Detailed version)

Target company group / Process	Equipment & mold supply company		Material processing company		Parts assembling company		Product assembling company	
Order intake/ procurement	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers 6-② Expansion of available technologies to offer	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers 6-① Improvement of capacity to respond to diverse needs	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers 6-① Improvement of capacity to respond to diverse needs
Product planning, development/ design	1. Quality improvement 2. Cost reduction 4. Shortening of product development and mass production 6. Provision of new added values and improvement of provided values	1-③ Improvement of design quality 2-① Reduction of the amount of materials to use 4-① Automatization of product development and design 4-② Speedy responses to specification changes 6-③ Provision of new products and services	2. Cost reduction 4. Shortening of product development and mass production	2-① Reduction of the amount of materials to use 4-① Automatization of product development and design 4-② Speedy responses to specification changes	1. Quality improvement 2. Cost reduction 4. Shortening of product development and mass production 6. Provision of new added values and improvement of provided values	1-③ Improvement of design quality 2-① Reduction of the amount of materials to use 4-① Automatization of product development and design 4-② Speedy responses to specification changes 6-③ Provision of new products and services	1. Quality improvement 2. Cost reduction 4. Shortening of product development and mass production 6. Provision of new added values and improvement of provided values	1-③ Improvement of design quality 2-① Reduction of the amount of materials to use 4-① Automatization of product development and design 4-② Speedy responses to specification changes 6-③ Provision of new products and services
Production	1. Quality improvement 2. Cost reduction 3. Productivity improvement 4. Shortening of product development and mass production 5. Responses to shortage of human resources and required fostering	1-① Reduction of fraction defective 1-② Stabilization of quality and reduction of variation in quality 2-② Reduction of production resources 2-③ Inventory reduction 2-④ Labor-saving on equipment management and monitoring 3-① Improvement of operating rate of equipment and workers	1. Quality improvement 2. Cost reduction 3. Productivity improvement 4. Shortening of product development and mass production 5. Responses to shortage of human resources and required fostering 6. Provision of new added values and improvement of provided values	1-① Reduction of fraction defective 1-② Stabilization of quality and reduction of variation in quality 2-② Reduction of production resources 2-③ Inventory reduction 2-④ Labor-saving on equipment management and monitoring 3-① Improvement of operating rate of equipment and workers	1. Quality improvement 2. Cost reduction 3. Productivity improvement 4. Shortening of product development and mass production 5. Responses to shortage of human resources and required fostering 6. Provision of new added values and improvement of provided values	1-① Reduction of fraction defective 1-② Stabilization of quality and reduction of variation in quality 2-② Reduction of production resources 2-③ Inventory reduction 2-④ Labor-saving on equipment management and monitoring 3-① Improvement of operating rate of equipment and workers	1. Quality improvement 2. Cost reduction 3. Productivity improvement 4. Shortening of product development and mass production 5. Responses to shortage of human resources and required fostering 6. Provision of new added values and improvement of provided values	1-① Reduction of fraction defective 1-② Stabilization of quality and reduction of variation in quality 2-② Reduction of production resources 2-③ Inventory reduction 2-④ Labor-saving on equipment management and monitoring 3-① Improvement of operating rate of equipment and workers

Target company group / Process	Equipment & mold supply company		Material processing company		Parts assembling company		Product assembling company	
		3-② Improvement of work efficiency, work duration and work load of workers 3-③ Improvement of capacity to respond to diverse needs 4-② Speedy responses to specification changes 4-③ Shortening of the design and construction times of a production line 5-① Utilization of diverse human resources 5-② Inheritance of skills		3-② Improvement of work efficiency, work duration and work load of workers 3-③ Improvement of capacity to respond to diverse needs 4-② Speedy responses to specification changes 4-③ Shortening of the design and construction times of a production line 5-① Utilization of diverse human resources 5-② Inheritance of skills 6-② Expansion of available technologies to offer		3-② Improvement of work efficiency, work duration and work load of workers 3-③ Improvement of capacity to respond to diverse needs 4-② Speedy responses to specification changes 4-③ Shortening of the design and construction times of a production line 5-① Utilization of diverse human resources 5-② Inheritance of skills 6-① Improvement of capacity to respond to diverse needs		3-② Improvement of work efficiency, work duration and work load of workers 3-③ Improvement of capacity to respond to diverse needs 4-② Speedy responses to specification changes 4-③ Shortening of the design and construction times of a production line 5-① Utilization of diverse human resources 5-② Inheritance of skills 6-① Improvement of capacity to respond to diverse needs
Inventory/ warehouse management	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers
Distribution/ sales	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers	2. Cost reduction 3. Productivity improvement	2-③ Inventory reduction 3-② Improvement of work efficiency, work duration and work load of workers
Product in use/ provision of services	1. Quality improvement 6. Provision of new added values and improvement of provided values 7. Other (strengthening of risk management)	1-③ Improvement of design quality 6-③ Provision of new products and services 6-④ Improvement of performance and functions of products 7-① Strengthening of risk management	7. Other (strengthening of risk management)	7-① Strengthening of risk management	1. Quality improvement 6. Provision of new added values and improvement of provided values 7. Other (strengthening of risk management)	1-③ Improvement of design quality 6-③ Provision of new products and services 6-④ Improvement of performance and functions of products 7-① Strengthening of risk management	1. Quality improvement 6. Provision of new added values and improvement of provided values 7. Other (strengthening of risk management)	1-③ Improvement of design quality 6-③ Provision of new products and services 6-④ Improvement of performance and functions of products 7-① Strengthening of risk management

The following tables show the results of the examination of applicable technologies which achieve smartification in the fields of high priority in line with the tendency mentioned above.

Table-43 Case of product planning, development/design process for an equipment and mold supply company

Purpose of Smartification	Applicable Technologies and Example of Utilization
1-③ Improvement of design quality	**IoT sensors** and **communication function** are loaded to a product to gather and utilize data on the situation and environment of product use for the purpose of improving the design specifications and quality.
2-① Reduction of the amount of materials to be used	Structural analysis and strength analysis are conducted using accumulated past design data (database) and **analysis/simulation software** to attempt weight reduction and a reduction of the number of parts to be used. Depending on the specific target, **3D printers** are used to consume the minimum amount of material required to achieve the final shape of the product.
4-① Automation of product development and design	Accumulated past design data (database) and **analysis/simulation software** are utilized for the purpose of developing shape/structure models as well as automation using **AI**, etc.
4-② Rapid response to specification changes	**Data** on **E-BOM** (Engineering Bill of Materials) and **M-BOM** (Manufacturing Bill of Materials) is **linked** for the centralized control of design and production data for the purpose of minimizing the response time to specification changes. In the case of specification changes involving shape, etc., **AI** trained with shape data for past products is used to automatically generate the post-change shape.
6-③ Provision of new products and services	**IoT sensors** and **communication function** loaded to a product are used to gather data on the situation and environment of the product used for the purpose of providing after-service, etc.

Table-44 Case of production process for a material processing company

Purpose of Smartification	Applicable Technologies and Example of Utilization
1-① Reduction of fraction defective	**Sending** of the contents of human work (work sequence and work results, etc.) is conducted to analyze careless mistakes[225] in the past in order to implement improvement measures. Data on such mistakes is used for the real-time detection of similar mistakes by **AI**.
1-② Stabilization of quality and reduction of quality variations	Quality data, such as the processing dimensions, etc. of a product, and the processing conditions of and specified values for an equipment are gathered/established through monitoring by **sensors** installed on the equipment. The gathered data is used for the real-time detection of quality by **AI**.
2-② Reduction of production resources	Using a **production management system**, such as **MES**, the progress situation of the production processes and input situation of man-hours, materials and energy are established for their optimization.
2-③ Inventory reduction	Using data from a **production management system**, such as **MES**, planned and actual data on order intake, production and shipment is linked for analysis and forecasting of the demand so that a production plan to minimize the inventory can be formulated.
2-④ Labor-saving on equipment and management and monitoring	The operating situation of equipment is monitored in real-time by **sensors** installed to the equipment and workers are automatically informed of any detected abnormality to minimize the management man-hours for monitoring and inspection.
3-① Improvement of operating rate of equipment and workers	The progress situation of equipment operation and human work of the entire production line are established using a **production management system**, such as **MES**, to modify and optimize the equipment operation plan, set-up change plan and human work plan.

[225] https://www.digital-transformation-real.com/blog/careless-mistake-in-manufacturing.html

Purpose of Smartification	Applicable Technologies and Example of Utilization
3-② Improvement of work efficiency, work duration and work load of workers	The utilization of **HMI** (mobile terminal and smart glasses, etc.) and **RFID**, etc. can quickly and concisely display or input the work sequence, management information or procured materials and completed products, production information and information on equipment operation. It is also possible to reduce the burden of handling heavy items by wearing a **power assisted suit**.
3-③ Reduction of operation stoppage caused by equipment breakdown	The situation of equipment operation is monitored by **sensors** installed to the equipment to predict a possible breakdown as part of preventive maintenance. An alternative device is automatically identified and operated at the time of breakdown through the link with a **production management system**, such as **MES**.
4-② Rapid response to specification changes	Input data and the processing sequence, etc. after a change of the specifications are automatically generated by **AI** using accumulated data from the past and are verified by a production simulator, etc. for their automatic application to the production line using a **production management system**, such as **MES**.
4-③ Shortening of the design and construction times of the production line	An optimal production line is designed in the cyber environment using a **production line simulator**, etc. and is then constructed in the real world. In this way, the number of trials and errors in the design and construction stages is reduced and the production construction time is shortened.
5-① Utilization of diverse human resources	Utilization of such **wearable devices** as a **HMD** (Head Mount Display) and **voice recognition** equipment, **power assist suits** and **biosensors**, etc.
5-② Inheritance of skills	The skills (set-up adjustment ability, ability to judge a situation, manual skills, ability to respond to problems, etc.) of skilled workers are identified by means of **sensing** to develop a database. These engineers can be replaced by **robots** which have an **AI** link to systematized skills, know-how and knowledge.
6-② Expansion of available technologies to offer	Data on a **production management system**, such as **MES**, is **linked between the companies** involved in joint order acceptance to share information on the production plan, progress situation of joint work, etc. In this way, the production plan, distribution plan, etc. can be optimized for the entire supply chain, making it possible to offer a joint order acceptance and production system as well as diverse processing technologies.

Table-45 Case of inventory/warehouse management system for a parts assembly company

Purpose of Smartification	Applicable Technologies and Example of Utilization
2-③ Inventory reduction	Using data from a **production management system**, such as **MES**, planned and actual data on order intake, production and shipment is linked for analysis and forecasting of the demand so that a production plan to minimize the inventory can be formulated.
3-② Improvement of work efficiency, work duration and work load of workers	The utilization of **HMI** (mobile terminal and smart glasses, etc.) and **RFID**, etc. can quickly and concisely display or input the work sequence, management information or procured materials and completed products, production information and information on equipment operation. It is also possible to reduce the burden of handling heavy items by wearing a power assisted suit.

Table-46 Case of product in use/provision of services for a product assembly company

Purpose of Smartification	Applicable Technologies and Example of Utilization
1-③ Improvement of design quality	**IoT sensors** and **communication function** are loaded to a product to gather and utilize data on the situation and environment of product use for the purpose of improving the design specifications and quality.
6-③ Provision of new products and services	**IoT sensors** and **communication function** loaded to a product are used to gather data on the situation and environment of the product used for the purpose of providing after-service, etc.
6-④ Improvement of performance and functions of products	Data on the situation and environment of use and product control data are gathered and established by **IoT sensors** and **communication function** integrated to a product to optimize the set control value for the product to match the tendency of product usage by users. In this way, the performance of the product can be maximized and/or customized.
7-① Strengthening of risk management	The quality of individual products can be certified by mounting a **RFID** and **communication function** to each product to accumulate data on processing, assembly, inspection and shipping. When a product defect occurs, the data accumulated on the product or materials is analyzed to quickly identify the cause of the defect.

7.1.3 List of Selected Companies and Applicable Technologies

The main targets for JICA's cooperation are believed to be mid-sized companies and SMEs which cannot launch a drive for advancement on their own and will be left behind due to being obsolete compared to the advanced market with the onset of Industry 4.0 in the future unless they achieve digitalization as well as smartification (in the case of tiny companies with only several employees, there is no strong need to respond to the wave of Industry 4.0 as the impacts of Industry 4.0 on these tiny companies are limited).

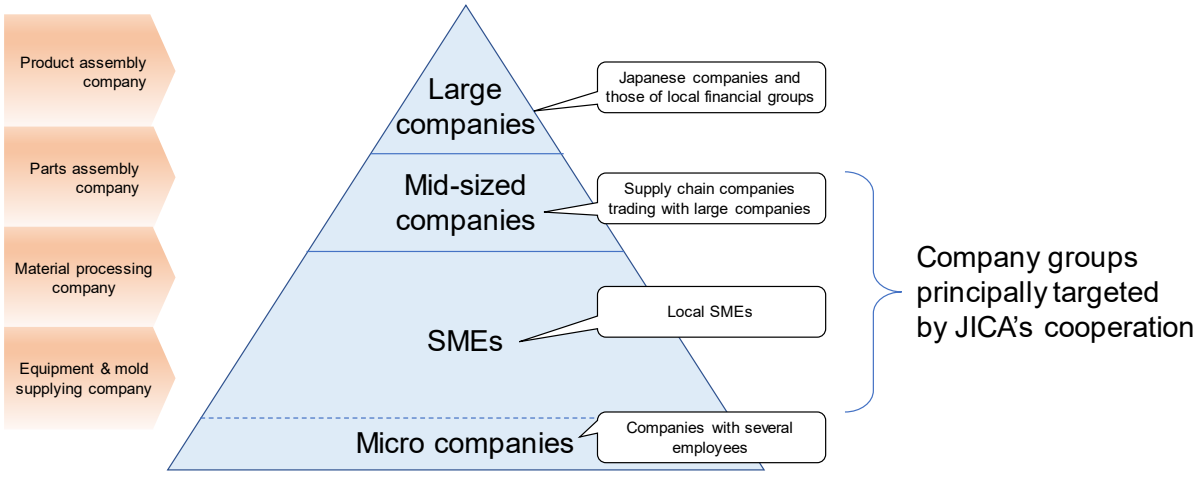


Figure-39 Company groups which can be expected to be advanced and image of size of manufacturing companies (rough image)

At the time of the start of the survey, it was assumed to match solution providers in Japan and the target countries concerning those processes which could expect to be advanced. However, as mentioned earlier, it was found that the current situation of SMEs in all of the target countries had not

reached the stage where the application of individual solutions to individual processes could be examined.

Conversely, there was a new discovery that Japanese solutions could be well matched in those cases of cooperation targeting equipment and mold supply companies and material processing companies as there were many cases of the introduction of Japanese machine tools at the production sites of these companies. However, it must be noted that there are some hurdles to consider when introducing a solution, including the likelihood of any maintenance agreement in place for these machine tools being nullified once the setting of the tools is modified.

7.2 Steps, Tasks and Action Plan for Smartification Using New Technologies

7.2.1 Roadmap for Smartification of the Manufacturing Industry Using New Technologies

The present situation of individual companies shows greatly differing levels of operation while understanding of the said situation is a precondition for the start of any thinking of a roadmap towards 4IR. For example, some Japanese manufacturing companies and local companies trading with Japanese companies have gathered and accumulated data on production sites while others exchange information with their parent companies using a communication network. On the other hand, there are many companies which have not obtained any data or which have not digitalized while utilizing it (conducting KAIZEN through manual process). Such a gap is particularly noticeable with local SMEs, some of which have not yet achieved safety at their production sites and/or simple efficiency improvement by KAIZEN, etc.

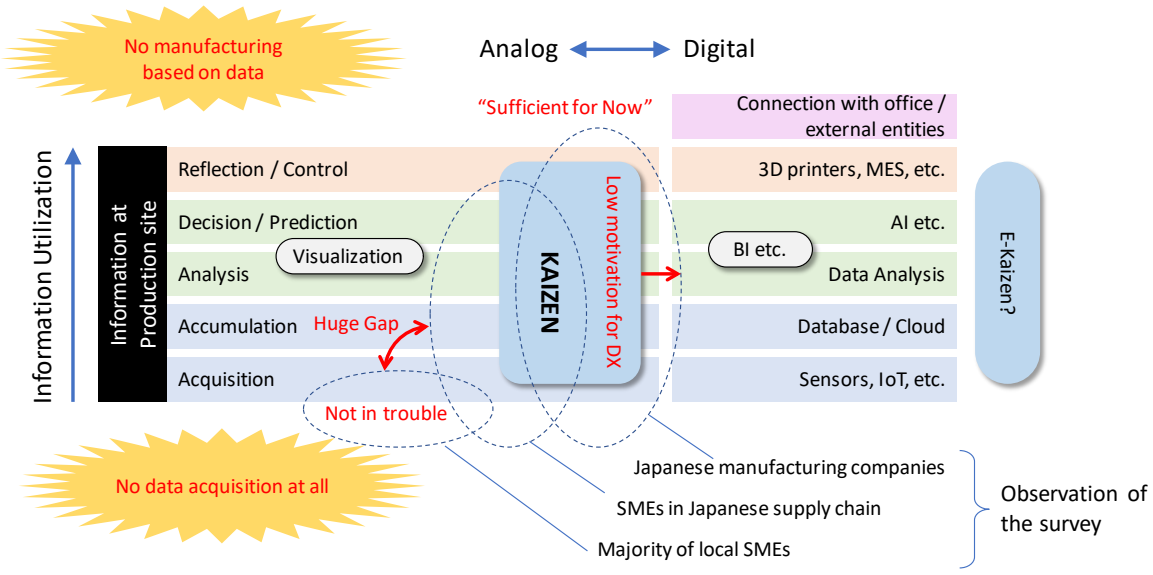


Figure-40 Basics for manufacturing advancement and present situation of Japanese SMEs and local SMEs in the surveyed countries

Meanwhile, there is a common understanding among all company groups regardless of the level of individual companies that it is too soon to seek 4IR. Although the reasons behind such understanding vary from one group to another, there are several common reasons as listed below.

- In most cases, mass production is sufficient in developing countries, meaning that mass customization, which is the main purpose of 4IR, is not required.
- As sufficient profit is generated under the current system, the management does not see any need for investment.
- As analogue operation achieves a sufficient level of efficiency, the management does not see any need for investment.
- 4IR is understood to be a topic to be discussed in the distant future or a topic for discussion by large companies or the government and has nothing to do with their own companies.

Under these circumstances, it is unrealistic to aim at jumping to adopt 4IR in the near future. It is important to draw a roadmap with the future in sight and to gradually move towards 4IR. As a general trend, the following steps should be followed.

Safety of production site → KAIZEN at production site → FA → smartification (data gathering and accumulation → data-based analysis and prediction → data-based control and optimization) → adaption to 4IR

One important point in following these steps is to propel such advancement in correct anticipation of 4IR as the final stage. At present, understanding of "what 4IR is to start with" is unclear as such understanding varies from one person or organization to another. It is essential to define 4IR and then to promote it based on a common understanding. The survey team has defined the basics of 4IR as "data-driven manufacturing through digitalization and networking". The roadmap presented in Figure-41 below is based on the idea that the advancement of digitalization and networking nudges towards the realization of 4IR. Advancement means that each element moves forward through the sequence of steps described below.

- Digitalization: non-digital → digitalization (step in each process)
- Networking: stand-alone machinery (no connection) → multiple machines connected at a production site → production site-wide connection of machines → connection between production site and the administration office → connection throughout the supply chain → global connection
- Data-driven operation: data acquisition → accumulation → analysis → judgement/ prediction → reflection/control → autonomous/self-organized operation

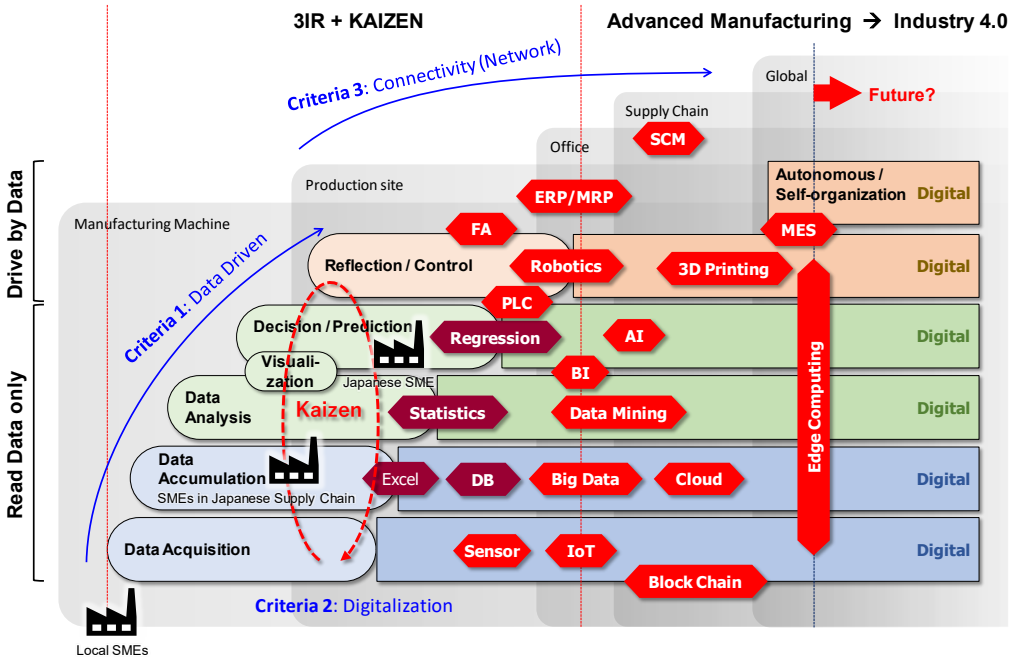


Figure-41 Roadmap towards advanced manufacturing and 4IR and status of each element technology

In the above figure, “autonomous/self-organization” means a situation where the entire administrative and manufacturing work, ranging from tender, order acceptance and contract signing for a product to the procurement of materials required to make the product, change of composition of the manufacturing line, formulation and execution of a manufacturing plan, product inspection, inventory control and shipment, is autonomously conducted without human involvement through the linkage of multiple systems connected by a digital network which has become possible due to the development of AI, etc. In other words, it is presented by Germany as an ideal form of Industry 4.0 in the manufacturing industry. In addition, regarding the generally accepted distinction between “Digitization” and “Digitalization”, the “acquisition” and “accumulation” parts of “data-driven operation” shown above correspond to "Digitization", while the other parts correspond to "Digitalization”.

7.2.2 Tasks for Smartification of the Manufacturing Industry Utilizing New Technologies and Action Plans

In the process of materializing the roadmap to 4IR from the present situation, many tasks were pointed out during the desk research and field research. The table below sorts and categorizes such tasks faced by the subject countries of the field research.

Table-47 Tasks of smartification of the manufacturing industry utilizing new technologies

Category		Tasks
Policy	System	・ Although each country has published a policy listing the broad policy principles and targets, a concrete action plan is lacking. ・ The interpretation of 4IR varies from one country to another and even the competent ministry does not have a sufficient understanding of the clear goals and advantages of 4IR. ・ Cooperation between the relevant ministries is weak. ・ Public-private cooperation, which is considered essential for the promotion of 4IR, is weak. ・ Support measures, such as subsidy, etc., are not readily available. Those which are available are not fully utilized because of the cumbersome procedure, etc. ・ Even if a support measure is implemented, many companies are unable to continue on their own when the support ends, making it difficult to sustain their actions. ・ Activities, including promotion and assessment, are primarily implemented in large cities and have not reached local areas. ・ In some countries, emphasis has been placed on innovation through digitalization and the promotion of new industries, such as new Internet-based businesses. As such, there is a lack of the viewpoint of advancing existing industries (especially the manufacturing industry). ・ Support for and the evaluation of SIers are inadequate compared to efforts to support SMEs. ・ There is concern regarding the loss of employment and the occurrence of labor disputes due to the introduction of new technologies.
	Infrastructure	・ Infrastructure has not been fully developed in some industrial zones and special economic zones, making the communication environment inadequate.
Smartification	Manufacturing companies	・ Such basic requirements as Seiri (sort), Seiton (set in order) and ensuring of safety have not been met and these are preconditions for the introduction of new technologies. ・ Support measures involving assessment and a funding scheme without proper guidance result in the recipient not understanding what to do. ・ Most SMEs are at the level of 2IR or 1IR. As they cannot make a single leap to the level of 4IR, they must start with automation. ・ As there is not a sufficient number of successful cases, the target companies question the advantages of 4IR or its return on investment (there is insufficient ability to apply successful cases in other fields or processes to one's own company. ・ SMEs and companies with stable management are reluctant to change and prefer the status quo. ・ There is a preconception that the introduction of a new technology incurs a high cost, requiring large investment. ・ The management does not have a sufficient understanding of the particulars of a production site. ・ A support measure involving assessment and a funding scheme without proper guidance does not lead to the selection of appropriate and reliable SIers. ・ Many companies already gather, analyze and evaluate analogue data through KAIZEN activities and, therefore, do not feel much incentive for digitalization. ・ Even if some companies use the latest equipment and systems, they have simply introduced them without much understanding. Consequently, they are unable to fully utilize equipment which demands a deep understanding. ・ As no equipment standards or protocols exist, there is no compatibility between equipment. ・ Such administrative systems as ERP and MRP operate independently from the production site control system, resulting in a lack of cooperation between them.

Category		Tasks
	SI	・ The number of companies is insufficient to start with. ・ The level is generally low as there are not sufficient human resources which can make own proposals or conduct consultations or which fully understand the particulars of the production sites of the manufacturing industry.
Human resources		・ There are not sufficient human resources in the private sector or university teachers who can provide adequate guidance in the field of Industry 4.0. ・ The training facilities at educational institutions are deteriorated or obsolete. ・ The industrial circle is separated from the educational circle (teachers do not know production sites; the latest knowledge held by teachers is not reflected on the industrial circles, etc.) ・ Smartification leads to a loss of certain jobs. ・ There is a decline of interest among students (unpopularity of the manufacturing industry and declining interest in science subjects, including mathematics, etc.)

In response to the tasks described above, action plans to achieve them were examined and are listed and explained in the following table. The principal target countries identified in each action plan list those countries which are considered to be relevant in the light of their current situation. As such, countries not included in individual action plans may well be targeted in the future.

<table>
<tr><th>Action Plan 1</th><th>Tasks to be Achieved</th></tr>
<tr><td>Formulation and revision of 4IR-related systems (category of policy: system)
Principal Target Countries
4 countries excepting Myanmar</td><td>・ Although each country has published a policy listing the broad policy principles and targets, a concrete action plan is lacking.
・ The interpretation of 4IR varies from one country to another and even the competent ministry does not have a sufficient understanding of the clear goals and advantages of 4IR.
・ Activities, including promotion and assessment, are primarily implemented in large cities and have not reached local areas.
・ Support for and the evaluation of SIers are inadequate compared to efforts to support SMEs.</td></tr>
<tr><td colspan="2">The definition of 4IR and the direction aimed at as a country are clarified to the extent of formulating an action plan. In addition, as many organizations, including government ministries and agencies, are involved in 4IR-related policies in many countries, efforts are made to establish a consensus among related organizations while aiming at the promotion of inter-ministerial cooperation. (Among the target countries of the field research, Malaysia in particular is relatively advanced in this context and the roles of individual ministries/agencies are clearly established. Nevertheless, the perception of 4IR varies from one ministry/agency to another and some aspects of the concrete action plans are found to be insufficient.)
In Thailand and Malaysia, support and promotion activities are already available for private companies but are mainly implemented in the capital and other large cities. In view of this situation, efforts are made to facilitate the spread of 4IR to local cities (especially industrial zones) by means of providing support and funding for local offices of the organizations concerned.
Moreover, support so far has primarily targeted SMEs in the manufacturing industry, etc. and the fostering of SIers has fallen behind. Mature SIers are essential for the promotion of 4IR and support for as well as the evaluation of SIers are important. Support for SMEs in particular requires SIers capable of presenting inexpensive solutions. The development of a system design to train such SIers is, therefore, a measure to be focused on in the coming years.</td></tr>
</table>

<table>
<tr><th>Action Plan 2</th><th>Tasks to be Achieved</th></tr>
<tr><td>Strengthening of the subsidy system (Policy: system)
Principal Target Countries
Thailand; Malaysia</td><td>・ Support measures, such as subsidy, etc., are not readily available. Those which are available are not fully utilized because of the cumbersome procedure, etc.
・ Even if a support measure is implemented, many companies are unable to continue on their own when the support ends, making it difficult to sustain their actions.</td></tr>
<tr><td colspan="2">In Thailand and Malaysia, more than one subsidy system have already been established, playing a part in the promotion of 4IR, especially among SMEs. Nevertheless, there are some private companies which know nothing about these systems or which are reluctant to use them because of the cumbersome procedure involved in a government support system. There are cases where multiple organizations provide similar support systems. In other cases, the demarcation between the systems of different ministries and agencies is unclear. Efforts should be made to improve these system to make them more easily accessible and also to focus on activities to promote the systems in view of their active utilization.
Another task relating to support systems is improvement of the sustainability of activities after support has ended. This is a difficult problem as permanent support is not possible. However, viable measures to improve sustainability should be examined. For example, the formulation of a system to extend support under certain conditions and the provision of a free consultation service when support ends are two possible measures.</td></tr>
</table>

Action Plan 3	Tasks to be Achieved
Infrastructure development (Policy: infrastructure) Principal Target Countries 4 countries excepting Myanmar	・ Infrastructure has not been fully developed in some industrial zones and special economic zones, making the communication environment inadequate.
Some industrial zones and special economic zones to which many manufacturing companies are attracted are located in local areas and do not necessarily enjoy a good communication environment at present. In the case of Malaysia for example, manufacturing areas are widely scattered throughout the country and the east coast area and Sabah State on the Malaysian Peninsular lag behind Kuala Lumpur, Johor Bahru, Penan, etc. The stabilization and speeding up of the communication environment are important when the smartification of factories in the future is considered, making investment in infrastructure essential. While the upgrading of infrastructure is costly and time-consuming because of the many target areas, efficient investment is possible due to the concentration of many factories in industrial zones and special economic zones.	

Action Plan 4	Tasks to be Achieved
Improvement of production site prior to smartification (Smartification: manufacturing companies) Principal Target Countries All 5 countries	・ Such basic requirements as Seiri (sort), Seiton (set in order) and ensuring of safety have not been met and these are preconditions for the introduction of new technologies. ・ Most SMEs are at the level of 2IR or 1IR. As they cannot make a single leap to the level of 4IR, they must start with automation.
Many SMEs in the target countries of the field research have such tasks as ensuring production site safety, implementing KAIZEN and introducing FA, all of which must be dealt with prior to smartification. It is important to continue conventional cooperation, including KAIZEN which Japan has been concentrating so far, and then gradually introduce digitalization such as inexpensive IoT devices that are easy to introduce, to raise the standard of these SMEs so that the global transition to 4IR will not simply benefit a small number of companies in industrialized countries and global enterprises.	

Action Plan 5	Tasks to be Achieved
Improvement of the mindset through the creation and dissemination of successful cases (Smartification: manufacturing companies) Principal Target Countries 4 countries excepting Myanmar	・ Support measures such as readiness assessment and a funding scheme without proper guidance result in the recipient not understanding what to do. ・ As there is not a sufficient number of successful cases, the target companies question the advantages of 4IR or its return on investment (there is insufficient ability to apply successful cases in other fields or processes to one's own company. ・ SMEs and stable companies are reluctant to change and prefer the status quo. ・ There is a preconception that the introduction of a new technology incurs a high cost, requiring large investment. ・ There is concern regarding the loss of employment and the occurrence of labor disputes due to the introduction of new technologies.
SMEs in particular lack strong awareness of 4IR and the smartification of a factory and many feel little incentive for digitalization. Although the reasons for such situation are diverse as described earlier, one particularly important point is the lack of familiar successful cases which can be considered to have implications for oneself. For this reason, the creation of good practices for SMEs for dissemination as successful cases at seminars and events is considered to be effective. Because the purpose is to change the mindset of SMEs, it is desirable that the contents of such successful cases are concrete and easy to understand by not only front-line workers but also by the management. When implementing this action plan, it is crucial to make SMEs understand the following points. ・ Good practice can start with the introduction of minor solutions rather than large-scale investment. ・ The utilization of small-scale and inexpensive solutions can promise a sufficient return on investment. It has been pointed out that the application of presented successful cases to one's own company cannot be imagined when the type of business or process involved in such successful cases differs from that of one's own company. It is, therefore, desirable to gather successful cases in different types of businesses and processes for the compilation of a collection of successful cases.	

Action Plan 6	Tasks to be Achieved
Development of a matching platform (Smartification: manufacturing companies) Principal Target Countries 4 countries excepting Myanmar	・A support measure involving investment and a funding scheme without proper guidance does not lead to the selection of appropriate and reliable SIers.
As some SIers are incapable of presenting appropriate solutions or prioritizing the sale of their own products, there are cases where the use of a SIer does not lead to the successful achievement of a task. However, many SMEs have no experience of introducing a solution and find it difficult to find a suitable solution provider without external help. The provision of a matching platform, which list the registered reliable solution providers and introduces the services and solutions offered by these registered solution providers, aim at avoiding such a problem. When this platform becomes capable of introducing services and training organizations from which the relevant knowledge can be learned, it will become possible for SMEs to find suitable solutions without external help.	

Action Plan 7	Tasks to be Achieved
Implementation of technology seminars (Smartification: manufacturing companies) Principal Target Countries 4 countries excepting Myanmar	・Many companies already gather, analyze and evaluate analogue data through KAIZEN activities and, therefore, do not feel much incentive for digitalization. ・Even if some companies use the latest equipment and systems, they have simply introduced them without much understanding. Consequently, they are unable to fully utilize equipment which demands a deep understanding. ・As no equipment standards or protocols exist, there is no compatibility between equipment. ・Such administrative systems as ERP and MRP operate independently from the production site control system, resulting in a lack of cooperation between them.
Some SMEs have already implemented KAIZEN activities in a sufficient manner or have introduced equipment and systems which can contribute to smartification. For this group of companies with a certain level of understanding of smartification, a seminar with more advanced contents should be organized to provide further education on the path to smartification. In the case of the former type of SMEs, the possible agenda is the digitalization of KAIZEN activities. In the case of the latter type of SMEs, the establishment of a connection between administrative systems and production sites may be the next step. Because the learning contents are more advanced, the implementation of a lengthy (approximately one week or so) training event, such as a boot camp, as well as a PoC experiment and a pilot project is considered to be effective in addition to a seminar, such as an ideathon or hackathon.	

Action Plan 8	Tasks to be Achieved
Fostering of SIers (Smartification: SIers) Principal Target Countries 4 countries excepting Myanmar	・The number of companies is insufficient to start with. ・The level is generally low as there are not sufficient human resources which can make own proposals or conduct consultations or which fully understand the particulars of the production sites of the manufacturing industry.
At present, the quality and quantity of SIers are insufficient in the target countries, excepting Myanmar, of the survey. As pointed out in Action Plan 1, the maturity of SIers is essential for the promotion of 4IR. From the viewpoint of the smartification of SMEs in particular, the ability of SIers to present inexpensive solutions and to present appropriate solutions based on an understanding of the particulars of the production sites of the manufacturing industry are required. As such, it is important to adopt measures designed to facilitate the fostering of capable human resources and SIers.	

Action Plan 9	Tasks to be Achieved
Fostering of educational human resources (Human resources) Principal Target Countries All 5 countries	・There are not sufficient human resources in the private sector or university teachers who can provide adequate guidance in the field of Industry 4.0. ・The training facilities at educational institutions are deteriorated or obsolete. ・The industrial circle is separated from the educational circle (teachers do not know production sites; the latest knowledge held by teachers is not reflected on the industrial circles, etc.)
The number of 4IR-related courses at educational institutions in the target countries has been gradually increasing. As it has been pointed out by some that the quality and number of teachers are insufficient, the fostering of capable teachers is important. University teachers in particular have knowledge of global trends and the latest technologies but often lack experience of the production front-line. In contrast, the size of the human resources in the industrial circles equipped with the latest knowledge of 4IR is limited. It is, therefore, desirable to encourage industry-academia cooperation. For example, the introduction of a facility for joint research with a Japanese company is one idea. It is also important to promote cooperation within individual educational institutions by means of improving the quality of teachers in an efficient manner through IoT. Moreover, universities and vocational training colleges provide technical lectures using production equipment, etc. but much of such equipment is deteriorated or even obsolete. The input of new equipment in tune with the 4IR era is required in the coming years.	

Action Plan 10	Tasks to be Achieved
Human resources development (fully-fledged members of society and students) (Human resources) Principal Target Countries All 5 countries	・Smartification leads to a loss of certain jobs. ・There is a decline of interest among students (unpopularity of the manufacturing industry and declining interest in science subjects, including mathematics, etc.)
The progress of automation and improved efficiency due to smartification lead to a loss of employment for some workers on production sites. It is, therefore, necessary to establish a legal system and policies, such as the creation of a safety net, to support these workers and also to provide assistance for their re-employment through human resources development efforts, such as Re/Up-skill. In some countries, including Thailand, the reluctance among students to take science subjects or mathematics has become noticeable in recent years while the finance and service industries have become popular employment fields. Meanwhile, the popularity of the manufacturing industry has declined. In view of this trend, such measures as the holding of events utilizing advanced technologies to attract excellent students to the manufacturing industry should prove useful.	

7.3 Medium to Long-Term Cooperation Programs of JICA

Here, the medium to long-term cooperation programs to be implemented by JICA in the field of advancement of the manufacturing industry are discussed for each target group (or issue) (government organizations, industrial circles, educational institutions and such boundary areas as public-private cooperation and industry-academia cooperation between these organizations/circles/institutions) based on the tasks and action plans regarding the smartification of industry described in the previous section. For each target group, the feasibility of implementing individual programs is considered from such typical viewpoints (angles) as “promotion of investment”, “strengthening of productivity and international competitiveness”, “strengthening of linkage between local companies and Japanese companies” and “fostering of industrial human resources”. The table on the next page classifies various cooperation programs using a matrix consisting of target groups, etc. and angles.

The number (such as C1) is a consecutive number attached to each cooperation program plan which is referred to in the following text.

Table-48 Medium to long-term cooperation programs of JICA

Angle / Target group, etc.	Promotion of investment	Strengthening of productivity and international competitiveness	Strengthening of linkage between local companies and Japanese companies	Fostering of industrial human resources / Mutual unification of qualification and skill	Promote cooperation within the region
Government organizations	[C1] Cross-ministerial matching event to support smartification of SMEs	[C2] Dispatch of advisors on Japanese-style 4IR approach		[C3] Fostering of human resources of SME support organizations to support advanced technologies	[C4] Establishment of intra-regional industrial human resources supply and adjustment system
Public-private cooperation	[C3] Establishment of a credit rating system for smartification of SMEs	[C4] Japanese-style joint research on 4IR between a national research institutes and private manufacturing companies [C5] Support for the formulation of guidelines on 4IR by prioritized industry in each target country	[C6] Establishment of a public digital supply chain infrastructure	[C7] Fostering of SIer human resources with good understanding of production sites	[C1] Dispatch of ASEAN smart manufacturing coordination advisor [C2] Dispatch of advisors on patent policy support in AI filed
Industrial circles	[C8] Introduction and dissemination of Japanese-style solutions for smartification of SMEs [C9] Awareness raising seminar for SME owners in preparation of 4IR	[C10] Dissemination of bottom-up 4IR through digital KAIZEN [C11] Smartification demonstration project starting with emerging countries	[C12] Development of a smart matching system between Japanese and local SMEs [C13] Training on smartification of local and Japanese supply chains [C14] Program to encourage the departure from the closed Japanese economic zone [C15] Seminar to facilitate the dissemination of Japanese-style solutions to local SIer	[C16] Data-driven manufacturing training for local and Japanese SMEs [C17] Development of CIO human resources towards 4IR	[C18] Wide-area dissemination of SME smartification in collaboration with FabLab
Industry-academia cooperation	[C19] Creation of a platform to facilitate industry-academia cooperation on advancement of the manufacturing industry	[C20] Research on fields and implementation methods of smartification which suit the culture, climate. etc. of individual target countries	[C21] Joint PoC project on smartification by a Japanese company with local university or local company with Japanese university	[C22] Consolidated 4IR human resource development and corporate support through digital kaizen [C23] Encourage motivation of science students to find employment in advanced manufacturing industries	
Educational institutions				[C24] Development of a re-training program of workers following smartification	[C25] Travelling Japan-ASEAN summer camp on advanced technologies

The table below summarizes which elemental technologies of the 4IR are covered by these cooperation proposals. As shown in the previous section, most of the advanced technologies in the 4IR are based on the cycle of acquiring, storing, analyzing, deciding, and reflecting on digital data, so it is important to first acquire and store digital data. As AI cannot be built without the accumulation of data, it can be seen from the table that IoT (sensors) is the technology that provides the foundation as the entry point (if there is no accumulation of existing data).

Table-49 Medium to long-term cooperation programs of JICA (matching elemental technologies)

Coop. Prog.	IoT	Big Data	Data Mining	AI	Block chain	Robotics	ERP/MRP	SCM	MES	Others	Note
C1	✓	✓	✓	✓		✓	✓	✓	✓		
C2	✓	✓	✓	✓	✓	✓	✓	✓	✓	All 4IR-related technologies	
C3	✓	✓	✓	✓			✓		✓		
C4	✓	✓	✓	✓	✓						
C5	✓	✓	✓	✓		✓	✓	✓	✓		
C6				✓							Patent-related
C7	✓	✓	✓	✓		✓	✓		✓		
C8	✓	✓		✓		✓	✓		✓		
C9	✓	✓	✓	✓	✓	✓		✓			
C10					✓		✓	✓	✓		
C11	✓	✓	✓	✓		✓	✓	✓	✓		
C12	✓	✓		✓		✓	✓	✓	✓		
C13	✓	✓		✓		✓	✓	✓	✓		
C14	✓	✓		✓		✓	✓		✓		
C15	✓	✓	✓	✓	✓	✓	✓	✓	✓	All 4IR-related technologies	
C16				✓							
C17	✓	✓	✓	✓			✓	✓			
C18	✓			✓			✓	✓			
C19	✓	✓		✓		✓	✓	✓	✓		
C20	✓	✓								BI	
C21	✓	✓	✓	✓		✓	✓		✓		
C22	✓	✓	✓	✓		✓					
C23	✓	✓	✓	✓	✓	✓	✓	✓	✓	All 4IR-related technologies	
C24										All 4IR-related technologies	
C25	✓	✓		✓			✓				
C26	✓	✓	✓	✓		✓	✓	✓	✓		
C27	✓	✓	✓	✓	✓	✓	✓	✓	✓	All 4IR-related technologies	
C28	✓	✓		✓		✓	✓		✓		
C29	✓	✓		✓	✓	✓					

The following figure summarizes the commencement timing, implementation order, and cooperating organizations of these cooperation proposals. The arrows indicate the dependency between the cooperation proposals, and the dotted lines indicate the desirability of cooperation with related organizations.

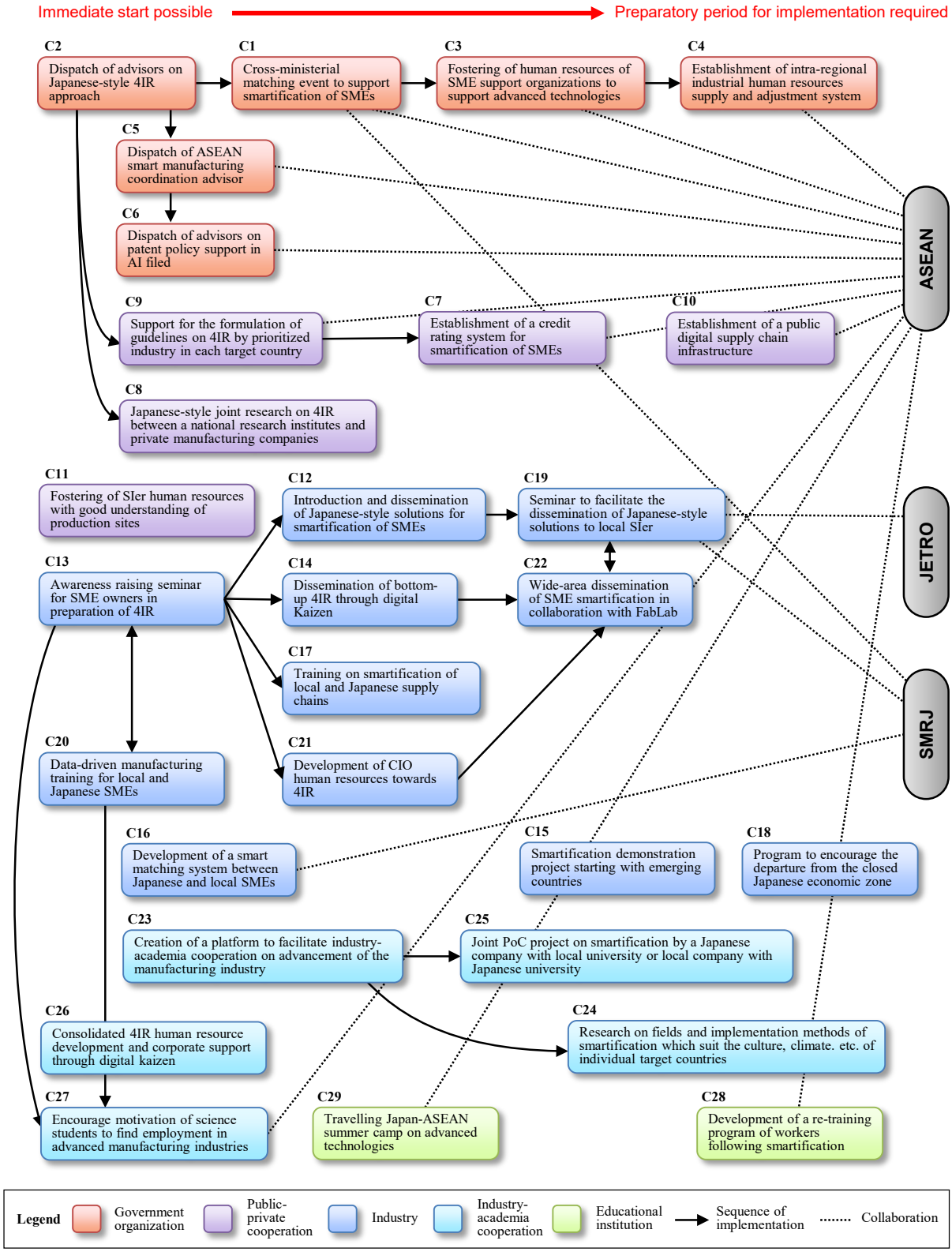


Figure-42 Commencement timing and sequence of implementation of cooperation programs and cooperating organizations

7.3.1 Cooperation for Government Organizations

The primary purpose of the basic cooperation policy for government organizations must make the government of a partner country understand the Japanese approach (Society 5.0, etc.) regarding 4IR while making common points with as well as differences from the approaches of Western countries clear. It is important to propose cooperation contents which only Japan is capable of implementing. A cooperation program which works on the government of a partner country to facilitate cooperation with industrial and/or educational circles and adjust the differences among stakeholders on the basis of such a basic policy is considered to be effective.

[C1] Cross-ministerial matching event to support the smartification of SMEs

Angles	Government organizations; Investment promotion; Facilitation of inter-ministerial cooperation; Subsidy; Matching; ASEAN
Target countries	Emerging countries in which multiple relevant ministries provide their own support measures and subsidies, or ASEAN Example: Thailand (DEPA, NIA, Ministry of Industry)
Form of cooperation	Technical Cooperation: Convening of events and follow-up
Necessity for cooperation	In the case of a government of which multiple ministries individually provide concrete measures to achieve 4IR, such as subsidies, it is often the case that cooperation involving multiple ministries cannot be readily established because of the vertically structured administrative set-up. There are cases where companies receiving support do not exactly know the target fields and application requirements of multiple support measures and, therefore, do not know where to apply for support. Possible consequences are that these companies make an incorrect choice of organization to which they apply for support or are reluctant to apply due to the cumbersome procedure to apply to multiple organizations.
Contents of cooperation	JICA should invite multiple government organizations which have 4IR support measures to a single event while publicly recruiting participating companies in need of support to achieve matching between support measures and companies. When participating companies are manufacturing companies, companies providing solutions, such as IoT, etc., should also be recruited to initially conduct matching between manufacturing companies and companies providing solutions. This initial matching should then be followed by matching between individual combinations of manufacturing company and company providing solutions and the most appropriate support measure(s) of a government organization. Such events should be periodically convened with the sponsorship of JICA. For the selection of the participating companies, efforts should be made to cooperate with the support measures of private sector entities, such as the Japan Human Resource Development Center. If an event proves to be popular, it may well be convened throughout the ASEAN region.
Timing, etc.	Implementation in association with [C2] is desirable. The event is convened once to several times a year, taking the response of the industrial circles into consideration.
Remote implementation	Can be conducted remotely (online conference format) Explanation: In the initial stage of the activity, it is desirable to provide on-site guidance by collaborating with the Japan Center and other organizations in the matching analysis; thereafter, the activity shifts to mainly remote implementation.

[C2] Dispatch of advisors on Japanese-style 4IR approach centering on Society 5.0

Angles	Government organizations; Strengthening of international competitiveness; Facilitation of inter-ministerial cooperation; Bottom-up
Target countries	All emerging countries which intend to promote 4IR
Form of cooperation	Technical Cooperation: Dispatch of individual experts
Necessity for cooperation	As described in 3.1, Western countries (especially Germany and the USA) greatly influence the 4IR policies of ASEAN countries through consulting firms. Japan which calls for Society 5.0 should actively appeal a 4IR approach conforming to the actual situation of Asia. In this context, Japan should dispatch policy advisors to the government ministry responsible for 4IR in each country. During the field research, Myanmar and Vietnam expressed their hope to receive a Japanese advisor on 4IR policies through JICA.
Contents of cooperation	Experts with knowledge of implementing the Japanese-style 4IR approach, including knowledge of cases of bottom-up smartification from the production site, should be dispatched as advisors to facilitate understanding of the governments of partner countries regarding the Japanese-style smartification. At the same time, cooperation with other JICA support based on the Japanese-style smartification and support activities of JETRO, the Japan Chamber of Commerce and Industry, etc. should be sought. In many cases, the competent ministry (Ministry of Industry, etc.) supervising the manufacturing industry which is the recipient side of 4IR differs from the competent ministry (Ministry of Telecommunications, etc.) supervising the information and communication industry which provide 4IR solutions. Because of this, advisors should be dispatched in pairs to both ministries with a view to harmonizing the policy of the side introducing 4IR with the policy of the side providing 4IR through close cooperation between advisors. Some policy ideas regarding the dissemination of the Japanese-style 4IR approach are listed below. ・ Preferential taxation system for the introduction of bottom-up type smartification ・ Deregulation in relation to smartification (such as Japan's deregulation of virtual currencies)
Timing, etc.	Immediate start and continuation if necessary, taking the outcomes into consideration
Remote implementation	Face-to-face cooperation by advisor dispatch is preferred. Explanation: Since advice on specific measures to be taken in response to the 4IR national policies of ASEAN countries is required, it is desirable to limit desk activities and to implement supporting activities based on an understanding of the actual situation of the industry.

[C3] Fostering of human resources of SME support organizations to support advanced technologies

Angles	Government organizations; Fostering of industrial human resources; Training; ASEAN
Target countries	Countries which have a government organization supporting SMEs or ASEAN
Form of cooperation	Pilot survey + Technical Cooperation or Topic-based Training
Necessity for cooperation	A SME support organization traditionally provides guidance on productivity and/or quality improvement through steady KAIZEN activities, etc. When the response to 4IR in the future is taken into consideration, it can be said that the use of ICT at the production site of a SME is essential. However, consultants supporting SMEs generally lack sufficient knowledge of ICT and often lack knowledge and applied skills of the most advanced technologies, such as IoT and AI, to respond to 4IR.
Contents of cooperation	Training on the technical knowledge and skills required for 4IR should be provided, targeting the consultants of government organizations supporting SMEs. To start with, pilot work should be conducted in the form of a seminar based on field research results with a view to determining the technical level for transfer and efficiency of transfer. Based on the analysis results of this pilot work, instructors capable of teaching 4IR technologies to consultants should be trained in the form of a ToT program. It is desirable that the Japanese expert acting as an instructor is either a SME management consultant with knowledge of digital technologies and 4IR or an ICT solution engineer with experience of upgrading production sites and an ordinary SME management consultant working in pair. It may be an idea to invite consultants of the supporting organizations of individual countries for the provision of ASEAN-wide training.

Timing, etc.	The implementation in combination with [C2] is desirable. Continuation of the program if necessary, taking the outcomes into consideration.
Remote implementation	Remote implementation is possible (by online training)

[C4] Establishment of an intra-regional human resources supply and adjustment system

Angles	Government organizations; ASEAN; Promote cooperation within the region
Target countries	ASEAN region and Japan
Form of cooperation	Technical Cooperation: Dispatch of advisors to the ASEAN Secretariat
Necessity for cooperation	The findings of the field research show a significant shortage of human resources familiar with IT which are necessary to respond to 4IR in all of the visited countries except Myanmar. Myanmar has surplus capacity to supply IT human resources outside the country and the level of these human resources is sufficiently high as they were nurtured under JICA projects in the past. As this case shows, there is a strong possibility of requiring a system to supply the necessary human resources for the advancement of industries in a flexible manner within the ASEAN region in the coming years.
Contents of cooperation	An advisor specializing in the cross-border supply and adjustment of advanced industrial human resources should be dispatched to the ASEAN Secretariat with the aim of establishing a stable supply system of engineers conversant with advanced industrial technologies in the ASEAN region and Japan. Collaboration with METI projects (such as AMEICC[226]) would also be effective.
Timing, etc.	It is desirable to dispatch them after the implementation of [C1] to [C3], as the governments of each country need to respond.
Remote implementation	Face-to-face cooperation by advisor dispatch is preferred. Explanation: Since many stakeholders (governmental organizations in the ASEAN region, Japanese companies operating in the region, chambers of commerce and industry, etc.) will be involved, it is important to make proposals and conduct PDCA management in line with the actual situation of each stakeholder.

[C5] Dispatch of ASEAN smart manufacturing coordination advisor

Angles	Government organizations; ASEAN; Promote cooperation within the region
Target countries	ASEAN countries
Form of cooperation	Technical Cooperation: Dispatch of advisors to the ASEAN Secretariat
Necessity for cooperation	The governments of ASEAN countries are trying to implement policies to promote the 4IRs, and while it is of course necessary for each country to have its own policies to give it a comparative advantage over other countries, it is also important to have multilateral cooperation in areas such as human resource development and industrial standards. In other words, there is a need for both policies in areas where there is a great benefit to be shared by the region (human resource development curriculum, industrial standards, etc.) and policies to develop the strengths of the home country. Collaboration with METI projects (such as AMEICC) would also be effective.
Contents of cooperation	An advisor will be assigned to the ASEAN Secretariat to coordinate policies related to the 4IRs in ASEAN countries, especially in areas that can be shared. The advisor will not only coordinate within the region, but will also make recommendations on cooperation with Europe, the United States, and neighboring regions. The advisor can be dispatched in conjunction with [C4].
Timing, etc.	Immediate start. It is desirable to implement in collaboration with [C2].
Remote implementation	Face-to-face advisor dispatch is preferred. Explanation: Because it is important to make proposals and conduct PDCA management in line with the actual situation, based on information exchange with related organizations in various fields (government-related organizations in the ASEAN region, related organizations in Europe, the United States, etc.).

[226] https://ameicc.org/

[C6] Dispatch of advisors on patent policy support in AI filed

Angles	Governmental Organizations Promoting Intra-regional Cooperation in ASEAN
Target countries	ASEAN countries
Form of cooperation	Technical Cooperation: Dispatch of Advisors to ASEAN Secretariat
Necessity for cooperation	While the construction of data-driven systems using IoT and other technologies is becoming widespread in the field of 4IR, it is certain that AI will become the most important elemental technology for analyzing the accumulated big data and making effective decisions. Even in fields other than manufacturing, the application of AI to the analysis and decision-making is becoming indispensable for big data accumulated through smartphones as integrated devices of digital sensors and Internet services, and the number of patent applications in the field of AI has been increasing rapidly in recent years. Under these circumstances, ASEAN countries and Japan are looking to apply AI to a wide range of industrial fields in the future, and there is a growing need for intra-regional cooperation in patent policy in this field.
Contents of cooperation	An advisor will be assigned to the ASEAN Secretariat to coordinate AI-related patent policies in ASEAN countries and Japan. The advisor will not only coordinate within the region, but will also make recommendations on cooperation with Europe, the United States, and neighboring regions.
Timing, etc.	Immediate start. It is desirable to implement in collaboration with [C5]
Remote implementation	Face-to-face advisor dispatch is preferred. Explanation: Because the support activities are related to specialized fields, it is important to build trust among the staff members in charge in the early stages of the activities. Therefore, during the period until the activity system is established, it is essential to conduct on-site activities that emphasize the formation of human networks and understanding of the characteristics of the industry in each country, and thereafter, the emphasis should be shifted to remote implementation.

7.3.2 Draft Cooperation Programs Related to Public-Private Cooperation

In those emerging countries targeted by the field research, public-private cooperation tends to be unpopular and the general feeling is that a limited number of large companies are implementing their own response to 4IR without relying on the government, making the best use of their own financial strength. However, 4IR is essentially a field requiring close cooperation between the most advanced applied technologies led by the private sector and government policies pushing forward the dissemination of such technologies. The government should actively work on a scheme which has advantages for private companies which are reluctant to enter into cooperation with the public sector. Cooperation program plans to facilitate public-private cooperation in emerging countries are presented next.

[C7] Establishment of a credit rating system for the smartification of SMEs

Angles	Public-private cooperation; Strengthening of international competitiveness
Target countries	All emerging countries which intend to promote 4IR
Form of cooperation	Pilot study + technical cooperation project
Necessity for cooperation	The biggest task for SMEs in developing countries is fund raising. Unlike large local companies, these SMEs find it extremely difficult to raise funds from financial institutions because of their much weaker financial base than Japanese SMEs[227] and can only borrow with very strict conditions. When a local SME plans to invest in smartification equipment corresponding to 4IR, it is difficult for a financial institution to evaluate the business plan submitted by the SME because of the small number of past cases of lending. There is concern that cases of no lending will increase as a result of such difficulty. In order to improve this situation, a fair credit rating system including evaluation of the technical validity of the smartification plans of SMEs, operated by a third party is required.
Contents of cooperation	A credit rating system regarding the smartification of SMEs should be jointly developed with the government of a partner country so that financial institutions can refer to this system. The target is to enable financial institutions to fairly and objectively evaluate loan applications by means of developing criteria and a standard procedure to evaluate the creditability of a SME which plans to invest in smartification-related equipment in particular instead of rating a huge number of SMEs individually based on investigation of each SME. The implementation of these criteria and standard procedure in clear steps is important. The ultimate target is to establish the system as a web-based system so that it can be freely used by financial institutions for the evaluation of credit requests by SMEs and offers of credit to SMEs.
Timing, etc.	The implementation in association with [C2] is desirable. Immediate start and continuation if necessary taking its outcomes into consideration.
Remote implementation	It is possible to develop the system through remote discussions with the partner country.

[C8] Japanese-style joint research on 4IR between national research institutes and private manufacturing companies

Angles	Public-private cooperation; Strengthening of international cooperation
Target countries	Emerging countries which have industrial technology and ICT-related national research institutions
Form of cooperation	Technical Cooperation: Joint research with the government of a partner country
Necessity for cooperation	Industrial technology and ICT-related national research institutions in emerging countries have less experience of joint research with private manufacturing companies to immediately benefit the industrial circles compared to those in Japan. Even if they do have experience, such experience is mostly related to the western-style advancement and digitalization of the manufacturing industry. In regard to Japanese-style bottom-up 4IR at manufacturing sites, such efforts have only recently started, even in Japan, and there is little chance of research on such bottom-up 4IR being conducted by research institutions in partner countries. For the wide introduction of the Japanese-style approach to partner countries, it is necessary to promote a deep understanding of the approach among partner countries and to conduct joint research work designed to ensure the implementation of this approach with a local Japanese company so that the approach may be implemented to suit the actual situation of individual partner countries.

[227] Final Report for JICA's "Information Gathering and Verification Study for Strengthening of the Foundations for Industrial Promotion in the Socialist Republic of Vietnam"

Contents of cooperation	A joint research project by JICA and a research institution in a partner country on the Japanese-style 4IR approach and method to apply this approach to the partner country should be launched, working on both a local Japanese company (or consortium of such companies which is familiar with the social infrastructure and technological background of the partner country) and a national research institution of the partner country. A researcher (of a university or research institution) with experience of involvement in the advancement of the manufacturing industry in Japan should be dispatched from Japan as an expert to join a team of researchers of a research institution of the partner country and person responsible for production management and/or person responsible for system operation at the local Japanese company to conduct the intended research work. The contents of this research should undergo a PoC experiment at the production site of the Japanese company or local company with the aim of submitting the research findings at an international conference.
Timing, etc.	Immediate start and continuation if necessary, taking the outcomes into consideration
Remote implementation	It is possible to implement remote research activities partially, but the PoC should be implemented face-to-face.

[C9] Support for the formulation of guidelines on 4IR by prioritized industry in each country

Angles	Public-private cooperation; Strengthening of international competitiveness; ASEAN
Target countries	Emerging countries which have identified prioritized industries for the promotion of 4IR Example: Indonesia (MOI), Malaysia (MIGHT), Thailand (DEPA, NIA)
Form of cooperation	Technical Cooperation: Development Study
Necessity for cooperation	Although prioritized industries for the promotion of 4IR have been identified in Indonesia, Malaysia and Thailand, a technological roadmap specifying the concrete sequence of the advancement of industries and detailed guidelines are absent in many cases. This situation is not limited to the manufacturing industry. In more than one country, guidelines for smartification are required in such prioritized industries as agriculture and medical equipment. The formulation of guidelines requires in-depth knowledge of the technical background, accompanied by an ideal sequence and lessons obtained from the relevant efforts of private companies. However, such experience is only owned by industrialized countries, such as Japan.
Contents of cooperation	Guidelines for the smartification of prioritized industries in the 4IR promotion policy of each partner country should be jointly formulated with those in charge of the government of each partner country. The research team should firstly study cases of advancement of the industries concerned in Japan (and Western countries, if necessary), examine the present situation of the targeted industries in their own country and the feasibility of moving to 4IR and formulate guidelines for the steps to be taken by those (private companies) operating in the targeted industries. These guidelines may as well be industry-specific common to all ASEAN countries.
Timing, etc.	After the implementation of or in parallel with [C2].
Remote implementation	It is possible to promote the development of the guideline through remote discussions with the partner country

[C10] Establishment of public digital supply chain infrastructure

Angles	Public-private cooperation; Strengthening of the linkage between local companies and local Japanese companies; Infrastructure; ASEAN
Target countries	Countries which have a well-developed supply chain involving local companies and local Japanese companies. Ideally, this program targets the entire ASEAN region or the entire world.
Form of cooperation	Finance and Investment Cooperation: ODA loan

Necessity for cooperation	Acecook and Omron operating in Vietnam have clearly shown the effectiveness of exchanging information on order acceptance, manufacture and inventory as digital data among companies in the supply chain from the manufacture of parts to assembly and sales as part of the infrastructure, which realizes the sharing of digital data between companies operating in different types of business as an important element of 4IR. Instead of establishing such a data exchange system by individual companies, the establishment of a system as a common base offers advantages for the individual companies involved. However, as it is possible for such information/data to be confidential business information, there is a need for a mechanism for secure data exchange between specific companies when required in addition to open information sharing which is the ideal state of 4IR. If the government can lead the establishment of such infrastructure for an information network, this infrastructure can be used for electronic tenders, etc. organized by the government.
Contents of cooperation	Instead of building a new physical network, an open system should be developed to create infrastructure for virtual supply chain data on the Internet. The design of this infrastructure should be consistent with various 4IR-related international standards and industrial standards of which the development has been led by Western countries. The design contents should match the real conditions of the manufacturing industry in Japan with careful attention paid to avoiding Galapagosization. A completed software should be made available as an open source. Funding by an ODA loan is used for software development and also preparatory work of government organizations to adapt to the system
Timing, etc.	If possible the program should start when consent has been achieved at the ASEAN level. Alternatively, a PoC experiment should be conducted in a country judged to be an easy target for program implementation before the shift to full-scale implementation.
Remote implementation	It is possible to develop the system through remote discussions with the partner country. Explanation: It is desirable to conduct on-site activities in order to align the perceptions of the parties involved in the project preparation phase and to keep pace with the activities in the initial phase of the project. Subsequent activities can be conducted remotely to pursue efficiency in a wide area simultaneously.

[C11] Fostering of SIer human resources with a good understanding of production sites

Angles	Industrial circles; Promotion of investment; Solution products; JETR; SMRJ
Target countries	Emerging countries into which many Japanese manufacturing companies and companies in support industries have moved
Form of cooperation	Project-type technical cooperation
Necessity for cooperation	The survey result indicates the tendency of SIers in emerging countries to be generally strong in such fields as web applications and smart phone applications in which many orders are placed by local industries and requiring no experience of specific businesses, but very weak in those fields requiring domain knowledge which can only be acquired through actual experience of engagement in particular work. Although some SIers provide solutions for specific types of business, such as medical equipment and plant control, they are in most cases actually local sales agents for solutions developed in Western countries. The reality is that there are hardly any SIers (except Japanese ones) which are capable of providing solutions to match the actual situation of production sites of individual companies in the manufacturing industry. The fostering of SIers with domain knowledge related to production sites is essential to enable the promotion of advancement of the local manufacturing industry.
Contents of cooperation	Following the example of LASI conducted by Denso in Thailand, a mechanism should be developed for training aimed at teaching essential knowledge and skills to local SIers for the design and proposal of solutions for the manufacturing industry. A curriculum to teach the basics of KAIZEN activities at productions sites and the basics of manufacturing processes at a public vocational training center, etc. should be prepared with the cooperation of Japanese companies and the Japan Chamber of Commerce and Industry in the partner country. A dispatched expert should implement ToT. The ultimate goal is to target countries in which Japanese companies in the principal manufacturing fields are operating throughout the world while making efforts to standardize the curriculum.

Timing, etc.	Based on requests made by local Japanese manufacturers and government of a partner country, the program should be implemented on a priority basis for a country where the fostering of SIers is an urgent task.
Remote implementation	Curriculum development can be promoted and ToT can be conducted remotely through remote discussions with the partner country. Explanation: Depending on the level of support from local companies for the development of SIers who understand manufacturing, the weight of JICA experts' activities in the field may vary greatly. Therefore, it is important to secure support from Japanese companies and chambers of commerce from the project preparation stage for the early stage of activities. Curriculum preparation can be done remotely.

7.3.3 Cooperation Programs for the Industrial Circles

In the case of cooperation for industrial circles, programs designed to support the dissemination of the unique approaches of Japanese companies to 4IR should be implemented, making the best use of the characteristics of Japanese companies which have established their own status on the global stage based on their advantages in such areas as KAIZEN, industrial robots, FA equipment, etc. compared to Western companies. Meanwhile, when compared with the future image of 4IR, i.e. the networking of manufacturing industries throughout the world beyond national boundaries, the uniqueness of Japanese companies often has a risk of creating a closed economic zone consisting solely of Japanese companies as well as a risk of Galapagosization of technologies. It is, therefore, desirable to simultaneously implement a program designed to make Japanese companies avoid such a risk.

[C12] Introduction and dissemination of Japanese-style solutions for the smartification of SMEs

Angles	Industrial circles; Promotion of investment; Solution products; JETRO; SMRJ
Target countries	Emerging countries planning to facilitate 4IR
Form of cooperation	Cooperation with the private sector
Necessity for cooperation	As far as smartification solutions to materialize or support small and medium manufacturing companies are concerned, Western products are in circulation in the market while Japanese products are in the background. This does not mean, however, that there are no Japanese products capable of competing with Western products. In fact, various local products are sold in Japan. The quality of these is good enough to compete with Western products as they allow linkage with machine tools and robots where Japan enjoys a competitive edge. Nevertheless, there are not many efforts to market these quality Japanese products abroad.
Contents of cooperation	The overseas marketing of Japanese smartification solutions for SMEs should be supported through cooperation with JETRO and SMRJ. Basically, solutions which can be used by simply changing the Japanese language used by a system to English or to local language should be selected. These solutions should then be introduced and disseminated after confirming the intentions of the solution providers to move into overseas markets. One precondition is that these providers should bear the cost of localizing the products. To be more precise, solutions should be introduced in 4IR projects already being implemented by JICA, JETRO or SMRJ or a virtual trade show should be planned on the Internet platform. If the response to a product is favorable, it may be an idea to expand the sales channels by means of creating a network of agents as in the case of [C19].
Timing, etc.	Immediate start and periodic implementation. One to several companies each time.
Remote implementation	It is possible to conduct it remotely (online seminars, etc.).

[C13] Awareness raising seminar for SME owners in preparation for 4IR

Angles	Industrial circles; Promotion of investment
Target countries	All emerging countries planning to promote 4IR
Form of cooperation	Convening of seminars
Necessity for cooperation	The findings of the field research have highlighted the actual situation in all countries where many SME owners do not place emphasis on production sites and are more interested in turnover and immediate profit. Those government officials responsible for SME support in each country are aware of this tendency and consider the necessity to change the mindset of SME owners a common task for the promotion of 4IR.
Contents of cooperation	A seminar on 4IR should be convened, targeting SME owners. As this seminar aims at raising the awareness of SME owners, its contents should be deliberately slightly tricky. To be more precise, presentations in the publicity materials and seminar program should give the impression that a proactive response to 4IR will quickly boost the profits of a company, appealing to the typical interest of SME owners described above to encourage their participation. However, the actual contents of the seminar should be designed to encourage awareness raising on the part of SME owners to accommodate 4IR, including the importance of an owner's understanding of the particulars of production sites and data-driven manufacturing through data acquisition, etc. Cases of responding to 4IR in Japan, etc. should be introduced in the seminar. Moreover, cases of common misunderstanding among ordinary people (for example, even though AI is often considered to cost jobs, it does in fact contribute to improving human capabilities as well as productivity) should be actively introduced for the purpose of correcting any erroneous understanding on the part of ordinary people and also encourage SME owners to properly understand the things that they should do.
Timing, etc.	Immediate start and periodic implementation. May be periodic convening at a Japan Human Resource Development Center, etc.
Remote implementation	It is possible to conduct it remotely (online seminars, etc.).

[C14] Dissemination of bottom-up 4IR through digital KAIZEN

Angles	Industrial circles; Strengthening of international competitiveness; Productivity improvement
Target countries	Emerging countries which have a cluster of manufacturing companies practicing KAIZEN at production sites
Form of cooperation	Technical Cooperation: PoC experiment and project-type technical cooperation
Necessity for cooperation	It is necessary to make those companies which are reluctant to respond to digitalization and 4IR (mostly local Japanese companies and Japanese companies in the local supply chain) as they are already routinely implementing manual KAIZEN activities understand that digitalization is an unavoidable step in the preparation for future 4IR.
Contents of cooperation	A KAIZEN expert and IT expert working as a pair should visit manufacturing SMEs which are already implementing KAIZEN to investigate the reality of KAIZEN in detail and to clarify areas in which digitalization promises significant efficiency improvement and operational advancement. They should construct a system capable of acquiring, accumulating and analyzing simple digital data to conduct the PoC experiment of digitalization. When the positive effects of digitalization have been subsequently verified and a request has been made by the government of a partner country, integration of the digital KAIZEN contents into the curriculum for KAIZEN dissemination should be considered in cooperation with the Japan Productivity Center and other organizations. It is also effective to introduce case studies of advanced efforts at Japanese companies as advanced examples of digital kaizen.
Timing, etc.	Immediate start and periodic implementation. Regular implementation of the program at a Japan Human Resource Development Centre, etc. may be an idea. Could be implemented as a successor to or additional support for an ongoing KAIZEN dissemination project.
Remote implementation	Site visits by experts will be necessary, but some technologies such as video conferencing and VR can also be used. Explanation: Since all the digital kaizen activities in SME manufacturing sites will be in different places, it is desirable for the kaizen experts (also using the Japan Center) to be able to diagnose the sites, and this information can be used to provide remote support for highly efficient kaizen.

[C15] Smartification demonstration project starting with emerging countries

Angles	Industrial circles; Strengthening of international competitiveness; Reverse import
Target countries	Emerging countries where the regulations regarding the PoC experiment of 4IR-related new technologies are lax compared to Japan
Form of cooperation	Cooperation with the private sector: PoC experiment under a SME support scheme Example: Thailand (NIA), Vietnam (NIC)
Necessity for cooperation	When looking at examples of innovation concerning Apps and services using smart phones, etc. in the world today, there is no doubt of the advantages of a country, represented by China, which can easily try new technologies and services as large-scale social experiments. In the world today, Japan is a country of too strong regulations to conduct such experiments. Because of this, there is concern that Japan will become a slow starter in the midst of the global current towards 4IR. This situation can be viewed as an advantage rather than a disadvantage, however, by means of conducting a PoC experiment of smartification, such as 4IR, in emerging countries rather than Japan with the possible result of speeding up the utilization of new technologies and also contributing to the facilitation of smartification in the partner countries.
Contents of cooperation	Smartification PoC experiment contributing to industrial advancement which cannot easily be implemented in Japan due to Japan's tight restrictions should be conducted in emerging countries. In some cases, even if there are no regulations, a test conducted in an emerging country rather than a factory in Japan may be more advantageous in terms of cost and knock-on effects. For this reason, a PoC experiment assisted by JICA should be conducted by recruiting companies hoping to conduct an initial test on smartification in an emerging country with a SIer providing solutions from Japanese manufacturing SMEs which are already operating in emerging countries. The results of such testing should be widely shared with local companies as well as local Japanese companies, boosting the momentum for the commencement of the digitalization and 4IR of manufacturing SMEs at factories of emerging countries.
Timing, etc.	Periodic implementation by recruiting Japanese SMEs for their participation
Remote implementation	It is desirable to implement the PoC on site.

[C16] Development of a smart matching system between Japanese and local SMEs

Angles	Industrial circles; Strengthening of linkage between local and Japanese SMEs; AI; Matching; SMRJ
Target countries	Emerging countries which have a local SME profile database
Form of cooperation	Cooperation with the private sector: Joint system development by related organizations
Necessity for cooperation	Although many emerging countries have already created a local SME profile database, there is a situation where the data so contained is not necessarily utilized to a good extent. For example, in the case of J-GoodTech which is a business matching site introducing technologies of Japanese SMEs to the world and T-GoodTech, the Thai version of J-GoodTech, information on a company providing a technology can be searched by a company requiring a technology. However, there is no integral function which automatically conducts the matching of these two companies when both of them are in the same database. Because the number of SMEs is very large, there is a limit for manual searching alone to find a potentially matching business partner.
Contents of cooperation	A system capable of extracting potential matching pairs from SME profile databased in Japan and multiple emerging countries should be jointly developed with SMRJ by making AI remember the actually successful business matching of SMEs in the past and other relevant facts. This system should not only extract all potential pairs but also have a search function on the Internet (for example, on the J-GoodTech site) so that inputting of the profile of one's own company (and the target field for business matching and other) results in the display of data of SMEs matching the said profile. The system should also have the function of automatic notification when a matching company newly registers. The target databases need not be those already on the Internet, like J-GoodTech, and unprocessed raw data may be used. The main responsibility of JICA is the development of SME profile data at SME support organizations of the partner countries, while obtaining cooperation for the use of data. As it is better to have as many target countries as possible, targeting of the entire ASEAN region or even the entire world is feasible. Cooperation with JETRO will be effective as Japanese companies which have moved to emerging counties should also be targeted.

Timing, etc.	Based on agreement with related organizations
Remote implementation	It is possible to promote the development of the system through remote discussions with the partner country.

[C17] Training on the smartification of local and Japanese supply chains

Angles	Industrial circles; Strengthening of linkage between local SMEs and Japanese companies; Supply chain; Practical training
Target countries	Emerging countries with clusters of Japanese manufacturing companies and their supply chain companies
Form of cooperation	Cooperation with the private sector: Practical training program
Necessity for cooperation	The findings of the field research suggest that one type of smartification which manufacturing companies can easily commence is the gathering and analysis of digital data through the supply chain and in the after-market. Such work can be said to be an initial approach towards future 4IR with an excellent cost-benefit performance as it can start relatively easily without the modification of manufacturing sites or large-scale investment in addition to the fact that utilization of the gathered data can feature multiple companies beyond the framework of a single company. Furthermore, when a supply chain company is a local company, the work in question is useful from the viewpoint of strengthening the linkage between Japanese manufacturers and local companies and also of transferring or sharing technologies.
Contents of cooperation	Practical training should be provided on the technical knowledge, preparation, equipment, etc. required for smartification of the exchange of information between a Japanese company and local companies supplying parts and raw materials to said Japanese company or local company selling the products of the said Japanese company. It is desirable that those responsible for the sharing of information at their respective companies participating in the training as a group. It may be an idea to develop a system which allows the sharing of information in a simple and practical manner by including the introduction of web services and systems which can be used to share information in the developed system.
Timing, etc.	Immediate start with periodic implementation. Training may be periodically held at a Japan Human Resource Development Center, etc.
Remote implementation	Can be conducted remotely (online training)

[C18] Program to encourage departure from the closed Japanese economic zone

Angles	Industrial circles; Strengthening of linkage between local SMEs and Japanese companies; Negative effects of Japanese community in other countries; JETRO
Target countries	Emerging countries into which the Japanese manufacturing industry and its Tier 2/3 companies have already moved
Form of cooperation	Cooperation with the private sector: Support for SMEs Example: Thailand
Necessity for cooperation	The field survey discovered that local Japanese SMEs operating in ASEAN countries in particular tend to confine their business within the supply chain of large Japanese companies and are reluctant to challenge the task of business expansion, targeting local companies and foreign companies. This situation indicates that the economic activities of Japanese companies are complete within the sphere of Japanese companies. As such, this situation not only contributes little to the expansion of the entire Japanese economy but also leads to the inflexibility and a qualitative decline of their operations due to their scramble to gain a portion of the limited business opportunities, resulting in a strong likelihood that the technologies in such a closed economic zone will eventually become Galapagosized.
Contents of cooperation	The necessary support for Japanese SMEs already operating locally to enable expansion of their scope of trading with companies other than Japanese companies should be provided in cooperation with JETRO. The planned work includes promotion of the widening of the scope of business by means of matching with local companies and networking of digital information through digitalization and promotion of the response to 4IR. It may also be an idea to convene educational seminars for those responsible for overseas operation at head offices in Japan with the cooperation of SMRJ and the Japan Chamber of Commerce and Industry in addition to support in the partner countries.

Timing, etc.	Immediate start. To be implemented based on agreement with JETRO in those countries which require this program.
Remote implementation	Can be conducted remotely (online seminars, etc.)

[C19] Seminar to facilitate the dissemination of Japanese-style solutions to local SMEs

Angles	Industrial circles; Strengthening of linkage between local and Japanese companies; Local SIers; Expansion of sales channels; JETRO
Target countries	Emerging countries with many SIers specializing in local companies which do not have a trading link with Japanese manufacturing companies.
Form of cooperation	Convening of a joint seminar
Necessity for cooperation	In many countries visited by the field survey team, almost all of the local solution providers expressing their ability to respond to 4IR have become de facto local sales agents for ERPs made in the West (German SAP, Belgian Odoo, etc.) and solely sell Western ERPs and related products to such customers as large local companies and government organizations. These SIers do not have a trading link with Japanese companies which want Japanese solutions using the Japanese language and are completely separated from Japanese SIers. However, some Japanese companies use a Western ERP. Likewise, some local manufacturing companies require solutions adapted to their production sites using Japanese equipment. In order to widely disseminate the Japanese-style 4IR approach to emerging countries in the coming years, it is necessary to promote the interest of local SIers in Japanese-style solutions to facilitate their sale of such solutions to local companies.
Contents of cooperation	A seminar should be jointly held with JETRO to facilitate understanding of the Japanese-style 4IR approach among local SIers so that these SIers can start to handle Japanese-style solutions. The key points of segregation, such as the differences between Japanese and Western approaches, etc., should be explained in this seminar. Matching with local SIers should also be attempted by means of inviting Japanese SIers operating locally and Japanese solution providers which are seeking to establish local agents to the seminar. One difference between [C17] and [C10] is that the purpose of [C17] is the establishment of a local network of agents which is equivalent to the ERP marketing system of Western companies.
Timing, etc.	Holding of the seminar approximately once a year. May be held at such events as Solution EXPO, etc.
Remote implementation	Can be conducted remotely (online seminar)

[C20] Data-driven manufacturing training for local and Japanese SMEs

Angles	Fostering of industrial human resources; Hands-on training; Strengthening of linkage between local and Japanese companies
Target countries	Emerging countries with many SMEs which have not achieved digitalization of production site or acquisition of digitalized production data
Form of cooperation	Cooperation with the private sector: Practical training program in a partner country
Necessity for cooperation	The findings of the field survey reveal that many SMEs in emerging countries acquire hardly any data from production sites and that even local Japanese companies seldom conduct the acquisition, accumulation and analysis of digital data even though they do conduct the analogue improvement of production sites. In order to sufficiently prepare now for 4IR which assumes the existence of a digital information network, it is essential to make owners and people in charge at both Japanese and local manufacturing SMEs (i) experience how much advantages can be enjoyed in terms of productivity and quality improvement once production site data is acquired by digital technologies such as IoT and (ii) understand the recent trend that the size of the capital investment required for the adoption of such technologies is smaller than expected.

Contents of cooperation	Hands-on training should be implemented whereby the participants themselves develop a system to acquire, accumulate and analyze digital data from manufacturing sites by means of utilizing a simple IoT sensor or smart phone. Refer to 7.1(2) "Hands-on training to introduce ToT to SMEs in Vietnam" for further details. When the technical level of the participants is relatively high or the participants have basic knowledge of IoT, the training contents may aim at achieving the application of more practical IoT, such as "7 tools of IoT for production sites"[228] proposed by the Japan Management Association.
Timing, etc.	Periodic implementation. May be periodically held at a Japan Human Resource Development Center, etc.
Remote implementation	Can be conducted remotely (online training) Explanation: In order to improve the efficiency of the dissemination of this activity in the field, it is desirable to hold the first few sessions jointly in the field, and to develop the environment for holding the subsequent sessions independently in parallel.

[C21] Development of CIO human resources towards 4IR

Angles	Industrial circles; Fostering of industrial human resources
Target countries	All emerging countries which intend to promote 4IR
Form of cooperation	Technical Cooperation: Development of curriculum and implementation of training
Necessity for cooperation	In order to promote 4IRs, it is necessary for SME management to understand ICT as well as to have an executive equivalent to a CIO who understands both management and IT and can lead the promotion of 4IRs within the company. According to the results of this Study, there are almost no such people in SMEs, and the development of such people is an issue for the promotion of 4IR.
Contents of cooperation	A training mechanism will be established for SME CIO candidates to acquire the necessary knowledge and skills. The curriculum will be developed with the cooperation of business schools and the IT Coordinators Association of Japan, and the training will be conducted locally, since it will cover a wide range of topics such as acquisition of the latest IT knowledge, program management, risk management, and establishment of IT governance such as security and internal control. In countries where the Japan Center is located, the course can be conducted as a corporate course at the Center. The content will also include the Japanese 4IR approach and examples of Japanese solutions to promote Japanese solutions.
Timing, etc.	This will be implemented from countries where SME management has made progress in raising awareness and understanding of the 4IRs among management through PGR12 and other measures.
Remote implementation	Can be conducted remotely (online training)

[C22] Wide-area dissemination of SME smartification in collaboration with FabLab

Angles	Industrial circles; Promote cooperation within the region
Target countries	All emerging countries which intend to promote 4IR
Form of cooperation	Regular matching events + system building through technical cooperation projects
Necessity for cooperation	Digitalization of SMEs is required to promote 4IR. Some SMEs, such as Asahi Tekko in Japan, are capable of developing IoT devices to make their production lines smarter, but in developing and emerging countries, there are only a limited number of companies that have the capacity to do so, or have management that understands the need to devote resources to it. PoC has been conducted in Vietnam, but most of them have not yet been able to continuously use the assembled IoT devices in their factories. On the other hand, there are FabLab which are engaged in activities aiming to solve problems by using digital fabrication know-hows and the students of technical colleges and universities who use the places.

[228] http://www.jmac.co.jp/consulting/theme/iot_7tools.html

Contents of cooperation	Like the PoC conducted in Thailand, hold matching events between SMEs with problems and FabLab (or its users), and support the cost of conducting events and manufacturing PoC devices so that FabLab can support the development of devices that contribute to making SMEs smarter. The devices developed with JICA's support will have their blueprints, etc. released as open source using the FabLab network, so that FabLabs in other countries can manufacture similar devices to support SMEs in those countries. There is also the possibility of holding events in conjunction with FabLab projects around the world, such as those being conducted by JICA in the Philippines, Indonesia, Bhutan, and Rwanda, and the possibility of forming a framework for regular events.
Timing, etc.	Immediate start. Periodic implementation
Remote implementation	Matching events can be conducted remotely (e.g., online seminars). Explanation: Although it may require an on-site survey to determine whether the FabLab (or its user) can realize the solution to the selected problem in line with the idea of Japanese-style SME smartification, the weight can be shifted to remote implementation by understanding this information.

7.3.4 Industry-Academia Cooperation Programs

Many of the countries visited by the field survey team do not practice active industry-academia cooperation involving educational organizations except for a small number of universities in Malaysia and Thailand. As 4IR uses the most advanced technologies, cooperation between higher educational institutions and research institutions as well as industrial circles is more important than public-private cooperation. Here, cooperation program plans to facilitate industry-academia cooperation are examined.

[C23] Creation of a platform to facilitate industry-academia cooperation for advancement of the manufacturing industry

Angles	Industry-academia cooperation; Promotion of investment
Target countries	Emerging countries where the level of education is high but industry-academia cooperation is weak
Form of cooperation	Technical Cooperation Project
Necessity for cooperation	A series of interviews with higher educational institutions in the target countries of the field survey revealed that many higher educational institutions have seldom been involved in industry-academia cooperation. The reasons cited are that university teachers emphasize academic research which is incompatible with the intention of private companies to seek a profit and that private companies do not believe it possible for university teachers to engage in joint activities contributing to the profit of private companies. In Japan, however, industry-academia cooperation benefiting both university and company is very popular. Such cooperation is considered to be particularly important in the field of advanced industrial technology to respond to 4IR in the future, making it necessary for emerging countries to establish a system designed to facilitate similar cooperation.
Contents of cooperation	The project-type technical cooperation scheme should be used to develop a system (platform) to realize Japan’s various industry-academia cooperation mechanisms (joint research, internship, acceptance of company-based researchers by universities, etc.) in emerging countries. Japanese companies which have past experience of industry-academia cooperation should be urged to actively participate while aiming at developing a system to enable to continuation of activities, such as patent application, leading to economic gain.
Timing, etc.	Commencement of the preparatory work after confirmation of the existence of a concrete desire to start cooperation on the educational institution side as well as private company side.
Remote implementation	It is possible to promote the project through online discussions with the partner country

[C24] Research on fields and implementation methods of smartification suiting the culture and climate, etc. of individual target countries

Angles	Industry-academic cooperation; Strengthening of international competitiveness; Utilization of cultural factors
Target countries	Emerging countries intending to seek their own ways of advancing industries
Form of cooperation	Joint research
Necessity for cooperation	Western countries basically try to disseminate common standards throughout the world, not only in the field of 4IR but also in all other industrial fields. Their intention is to make it possible to uniformly manage industrial operations using the same method in countries with a different culture and mentality of the people. There is no guarantee that this approach is the best approach for 4IR. Instead, the international competitiveness of a country is ultimately likely to increase if support is provided to enhance the specialist fields of individual countries based on a conscious recognition of the best and worst fields of individual countries of which the culture and mentality of the people differ from one country to another.
Contents of cooperation	There is a possibility that elements capable of contributing to productivity and quality improvement through digitalization is hidden in information concerning cultural differences which have so far been handled as analogue, qualitative and individualistic types of information. Some examples are “local ways of working” and know-how of personnel issues, both of which are routinely encountered by Japanese companies operating overseas. The planned joint research with JICA, local universities, etc. intends clarification of the contributory elements of industrial promotion deriving from the national character so that the findings can be reflected on the industrial advancement policies and human resources development plans of a partner country. Participants in the research from a partner country should include a folklorist familiar with the culture of the partner country and others on an inter-disciplinary basis as the goal of this research is the development of synergy effects between the industrial advancement aimed at by 4IR and elements of cultural anthropology. The research should continue up to a PoC experiment of the productivity improvement effects, etc. at production sites.
Timing, etc.	Could be implemented as soon as a request and approval are obtained from a partner country.
Remote implementation	It is desirable to implement the survey and PoC on site

[C26] Consolidated 4IR human resource development and corporate support through digital kaizen

Angles	Industry-academia collaboration; Fostering human resources for industry; Strengthening international competitiveness; Improving productivity; Promoting cooperation within the region
Target countries	All emerging countries which intend to promote 4IR
Form of cooperation	Technical cooperation projects
Necessity for cooperation	Conventional ToT support in TVET has the following problems for the industrial needs of the 4IR era. 1) Inability to keep up with the speed of advancement In the conventional ToT support method, the technologies and skills accumulated in Japanese industry are first standardized and then ToT is implemented, but this method cannot keep up with the speed of industrial advancement. It will also take a considerable number of years before the effects of the cooperation can meet the needs of the industry. 2) Industrial human resource development measures targeting technical high schools are insufficient in terms of the sophistication of the human resources (skills) they produce. Measures to support the development of human resources, such as opening new departments in technical high schools with the aim of fostering industrial technology personnel, are insufficient in terms of sophistication to meet the needs for digital technology personnel that industry will require in the 4IR era.

	3) No suitable sites for 4IR in dual system industry-university collaboration The dual system, which is considered to be a unique feature of Germany, can only be expected to be effective to the extent that students gain actual experience in (non-4IR) companies prior to employment, as there are currently almost no sites on the corporate side that are suitable for 4IR education. The industrial human resource needs of the 4IR era are technological human resources that can optimally apply the technological means of the 4IR era (IoT, AI, etc.) to improve the competitiveness of companies, and it is necessary to consider a new method of industry-academia collaboration that can strengthen competitiveness by simultaneously fostering human resources on the corporate side as well as on the educational institution side (students).
Contents of cooperation	The following projects can be envisioned to address the above issues. [Objective] Improve corporate competitiveness and ensure continuity by rapid strengthening of the human resources of Japanese-style 4IR companies [Concept] Fostering digital human resources through a new industry-academia collaboration method that is not a dual system [Cooperation details] ① Provide ToT support (focusing on new technologies of 4IR) to technical colleges or institutes of technology (or to those that have provided such support in the past). ② With the aim of enhancing corporate competitiveness through strengthening corporate human resources, a task team of students or recent graduates from technical colleges or universities and corporate personnel will be formed that will collaborate to conduct technical support tasks on the theme of solving specific problems in the workplace through digital kaizen. The educational institution can treat this as a conventional internship at a company, but the company's objective is not to simply accept students, but to clearly improve productivity (actual profit) through the introduction of new technology. In addition, this industry-academia collaboration process will be used effectively to encourage engineering graduates to work in the manufacturing industry. ③ Since the characteristics of Japanese style manufacturing can be incorporated in the process of selecting themes, the educational load for kaizen in the curriculum of engineering colleges will be kept to a minimum, and a new curriculum for digital human resources in the 4IR era will be developed with an awareness of connectivity with existing schemes such as LASI, which has been implemented as a demonstration project in Japan and ASEAN. [Notes on implementation] • Since this is a technical support for 4IRs, we should try to adopt remote support methods. • In order to effectively collaborate between companies to solve problems at their production sites and student education at the university of technology, it is necessary to identify possible means (hardware and software), such as IoT sensor technology and data processing software, that are necessary to solve problems at companies, and to incorporate into research topics of the students. • Depending on the topics, it is important to design appropriate research subjects for students in order to prevent the leakage of trade secrets (process information, etc.) and other information in this industry-academia collaboration process. [Implementation cycle and others] • The period of company support by a team consisting of target university student (2nd or 3rd year) and new graduate personnel will be one year. • Depending on the agreement with the university, it can be implemented as an activity equivalent to a graduation project. [Intra-regional cooperation and extension to other industries] • In collaboration with exchange student programs within the ASEAN region, it is also possible to promote cross-border mobility of industrial human resources that are in short supply in each country by adding students from other ASEAN countries to the team in departments related to industries in which their countries have comparative competitiveness (or industries in which they want to strengthen their competitiveness). • From the perspective of contributing to the enhancement of competitiveness through 4IR and digitalization on the industrial side, it can be applied not only to the manufacturing industry but also to other industries (logistics, agriculture, fishery, medicine, etc.). In particular, collaboration with IT departments will lead to the development of IT engineers and SIers with domain knowledge in various industries.

Timing, etc.	Cooperation on the educational institution side can be started immediately, SME side should start only after implementing [C13], [C14], [C15], [C22], etc. if the awareness of the management has not yet been changed.
Remote implementation	The project will focus on remote implementation. Explanation: Major local activities include: ① Establishment of the initial response system after kick-off, ② Training in Japan, and ③ The initial period of on-site kaizen activities at companies (until the activities take root). Major remote activities are expected to include ④ Joint curriculum development, ⑤ ToT instruction (classroom and practical training) and evaluation, and ⑥ Holding events to share results.

[C27] Encourage motivation of science students to find employment in advanced manufacturing industries

Angles	Industrial circles; Fostering of industrial human resources; ASEAN
Target countries	All emerging countries which intend to promote 4IR
Form of cooperation	Curriculum development and training implementation
Necessity for cooperation	In order to promote the 4IR, it is essential for talented young people to find employment in the manufacturing workplace. However, in many countries, including Japan, the number of science students who wish to work in the manufacturing workplace is small, and a chronic shortage of human resources is an issue.
Contents of cooperation	Provide opportunities for science students in the ASEAN region to learn about the application of IT-related advanced technologies in advanced manufacturing industries in Japan and ASEAN region, and encourage them to correct the false image they have of the manufacturing industry. For example, provide opportunities for students to hear from executives of companies that are at the forefront of 4IR in applying the latest technology (mainly Japanese and foreign companies, but if there is an advanced manufacturing industry in their home country, that is also fine), and show them their career paths so that they will be interested in working in the manufacturing industry (aiming for 4IR). At the same time, show that even manufacturing companies that are not currently applying advanced technologies can be transformed into internationally competitive companies in the future if these students can find employment and lead the bold introduction of 4IR-related technologies. As for lecturers, those who have been in charge of manufacturing sites and its technology in Japanese manufacturing companies and are now executives of the companies are considered to be suitable. With the approval of the lecturer, the lecture will be recorded, translated into each language in ASEAN (with subtitles), and made available to the public.
Timing, etc.	Start immediately. Continue if necessary while monitoring results.
Remote implementation	Can be conducted remotely (online seminars, etc.).

7.3.5 Capacity Development Programs for Educational Institutions

Of the cooperation programs for educational institutions, the number of those not assuming cooperation with industrial circles is not many in the field of 4IR. One program listed below is designed to facilitate cooperation between educational institutions and another is designed to address an issue which may not be fully dealt with by industrial circles.

[C28] Development of a re-training program for workers following smartification

Angles	Educational institutions; Fostering of industrial human resources; ASEAN
Target countries	All emerging countries intending the promotion of 4IR
Form of cooperation	Support for the development of a curriculum and ToT
Necessity for cooperation	The progress of the digitalization and smartification of production sites as a response to 4IR will definitely produce workers who must leave long-held jobs. It will be necessary to retrain these workers on new vocational skills required in the age of 4IR so that a situation of mass redundancy, etc. due to the introduction of digitalization can be prevented.
Contents of cooperation	The occupational functions that are expected to be lost due to the digitization and smartification of industry and the newly required occupational functions should be studied, predicted and listed for the development of worker retraining programs corresponding to the newly required functions. These programs should then be implemented by the TVET or institutions for adult education.
Timing, etc.	Commencement when the response to 4IR has been disseminated to a certain extent.
Remote implementation	Can be conducted remotely (online meetings, etc.).

[C29] Travelling Japan-ASEAN summer camp on advanced technologies

Angles	Educational institutions; Strengthening of productivity and international competitiveness; ASEAN; SEED-Net; Promote cooperation within the region
Target countries	ASEAN and Japan
Form of cooperation	Foreign youth invitation program and Japanese youth dispatch program
Necessity for cooperation	Young students are quicker than older people to learn the most advanced technologies, such as IoT and AI, required for 4IR. The intentions of students and the manner of research work differ from one country to another even though the research subjects are the same most advanced technologies. Opinion exchange and interchanges on research contents among students of multiple nationalities are, therefore, believed to have a positive impact on the creation of new ideas and innovation in research work.
Contents of cooperation	A summer camp should be organized on a round-robin basis at a university of an ASEAN country or Japan to which university teachers and representatives of students of other countries should be invited to present the contents of research on the most advanced technologies in their own countries. Universities with past experience of interchange through SEED-Net should play a central role. At this camp, workshops should be held on common themes set for each camp and the results presented on the final day. The scale of participation should be approximately one university (one teacher plus one or two students) from one country each year so that the total number of participants is several tens at the most for Japan and ASEAN countries combined.
Timing, etc.	Commencement as soon as the agreement of the participating universities is secured. The duration of the camp should be approximately one week each time. The continuation of this summer camp for a number of years is necessary to allow each participating country to host the camp at least once.
Remote implementation	It is desirable to implement the workshop face-to-face.

7.3.6 Cooperation Program Plans by Target Country of the Survey

The cooperation programs conforming to the situation of the government, industrial circles and educational institutions of the specific target countries of the survey are described in this section.

(1) Indonesia

Table-50 Hackathon on manufacturing SCM solutions with the application of new technology

Cooperation area	Promotion of manufacturing smartification (productivity improvement; strengthening of international competitiveness)
Cooperation period	Five + one days
Target persons	Persons in charge of production management of local and Japanese SMEs which form the supply chain of each Japanese automobile manufacturer in Indonesia
Venue	Meeting room of Japanese partner automobile manufacturer or laboratory of a local engineering vocational school, training facility of PIDI 4.0, etc.
Support from external source	・ Engineer of a partner company (lecturer-cum-facilitator) ・ Local/Japanese solution provider for IoT (provision of laboratory equipment)
Partner organizations	・ Japanese automobile manufacturers operating in Indonesia ・ Indonesian Automotive Parts & Components Industries Association (GIAMM)
Challenges and needs of Japanese partner companies	・ The main issues of local suppliers are “non-delivery” and “defects”. ・ It is difficult to share real-time information among suppliers and their response tends to be slow. ・ It is necessary to avoid a long downtime of the production line by conducting equipment maintenance and “preventing” human” mistakes.
Aimed outcomes	・ (Simple) information sharing among suppliers by IoT regarding the state of production ・ Sharing of real-time production progress (output performance) and operation status of the production line of suppliers ・ Verification of the shared SCM system based on the accumulation and analysis of data automatically obtained from multiple companies
Activity contents/ process	1. Identification of the current challenges and issues of the supply chain by means of conducting a pre-event questionnaire with the participants. The challenges faced by automobile manufacturers who are the partner companies should also be identified. 2. All of the participants should sort out the identified challenges together, followed by discussions from multiple angles, such as cause (location, behavior or within/outside the company) and attributes (human or machine) using a cause and effect diagram used for KAIZEN.
	3. The brainstorming of ideas whereby issues may be solved by the application of new technologies should be conducted and teams among the participants should be voluntarily formed based on their solution ideas. 4. Actual development of a system prototype to solve issues with IoT. 5. Each team should give a presentation attended by government organizations, industrial organizations, the media, etc., followed by exchanges on the presentation. 6. The team members should take back the outcomes to their own companies after completion of the hackathon and conduct a verification experiment at the production site. 7. A reunion should be held 3 – 6 months later to present/share the outcomes and lessons learned from the verification experiment.
Schedule	Day 1: Summarization and discussion of pre-identified challenges Day 2: Sharing of ideas to solve the problems and formation of teams Day 3/4: Development of an IoT system prototype for the solving of problems Day 5: Presentation and evaluation of the outcomes by each team Day 6 (3 – 6 months later): Presentation/sharing of the outcomes of the verification experiment and lessons learned (follow-up session)

Cost burden	Fees required for media PR to disseminate the contents, objectives and outcomes of the hackathon
Monitoring/ evaluation method	・ Questionnaire on the challenges and problems of the supply chain (in advance) ・ Evaluation questionnaire on the implementation method and contents of the hackathon (immediately after the event) ・ Evaluation questionnaire with the invitees to the hackathon at the time of presenting the outcomes ・ Evaluation of the cost performance of the verification experiment at the time of the follow-up session
Securing of public nature	Publication of the issues and ideas discussed at the hackathon and outcomes via the government of the partner country
Follow-up JICA support	・ Widening of the scope of the hackathon beyond the automobile industry to those industries which have a supply chain of manufactured parts (electrical/electronic products) ・ Dispatch of an advisor, etc. to provide technical advice for the government of a partner country so that the government concerned can play a leading role to organize a similar hackathon event.

The concept of this program is shown in Figure-43.

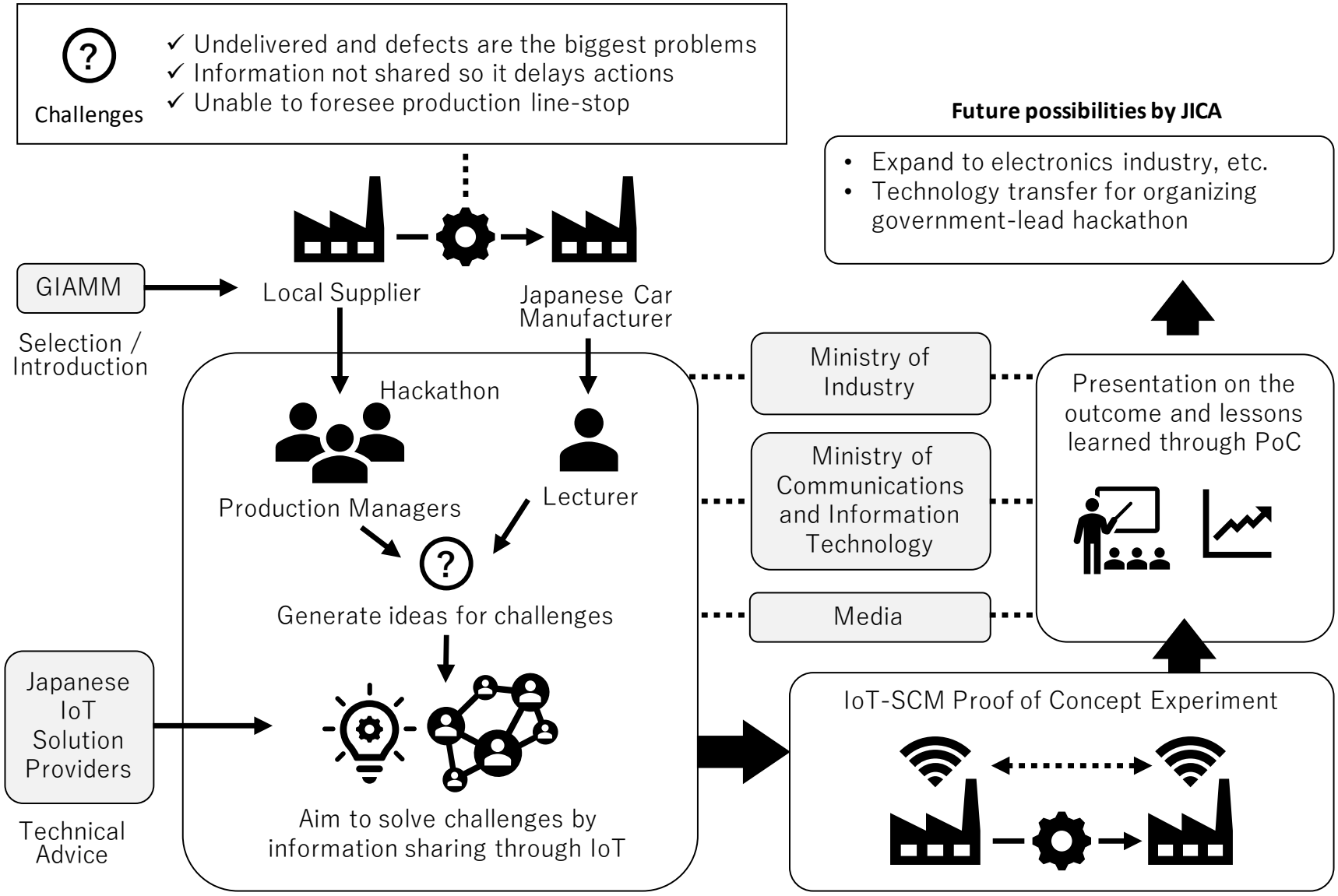


Figure-43 Conceptual diagram of hackathon on manufacturing SCM solutions with application of new technology

Table-51 Cross-industrial matching event with manufacturing industry by open innovation

Cooperation area	Policy assistance/framework building (strengthening of linkage between local and Japanese companies; promotion of investment)
Implementation Period	4 days (December 4 to 7, 2019)
Target organizations	・ Japanese manufacturing companies operating in Indonesia (targeted industries only), especially in peripheral/supporting industries) ・ Local venture/start-up enterprises for new technologies ・ Local ICT-related solution providers ・ Local investment-related companies (banks and venture capital, etc.)
Partner institutions	・ Department of the Indonesian Ministry of Industry in charge of "Making Indonesia 4.0" ・ Department of the Indonesian Ministry of Communication and Information Technology in charge of "Making Indonesia 4.0" ・ JETRO ・ Indonesian Automotive Parts & Components Industries Association
Venue	Jakarta: 31st "Manufacturing Indonesia" Exposition
Support from external resources	Employees in charge of new technologies at Japanese manufacturing companies (assistance for the preparation of the presentation contents, etc.)
Challenges and needs of Japanese partner company	・ Would like to find ideas to advance productivity through the use of new technologies ・ Would like to find local companies which could be partners
Aimed outcomes	・ Japanese manufacturing companies are able to find collaboration partners in Indonesia for the application of new technologies. ・ Opportunity for local ventures and solution providers for new technologies to learn about the needs of Japanese manufacturers.
Activity contents/ process	1. Establishment of a JICA booth and qualification for presentation at "Manufacturing Indonesia", the largest manufacturing Expo in Indonesia. 2. Notification of the booth, presentations to the above-mentioned local target companies/government in advance to invite them 3. Firstly, the advantages of Japanese manufacturing companies are emphasized compared to other developed countries and examples of introducing new technologies in Japan are given. The specific challenges and needs identified in a survey with Japanese companies in Indonesia are summarized and presented and the required solutions are clarified. Some time is used for the free sharing of the opinions of invited companies and cross-industry participants. 4. The same presentation materials are distributed at the booth and support for matching between Japanese manufacturing companies, local solution providers, venture enterprises, investment companies, etc. interested in new technologies is provided.
Schedule	・ The needs and preferences of Japanese manufacturing companies regarding the introduction of new technologies are identified during the field research and a list of companies which agree to an open call for solution ideas at the Expo is prepared. ・ A reference material describing the specific needs of agreed companies is announced at the time of presentation in the Expo.
Cost burden	Expo participation fees
Monitoring/ evaluation method	・ List of companies coming to the booth to seek specific advice ・ In the case of those companies which actually found a matching partner(s), conduct a follow-up interview survey within three months.
Securing of public nature	Attention should be paid to avoiding any bias towards a specific company at the preparatory and implementation stages of the even
Follow-up JICA support	・ Making the event a regular annual event ・ Expansion of the event to other ASEAN countries

(2) Malaysia

Table-52 Third country training: "Approach, Theory and Practice of Industry 4.0 in Malaysia"

Cooperation area	Policy assistance/framework building
Country	Malaysia with the participation of four other countries
Implementation period	Approximately one week (around January, 2020)
Target persons	One person each from the organization to implement 4IR.0 and an industry body in each of the five target countries
Partner institutions	・ Malaysia-Japan International Institute of Technology ・ Japan-Malaysia Cooperation Platform (Embassy of Japan; JETRO) ・ Japanese Chamber of Commerce and Industry, Malaysia; MITI; SIRIM; MIDA ・ Japanese universities cooperating with the MJIIT (consortium of 27 universities) ・ German Malaysian Institute (GMI)
Venues	MJIT; GMI; factories of Japanese companies
Support from external sources	・ MJIT; consortium of Japanese universities cooperating with the MJIT; GMI ・ Japanese companies on the Japan-Malaysia cooperation platform
Challenges and needs of Japanese partner companies	・ Would like to extend the solutions of Japanese companies to local companies in the five target countries (ASEAN). ・ Would like to raise the awareness of local companies in the five target countries (ASEAN) of smartification.
Aimed outcomes	・ The participants from the four target countries other than Malaysia learn about the approach of the Malaysian government to facilitate 4IR.0 and prepare their own 4IR.0 facilitation plan (action plan). ・ The target persons deepen their understanding of the concept of Japanese-style Industry 4.0 through 4IR.0-related lectures offered by the MJIT and lectures at the GMI. ・ In cooperation with the MJIT which has been disseminating Japanese-style engineering education, convey the idea of Japanese-style industry 4.0 to the participants of the five target countries.
Activity contents/ process	1. Selection of the target organizations for participation based on the results of the field research 2. At the same time, request for cooperation to these organizations for cooperation with the field research, prepare the curriculum and decide on the division of work. 3. Preparation for implementation (development of teaching aids and arrangement of logistics) 4. Implementation
Schedule	Day 1: Learning of the relevant efforts of the Malaysian government and related organizations (various subsidy systems, reporting of the readiness assessment findings, SIer assessment, industry-academia cooperation, etc.) Day 2: Lectures on KAIZEN and introduction of IoT, etc. (both the MJIT and University of Technology, Malaysia (UTM), the parental body for the MJIT, have a 4IR.0 course) Day 3: Study at the GMI (German-style 4IR.0; lectures using equipment, etc. not owned by the MJIT) Day 4: Study visits to actual companies (a request for cooperation is made to Panasonic, etc.) Day 5: Preparation of action plans (the implementation organization and industry body acting as a pair prepares plans on: educational activities targeting SMEs; introducing incentives, such as a subsidy, etc., in one's own country)
Cost burden	Use fee payable to the MJIT; travelling cost of the participants; daily allowances; accommodation expenses; gratuities for lecturers from the UTM and GMI
Monitoring/ evaluation method	・ Questionnaire with the participants ・ Confirmation of the progress of the action plans during the study visit to Japan
Securing of public nature	The public nature of the training is secured by treating the participating Japanese companies as cooperation based on the Japan-Malaysia Cooperation Platform rather than them acting as independent companies.
Follow-up JICA Support	・ 3rd country training as an ASEAN-wide project in collaboration with theme-specific training ・ Wide-area project aimed at the dissemination of Japanese-style engineering education and Japanese-style Industry 4.0 based on the MJIT

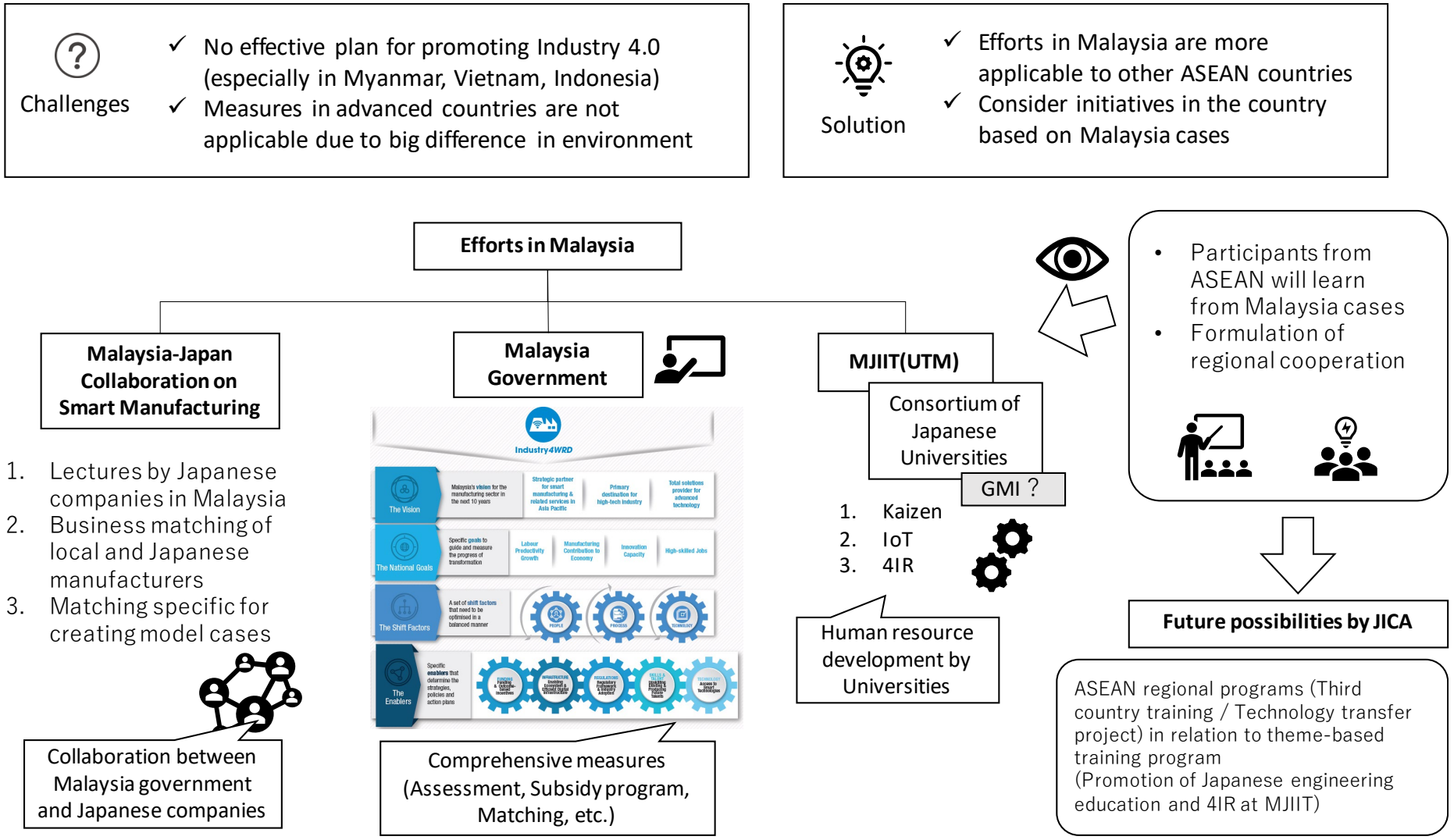


Figure-44 Conceptual diagram of the third country training titled as "Approach, Theory and Practice of Industry 4.0 in Malaysia:"

(3) Thailand

Table-53 Building of a private IoT promotion framework in accordance with the Eastern Economic Corridor (EEC) development plan

Cooperation area	Policy assistance/framework building
Country	Thailand
Implementation period	Approximately five months
Target organizations	・ Japanese manufacturing companies located within the Eastern Economic Corridor ・ IoT companies (local/Japanese) located within the Eastern Economic Corridor ・ EEC office
Partner institutions	・ EEC office ・ Department of the Thailand Ministry of Industry in charge of "Thailand 4.0" ・ Japanese Chamber of Commerce in Thailand
Venue	Meeting room at an industrial park in the industrial district in eastern Thailand
Support from external sources	Preparations for the meeting will be voluntarily conducted by the participating companies.
Challenges and needs of Japanese partner companies	・ Would like ideas on how to introduce IoT while existing manufacturing equipment is currently aging. ・ Would like to promote manufacturing automation by IoT, etc. compatible with the future course of the labor market in Thailand. ・ Would like to have an information sharing network for the introduction and utilization of IoT, including smart logistics which will grow in the future.
Aimed outcome	Establishment of an IoT promotion framework (association) approved by the EEC office within the EEC
Activity contents/process	1. Detailed survey on the above needs of Japanese manufacturing companies within the EEC as part of the field research 2. Creation of a list of local IoT providers, etc. 3. Visit to the Thailand Ministry of Industry and EEC office to explain the above need and Japan's uniqueness in the advancement of the manufacturing industry and to obtain consent for the establishment of a private IoT promotion association 4. Discussion of the proposed establishment and activity contents of the association with the target companies. This association will not be simply an industrial body and its main activities will be clearly stated and include the actual creation of an information sharing mechanism using ICT-related new technologies, such as IoT and AI, etc. (database which automatically extracts and sends information related to member companies, sharing of technical information online, etc.), human resources development activities related to new technologies and convening of a hackathon on the introduction of IoT. Ensuring of consistency with JICA's future cooperation policy and functioning of the association as a local cooperation organization for JICA projects in the future 5. Announcement of the news of establishment of the association to the media by also inviting officials in charge at the Ministry of Industry and EEC office.
Schedule	・ Around one month: implementation of a survey on the needs within the EEC and IoT providers, etc. ・ Around three months: obtaining of the consent of the Ministry of Industry and EEC office; holding of meetings in preparation for the establishment of the association with companies hoping to join ・ Around six months: establishment of the association; commencement of concrete activities ・ After starting activities for six months: evaluation of the progress of the activities
Cost burden	Sharing of the cost for the inauguration ceremony
Monitoring/evaluation method	・ JICA, JDS and Abeam will participate as observers at the time of establishment ・ Monthly activity report as well as participation in online information sharing ・ Online meetings on the activity contents as required
Securing of public nature	・ Concrete activities will be left to autonomous decision-making by the participating companies while JICA confines itself to providing support for the creation of the relevant framework and system.
Follow-up JICA support	Strengthening of the function of the association as a local support organization for 4IR-related JICA projects in the future

(4) Common Plans for Thailand and Malaysia (Countries Whose Advancement Efforts Are Relatively Ahead)

As shown in the Figure-26, based on the results of the interviews conducted during the first field survey with local government organizations and private sector manufacturing enterprises, the ideas held by local SMEs about 4IR can be classified into three kinds, suggesting skepticism or indifference towards their own transition to 4IR.

In general, those in charge of implementing and sustaining major transformation must conquer several obstacles. This concept is called "change management"[229] widely recognized in the IT system industry. The intended transformation is successfully achieved by not only the introduction of a system but the implementation of measures to change the awareness of the very people in charge. Table 54 shows the application of this concept of change management to the introduction of 4IR.

Table-54 Change Management Related to Introduction of 4IR

Stage	Title	Outline
1	Recognize	Recognize the purpose and necessity of 4IR (recognition of the necessity for and checking of the return on investment)
2	Understand	Understand one's self-image after the introduction of 4IR and identify clear targets (achievement of increased production through improved productivity, secured employment, etc.)
3	Learn	Learn how to use digital tools and data analysis method
4	Sustain	Sustain 4IR through continuous use

When the mind is too greatly occupied with digital tools, focusing on Stage 3 (Learn) to the extent that Stage 3 becomes the starting point may occur. In such a case, there is a strong possibility that the commitment to achieving the targets is rather weak, resulting in the breaking down of a project because of a minor failure.

As the findings of the Study show, while both countries have a range of menus, including assessment, financial support, the matching of SIers and consultants, etc., many SMEs are still unable to pass Stage 1. This is presumably because the existing system design is not conscious of change management and consists of individual menu items, presenting a so-called state of specific optimization (Figure-45).

[229] EAM Research Workshop: "Ho-nual Business Guide Book", 2009

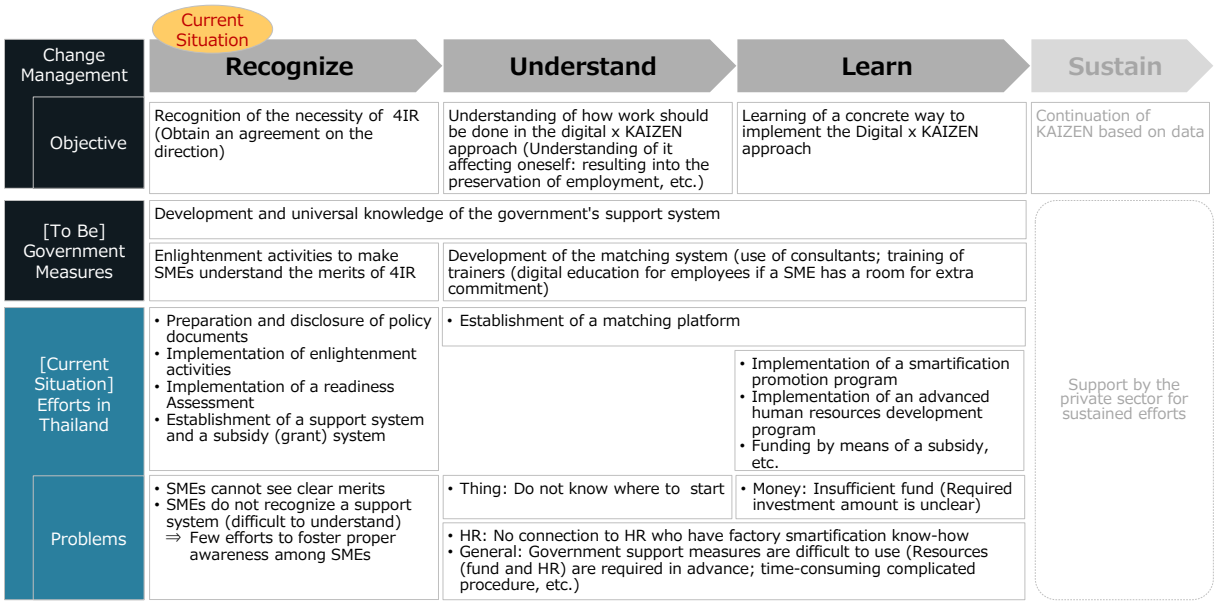


Figure-45 Efforts of two countries compiled on the change management framework and problems

One viable way to solve this problem is believed to be the existence of a one-stop type organization which provides various assistance required for SMEs to recognize the necessity for 4IR and move forward on their own in accordance with the stages of change management. In those fields, such as digital technologies, where the updating of information is constantly required, the quality of an organization is secured by standardizing the management mechanism, including the evaluation of external resources, as an in-house mechanism while preventing the functional deterioration of such information by utilizing external resources instead of making the organization itself the sole source of information. It is believed possible to support the expansion of the said one-stop service functions by means of combining the necessary functions with the draft plans described in 7.3 (Figure-46).

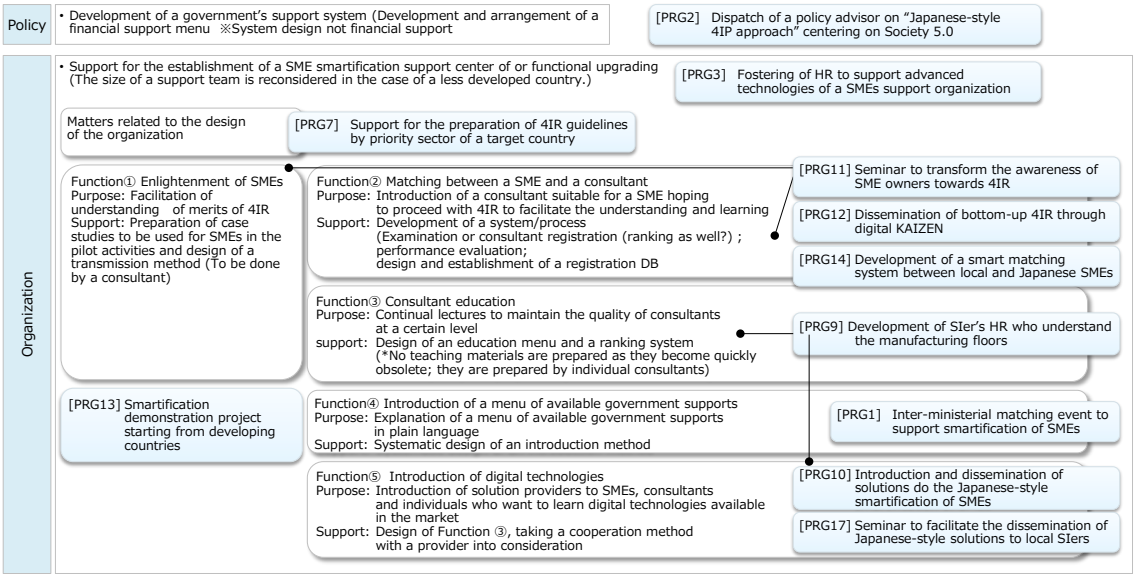


Figure-46 Tentative support menu

As 4IR in these countries aims at improving productivity through the use of technologies, what can be assumed is the provision of support for those efforts designed to improve productivity in a relatively short time by incorporating suitable digital technologies in conventional guidance on KAIZEN.

In such a case, the target organization for such support may be a government organization tasked to assist the productivity improvement of SMEs in each country. The Thailand Productivity Institute (FIPI) and the Malaysia Productivity Corporation (MRC) are such organizations. Both are recognized as the main KAIZEN dissemination organizations in these two countries in JICA's "KAIZEN Handbook" (June, 2018). It is assumed that high levels of efficiency and the sustainability of support can be achieved using the approach of expanding functions through the use of existing assets. Malaysia in particular is a country to accept third country KAIZEN training and a spin-off benefit of spreading the idea of Digital x KAIZEN to third countries can be expected after the completion of a project.

Table-55 Organizations Promoting 4IR and KAIZEN in Thailand and Malaysia

	Thailand	Malaysia
Target Policy (Aim)	・ Thailand 4.0/SME 4.0 (Productivity improvement using technologies)	・ Industry 4WRD (Productivity improvement using technologies)
Target Organizations	・ Thailand Productivity Institute (FTPI) ・ A project to enhance its management system was implemented in the 1990s. (KAIZEN dissemination organization)	・ Malaysia Productivity Corporation (MPC) ・ The MPC is a body which accepts third country training on KAIZEN. (KAIZEN dissemination organization)

WORLDWIDE

DATA COLLECTION SURVEY ON UPGRADING MANUFACTURING INDUSTRY USING THE LATEST TECHNOLOGY

List of digital / innovation-related subsidies for manufacturing SMEs by Thai government agencies

JANUARY, 2022

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

JAPAN DEVELOPMENT SERVICE CO., LTD. (JDS)

ABEAM CONSULTING LTD.

1. Background and Objectives of This Report

In Thailand, several government agencies have established subsidy schemes to support the advancement, digitization, and innovation of small and medium-sized manufacturing enterprises (SMEs). As for the factory smartification experiment project (hereinafter referred to as the "PoC") conducted in Thailand as one of the pilot programs carried out in this JICA project, the information on these schemes collected in the first field survey was referred to in order to design the PoC to be financially appropriate for local SMEs. The purpose of this report is to summarize those subsidy systems that can be utilized by local SMEs and to show that the budget scale of the PoC in Thailand was appropriate.

2. Scope of the Survey

In this survey, the subsidy schemes of the Department of Industrial Promotion (DIP), Digital Economy Promotion Agency (DEPA), National Innovation Agency (NIA), and National Science and Technology Development Agency (NSTDA), which were the interviewees in this JICA project, were examined. In addition, the subsidy schemes of each ministry which these institutions belong to were surveyed. As a result, it was found that the Office of the national Digital Economy and Society Commission (ONDE) also has a related scheme. The table below lists the names and roles of the surveyed ministries and agencies.

Table-1 Names and roles of the targeted government agencies for this survey

Ministry	Organization	Role
Ministry of Industry (MoI)	Department of Industrial Promotion (DIP)	To promote various industries of Thailand by supporting, governing, protecting, and regulating them and conducting research
Ministry of Digital Economy and Society (MDES)	Digital Economy Promotion Agency (DEPA)	To promote the digital economy and society by supporting and promoting the development of digital industry and innovation and adopting the digital technology that benefits national economy, society, and culture
	Office of the national Digital Economy and Society Commission (ONDE)	To improve the standard of living and the abilities of Thai citizens to be able to compete in the global world by driving the digital economy and society with supporting development of national policies in those areas
Ministry of Higher Education, Science, Research and Innovation (MHESI)	National Science and Technology Development Agency (NSTDA)	To contribute to national economic and social development by accelerating science, technology, and innovation development to respond to the need of the industry and enhance the country's competitiveness in the global economy
	National Innovation Agency (NIA)	to support and promote the development and enhancement of Thailand's innovation system in order for Thai citizens to improve the quality of life and compete in an increasing competitive global economy

3. Survey Results

Tables 2-4 below summarize the outline of the subsidy schemes provided by MoI, MDES, and MHESI for supporting the advancement and digitization of SMEs.

Table-2 Subsidy schemes offered by Ministry of Industry (MoI)

Name	Outline	Type	Limit of Subsidy	Application requirements	Scope of subsidy	Date	Remarks
Department of Industrial Promotion (DIP)							
Loans to revitalize SMEs[1]	To help improve investment, working capital, liquidity in business operations, rehabilitating the current business or starting a new business	Loan	-Up to 3 million Baht / company -Interest rate of 2% per year[2] -When combined with the outstanding debt of the SME Development Fund loan must not exceed the original approved credit limit	1. For SMEs with SDF debt, remaining long-term credit lines with the fund 2. SDF's past loan obligations have not become non-performing loans and have been properly repaid, and are not in dispute with the fund 3. Not receiving a loan from another grant designated by the fund	-Can use for any purpose -SME loanable to SDF	until 31 May 2022 or the total loan amount, 500 million baht is all given out	
			-Starting from 100,000 Baht but not exceeding 2 million Baht / company -Interest rate of 2% per year -Loan term of up to 7 years	1.Corporations with more than 51% of Thai shareholders 2.SMEs manufacturing products or providing services with no more than 200 employees or a fixed asset value excluding land not more than 200 million Baht 3.Business of retail or wholesale trade with no more than 50 employees or a fixed asset value excluding land not more than 100 million baht 4.Companies in the industries listed in the right column 5. There are no non-performing loans or disputed cases at the time of application 6. There are no outstanding debts to financial institutions at the time of application, and they have been properly repaid 7. Not receiving a loan from another grant designated by the fund	-Can use for any purpose -Considering the necessity and ability of the borrower to repay the debt -Industry included: Tourism industry, Agro-Industry and Food Processing industry, Fashion industry, Automotive and parts industry, Electrical and Electronic Industry, Plastics Industry, Construction Industry, Logistics Industry, Others allowed by MoI	until 31 May 2022 or the total loan amount, 500 million baht is all given out	

[1] https://thaismefund.com/loan/package500turn/
https://thaismefund.com/loan/package500/
https://thaismefund.com/loan/package1000/
https://www.prachachat.net/economy/news-775535

[2] Most of the general loans from banks, etc., have a minimum annual rate of 5% and a loan period of up to 5 years.

			-Up to 15 million Baht / company -Interest rate of 2% per year -Loan term of up to 10 years	1.Corporations with more than 51% of Thai shareholders 2.SMEs manufacturing products or providing services with no more than 200 employees or a fixed asset value excluding land not more than 200 million Baht 3.Business of retail or wholesale trade with no more than 50 employees or a fixed asset value excluding land not more than 100 million baht 4.Companies in the industries listed in the right column 5. There are no non-performing loans or disputed cases at the time of application 6. There are no outstanding debts to financial institutions at the time of application, and they have been properly repaid 7. Not receiving a loan from another grant designated by the fund	-Can use for any purpose -Considering the necessity and ability of the borrower to repay the debt -Industry included: Agro-Industry and Food Processing industry that use biotechnology, Renewable energy industry including solar energy or biomass energy, Medical equipment industry, medical service, modern medicine, and herbal medicine, manufacturers/users of robotics or automation technology, Electric vehicle industry including parts or equipment used to assemble an electric vehicle.	until 31 May 2022 or the total loan amount, 500 million baht is all given out	
	To enable SMEs across the country to access funding sources to improve production efficiency with help from system integrator (SI) specialists and experts from the Center of Robotic Excellence in Thailand (CoRE) to monitor, analyze the production process, and give advice on suitable technology for the factory	Loan / Tax incentive	-Up to 15 million Baht -Interest rate of 1% per year -No announcement for the loan term so far -Companies could ask for 3 years tax exempt	Filtered by the Provincial Industry Office (criteria not provided)	SMEs related with IT, Automation, Robotics, and innovation	No announcement	The plan was announced in Oct 2021 but not mentioned the details yet

DIPROM Pay[3]	Guidelines and measures to help and rehabilitate entrepreneurs affected by the Covid-19 pandemic	Loan	-The maximum amount is no more than 5 million Baht / project. -Fixed short-term step up interest rates starting at 3% per annum.	SMEs who have registered with DIPROM during the fiscal year 2021-2022	-Can use for any purpose -Loan repayment period must be under 3 years	until 30 Apr 2021	

Table-3 Subsidy schemes offered by Ministry of Digital Economy and Society (MDES)

Name	Outline	Type	Limit of Subsidy	Application requirements	Scope of subsidy	Date	Remarks
Digital Economy Promotion Agency (DEPA)							
Digital Manpower Fund[4]	To develop and support manpower with the industrial and digital innovation capabilities from basic usage levels to expert level	Grant	-Up to 100,000 Baht/person depending on skill level and no more than 5 people per company -Skill level is classified into 4 -Digital Literacy up to 5,000 Baht / person -Digital Professional up to 10,000 Baht / person -Digital Specialist up to 15,000 Baht / person -High Demand Skill up to 100,000 Baht / person	1.Any government agency or private company, students, employees of any company, or unemployed. 2.Thai corporations with more than 51% of Thai shareholders, but if not, will have to be determine by case 3.Must not be supported by other agencies in the same category 4.Must be registered with DEPA and provide all necessary documents to DEPA 5.Private companies must have clear project objective, structure, and plan 6.Must not be bankrupt or under any criminal cases that might hinder the project progress	For the development of human resources regarding technological capabilities including payment for certification, training courses, webinar on digital innovation capabilities	On-Going since 2017	

[3] https://www.bangkokbiznews.com/business/978758

[4] https://www.depa.or.th/th/digital-manpower

Digital Manpower for Executive[5]	To develop and support manpower with the industrial and digital innovation capabilities at the executive level	Grant	Up to 300,000 Baht/executive and no more than 3 executive per company	1.Any government agency or private company, students, employees of any company, or unemployed. 2.Thai corporations with more than 51% of Thai shareholders, but if not, will have to be determined by case 3.Must not be supported by other agencies in the same category 4.Must be registered with DEPA and provide all necessary documents to DEPA 5.Private companies must have clear project objective, structure, and plan 6.Must not be bankrupt or under any criminal cases that might hinder the project progress	For the development of human resources regarding technological capabilities at the executive level including payment for certification, training courses, webinar on digital innovation capabilities	On-Going since 2017	
Digital Transformation Fund[6]	To support the study of industrial development and digital innovation guidelines that focus on the application of technology and digital innovation. Digital Transformation includes: 1.Artificial Intelligence 2.Machine Learning 3.Intelligent Applications 4.Internet of Things: IoT 5.Virtual Reality 6.Digital Twin 7.Block Chain 8.Conversational System 9.Digital Platform 10.Mesh Applications and Service Architecture; MASA 11.Adaptive Security	Grant	Up to 1 million baht / project (up to 60% of the project cost)	1.Any government agency or private company that provide product or services within the 11 technology categories listed in the left column. 2.Must be registered with DEPA and provide all necessary documents to DEPA 3.Should be Thai corporations with more than 51% of Thai shareholders. If not, will have to be determined by case 4.Must not be supported by other agencies in the same category 5.Private companies and SMEs must have clear project objective, structure, and plan 6.Must not be bankrupt or under any criminal cases that might hinder the project progress	-Patent: up to 100,000 baht -Copyrights: up to 100,000 baht -ISO/IEC29110: up to 70,000 baht (70% proportion) -Cost of equipment and machinery related to or necessary in the application of digital technology and innovation (no more than 50 % of the cost of that particular item) - Digital Technology and Innovation Licensing Fees -Other expenses such as rent for using software or computer programs, test analysis fee etc.	On-Going since 2018	

[5] https://www.depa.or.th/th/digital-manpower

[6] https://www.depa.or.th/th/transformation

Digital Transformation Fund for Community[7]	To support the study of industrial development and digital innovation guidelines that focus on the application of technology and digital innovation at the community level. Digital Transformation includes: 1.Artificial Intelligence 2.Machine Learning 3.Intelligent Applications 4.Internet of Things: IoT 5.Virtual Reality 6.Digital Twin 7.Block Chain 8.Conversational System 9.Digital Platform 10.Mesh Applications and Service Architecture; MASA 11.Adaptive Security	Grant	Divided into 2 phases: -Conceptual plan: up to 50,000 Baht / plan -Digital Transformation: up to 500,000 Baht / project	1.Any government agency, private company, community enterprise, and juristic person or group at the community level established under a specific law or statute. 2.Must be registered with DEPA and provide all necessary documents to DEPA 3.Should be Thai corporations with more than 51% of Thai shareholders. If not, will have to be determined by case 4.Must not be supported by other agencies in the same category 5.Private companies and SMEs must have clear project objective, structure, and plan 6.Must not be bankrupt or under any criminal cases that might hinder the project progress	-Patent: up to 100,000 baht -Copyrights: up to 100,000 baht -ISO/IEC29110: up to 70,000 baht (70% proportion) -Cost of equipment and machinery related to or necessary in the application of digital technology and innovation (no more than 50 % of the cost of that particular item) - Digital Technology and Innovation Licensing Fees -Other expenses such as rent for using software or computer programs, test analysis fee etc.	On-Going since 2020	
SME Digital Coupon[8]	To support SMEs to operate their business with a better plan, lower cost, and more efficiency through the technology	Grant	Up to 10,000 baht / project	1.Must be registered with DEPA and provide all necessary documents to DEPA 2.SMEs which means revenue does not exceed 500 million baht for the manufacturing sector and 300 million baht for the service and trade sectors	-Software Cost -Hardware such as smart devices cost (up to 50%) -System Licensing cost for at least 6 months	Last round was in 2021 but will announce this coupon again in 2022	
Office of the national Digital Economy and Society Commission (ONDE)							
Digital Economy and Society Development Fund[9]	To promote and support government agencies, private companies, or the general public in the implementation of digital development for the economy, society, and public services	Grant	This year total fund is 2.5 billion Baht for the overall the program and the amount per project will be approved individually	1.Government Agencies, Private companies, Normal Thai Citizens 2.Must not be bankrupt or under any criminal cases that might hinder the project progress 3.Is not a part of the fund committee	-Digital Manpower -Digital Health -Digital Agriculture -Digital Technology	On-Going since 2017	

[7] https://www.depa.or.th/th/digitalservice/digital-transformation-Fund-for-community/promotion-tools

[8] https://www.depa.or.th/th/smedigitalcoupon

[9] https://defund.onde.go.th/th/page/item/index/id/9

Table-4 Subsidy schemes offered by Ministry of Higher Education, Science, Research and Innovation (MHESI)

Name	Outline	Type	Limit of Subsidy	Application requirements	Scope of subsidy	Date	Remarks
National Science and Technology Development Agency (NSTDA)							
iTAP (Industry Innovation and Technology Assistance Project)[10]	It supports SMEs which want to introduce technology and innovation with three ways below. 1.providing technical consultancy services to design the project 2.introducing appropriate experts to manage the project 3.and provide financial assistance of the project costs	Grant	Up to 400,000 baht / project (up to 50% of project cost)	1. Corporations with more than 51% of Thai shareholders 2. SMEs which means revenue does not exceed 500 million baht for the manufacturing sector and 300 million baht for the service and trade sectors 3. Those who commit to developing business potential with technology and innovation	- Targeted to the manufacturing sector and service and trade sectors - Project based activity	Last round was in 2021 and the next round will be announced later 2022	Preliminary consultancy service is also offered with free of charge
Startup Voucher[11]	Support for startups that are already selling products and services which utilize science and technology and innovation in the manufacturing process or service provision in the market and are expected to grow	Grant	Marketing fund at a rate of 75% of the project (not more than 800,000 baht /project)	1.A juristic person registered to establish a business under Thai law Between 1 January 2013 to 31 December 2017 and with more than 51% of Thai shareholders 2.Product or service that uses science and technology and innovation in the production process or service and is already on the market to be sold. 3. Have a marketing activity plan, clear and feasible cost estimates, and income plans 4. Personnel of the team are ready to carry out activities 5. Have not received financial support for 2 consecutive years	Activities related to business development of products and services utilizing science and technology and innovation (market research, marketing both domestically and internationally, recruitment of technology and business specialists, technology development, content development, etc.)	starting from 1 May 2020 – 31 December 2020 (ended)	

[10] https://itap.nstda.or.th/th/

[11] https://www.nstda.or.th/home/news_post/startup-voucher-2020/

National Innovation Agency (NIA)							
Open Innovation[12]	To provide Financial support for SMEs in the manufacturing and service industries that develop innovative products and services which are scalable, high value-added, and have high growth potential.	Grant	Up to 1.5 million baht / project (divided into 3 times according to the progress of the project)	1.Corporations with more than 51% of Thai shareholders 2.Manufacturing companies with revenue less than 500 million baht and less than 200 employees 3. Trade and Service companies with revenue less than 300 million baht and less than 100 employees	Provision of each cost below -Material Cost 50% -Technological Cost 50% -Operation Cost 100% -Analytical Cost 100% -Consulting Fee 100%	On-Going (This year second round application: 1 Feb 2022 - 30 Apr 2022)	
Youth Startup Fund[13]	The following supports for young entrepreneurs 1.Support the creation of Innovation Driven Entrepreneur (IDE) and universities for entrepreneurs by reducing entrepreneurial risk by providing scholarships to students who aim to become entrepreneurs. 2. Promote the business success of funded entrepreneurs to generate income and create economic and social impact 3. Build partnerships between the fund, government agencies and the private sector to facilitate the integration and improvement of access to funds by young entrepreneurs	Grant	-Idea phase: 100,000 baht / project - PoC phase: 1.5 million baht / project	1. A Thai corporation 2.With a person within 5 years of college graduation who owns 30% or more of the shares	-Cost for business plan development -Fee for network services to develop entrepreneurs -Prototype development costs -Test analysis fee -Market testing cost -Consultant or expert wages	On-Going since 2020	

[12] https://open.nia.or.th/%E0%B8%82%E0%B9%89%E0%B8%AD%E0%B8%A1%E0%B8%B9%E0%B8%A5%E0%B9%82%E0%B8%84%E0%B8%A3%E0%B8%87%E0%B8%81%E0%B8%B2%E0%B8%A3

[13] http://www.tedfund.most.go.th/index.php/youth-startup-news/item/14-youth-startup-fund-2021

NIA Zero Interest Loan[14]	To support disseminating innovative products. In particular, support and promotion of SME establishment and growth by providing credit guarantees, joint investment, and financial support	Loan	Loan with 0% interest up to 5 million Baht for 3 years	1.Corporations with more than 51% of Thai shareholders 2.SMEs which means revenue does not exceed 500 million baht for the manufacturing sector and 300 million baht for the service and trade sectors 3.Companies aiming to develop potential businesses through innovation	-Innovative projects that extends from the prototype development or pilot projects to start leading to industrial production processes -Innovative projects developed from research results, inventions, patents, or existing technologies and has commercial potential -Innovative projects resulting from the expansion of strategic innovation projects. -Innovative projects with opportunities and market potential with clear business plans and investments	On-Going until 30 Sep 2022	

[14] https://www.kasikornbank.com/sme/good-innovation-zero-interest

Figure 1 summarizes the scope of above-mentioned subsidy systems based on the application requirements and the scope of support.

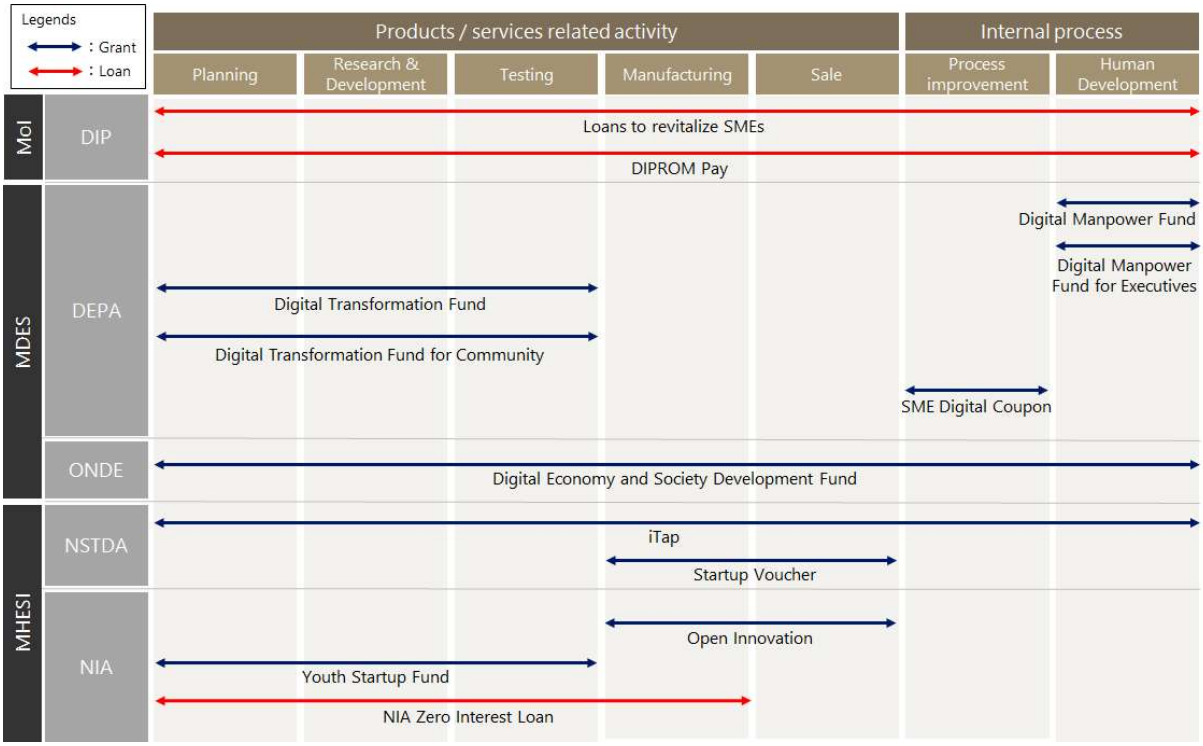


Figure-1 Scope of the subsidy systems

In figure 2, the maximum amount of each of the above-mentioned subsidy systems (excluding the loan system) and the amount of PoC implemented in this JICA project are plotted. Although the amount of PoC was set with reference to the amount of the subsidy schemes offered by the Thai government agencies, the former is slightly larger than the latter as shown in the figure. This is because it was taken into consideration when designing the PoC project that the budget for this PoC, which is a subcontracting work for the JICA project, should include the costs for creating regular reports to the study team and the completion report, so this point was .

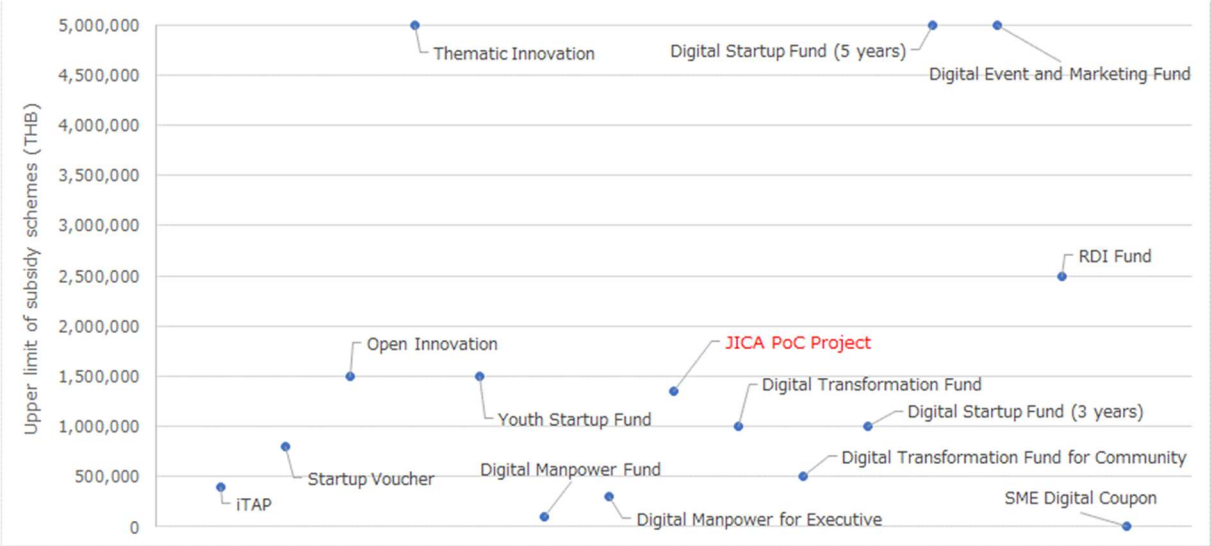


Figure-2 Comparison of Thai government subsidy schemes (grant) and the cost of the PoC

4. Referrence

While researching the subsidy schemes of the target organizations, some schemes to promote the development of solutions utilizing digital technologies were also found. In this regard, it can be seen that the Thai government is also focusing on the support of solution providers, and is preparing measures for the medium- to long-term advancement and digitalization of the manufacturing industry throughout the country. Table 5 below outlines these subsidy programs.

Table-5 Subsidy schemes for promoting digital solution development

Name	Outline	Type	Limit of Subsidy	Application requirements	Scope of subsidy	Date	Remarks
Digital Economy Promotion Agency (DEPA)							
Digital Startup Fund[15]	- Support for individuals or companies that have launched digital startups in the early stages of their business within three years of establishment - Support for digital start-up companies in the growth stage within 5 years after incorporation	Grant	-Up to 1 million baht for companies within 3 years of corporate registration -Up to 5 million baht for companies within 5 years of corporate registration	1. SMEs and general public / students with entrepreneurial plans 2.Must be registered with DEPA and provide all necessary documents to DEPA 3.Should be Thai corporations with more than 51% of Thai shareholders. If not, will have to be determined by case 4.Must not be supported by other agencies in the same category 5.Private companies and SMEs must have clear project objective, structure, and plan 6.Must not be bankrupt or under any criminal cases that might hinder the project progress	Can use for any purpose as long as having passed the elevator pitch round	Application Period was 22 Nov - 15 Dec 2021 (ended), but expected to be implemented in 2022	
RDI Fund[16]	To support the research and development for technology and digital transformation that is beneficial to Thailand	Grant	Up to 2.5 million baht / project (up to 50% of the project cost)	1.Must be registered with DEPA and provide all necessary documents to DEPA 2.Should be Thai corporations with more than 51% of Thai shareholders. If not, will have to be determined by case 3.Must not be supported by other agencies in the same category 4.Private companies and SMEs must have clear project objective, structure, and plan 5.Must not be bankrupt or under any criminal cases that might hinder the project progress	This year's concept is technology for the elderly (including support for the elderly) (machine learning, intelligent applications, IoT, big data processing, etc.)	On-Going This year first round will end on 31st May 2022	

[15] https://www.depa.or.th/th/digitalservice/digital-startup-fund/promotion-tools

[16] https://www.depa.or.th/th/article-view/rdi-income-elder-cyberawareness-quality

National Innovation Agency (NIA)							
Thematic Innovation[17]	To support companies that provide innovative solutions in the supporting industry (specific target industries change every year)	Grant	Up to 5 million baht / project (up to 75% of the project cost) (divided into 3 times according to the progress of the project)	1.Corporations with more than 51% of Thai shareholders 2.Its core technology is owned or licensed as the company's intellectual property 3.clear business model and plan that can be expanded by the project 4.Funds required for the project implementation can be prepared (because funding is after the implementation) 5. Being active in the industry for more than 3 years	-This year's targets are AI, robots, immersive technology, and IoT -Provision of each cost below -Material Cost 50% -Technological Cost 50% -Operation Cost 100% -Analytical Cost 100% -Consulting Fee 100%	Application ended on 31 Jan 2022	

[17] https://thematic.nia.or.th/