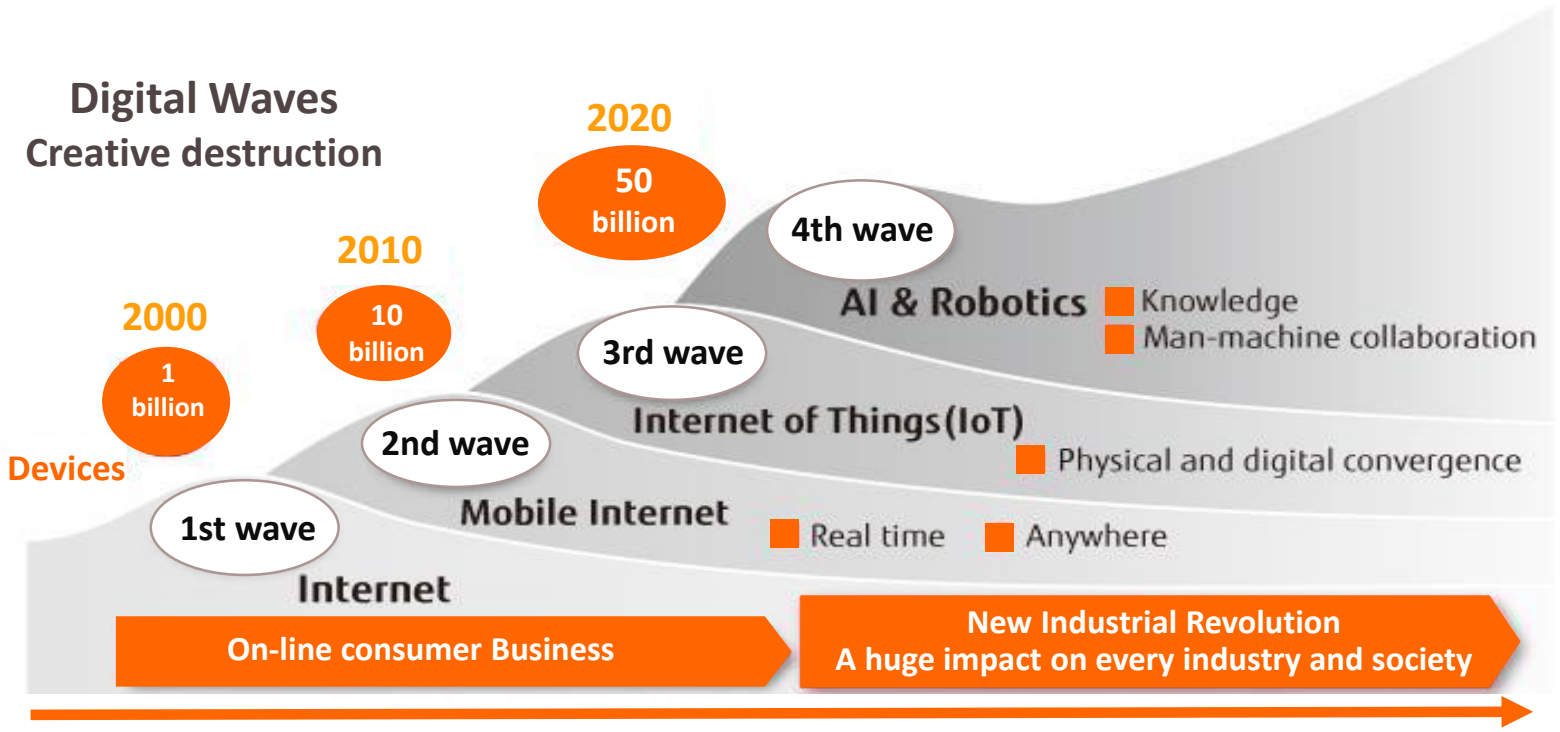

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October 2021
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01 TECHNOLOGY TRANSFORMATION (GLOBAL)

02 INDUSTRY OUTLOOK

4th wave of digital technology causes global industrial transformation

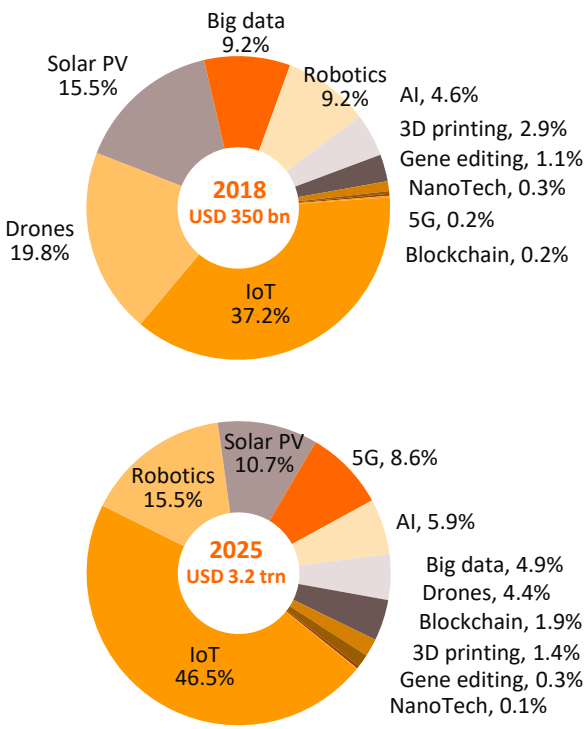


The emerging fourth wave of digital technology involves artificial intelligence (AI) and robotics following third wave of internet of things. Commercialization of AI and robot systems is underway together with a wider commercial adoption of IoT. In this way, new technologies will address the new age of global industrial transformation.

Source: How digital technology Will transform the world , Fujitsu Journal, Krungsri Research

Frontier technologies offer a window of opportunity to increase productivity

Market size estimates



Key Driving Forces of Global Frontier Technologies

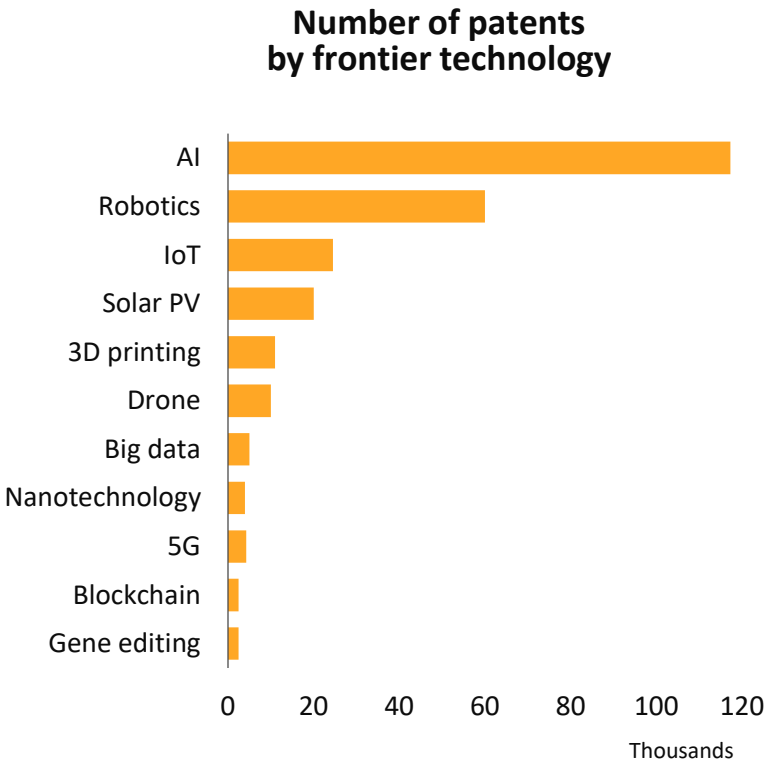
Technology	Driving forces
IOT	Technological advances and rising demand for advanced electronics and devices
Robotic	Production process transformation coping with shrinking workforces amid aging society
Solar PV	Circular economy trend to utilize sources of renewable energy
5G	Infrastructure development with rising demand for mobile broadband, and smart devices
AI	Increasing adoption of cloud-based applications and demand for intelligent virtual assistants
Big data	More adoption of cloud solutions with high demand for data real-time analytics
Drone	Advance drone technology to serve increasing demand in various sectors
Blockchain	Growth in online transactions, digital currencies and secure online payment gateways
3D printing	Demand for faster and cheaper low-volume production and rapid iterative prototype
Gene editing	Advanced technology of genetic engineering to use in agriculture, food and medical industry
NanoTech	Increasing government support and rising demand for minimal scale of products

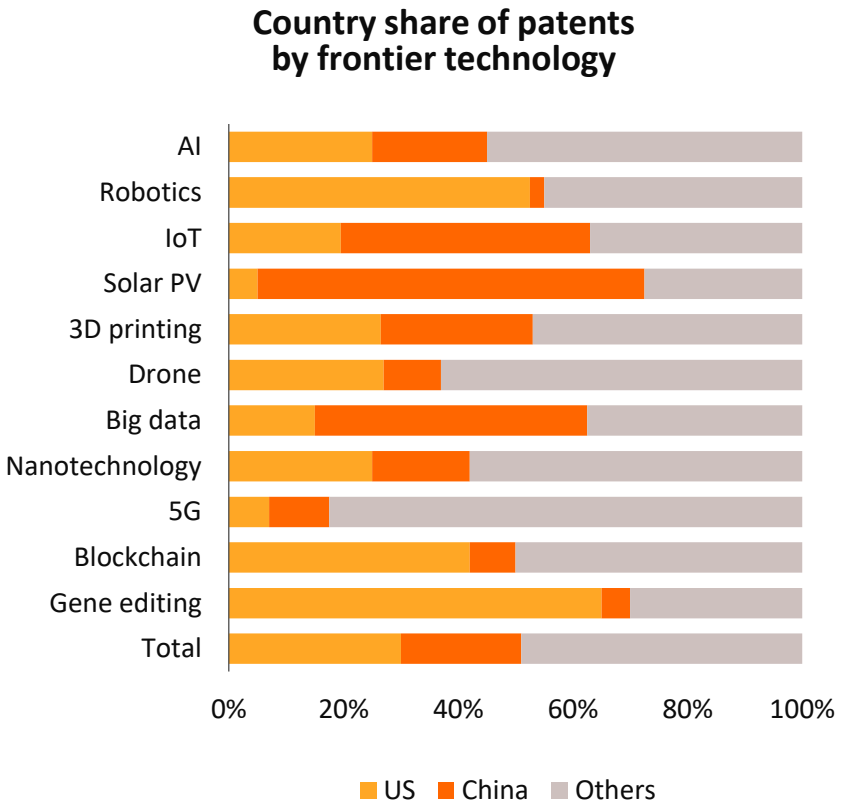
Note: The "frontier technologies" are a group of new technologies that take advantage of digitalization and connectivity which enable them to combine to multiply their impacts.

- According to UNCTAD estimation, 11 frontier technologies have dramatic impacts on productivity enhancement of global industries. Those include IoT, Robotics, Solar PV, 5G, AI, Big data, Drones, Blockchain, 3D printing, Gene editing and NanoTech.
- Market size of 11 frontier technologies is estimated to totally increase by 37.2% (CAGR) during 2018-2025. The largest by market revenue will be IoT which is around half of frontier technology revenues, followed by robotics that is set to expand rapidly driven mainly by continued technical improvements and the development of AI-enabled self-programming robots.

Source: UNCTAD 2021, Krungsri Research

Commercialized technology patents concentrated in AI, Robotics and IOT with US and China as major players





The development of frontier technologies has generated a large number of patents that will be commercialized to industrial sectors globally. The two major players are the United States and China. The United States is especially active in robotics, gene editing and blockchain while China is active in IoT, big data and solar PV.

Source: UNCTAD 2021, Krungsri Research

Manufacturing and Finance are among the most early adopters of new technology

Major Sectors that were Early Adopters of Frontier Technologies

AI	IoT	Big data	Blockchain	5G
Retail	Consumer	Finance	Finance	Utilities
Finance	Finance	Manufacturing	Manufacturing	Manufacturing
Manufacturing	Healthcare	Professional services	Retail	Public safety

3D printing	Robotics	Drones	Gene editing	Nanotechology	Solar PV
Manufacturing	Manufacturing (discrete)	Utilities	Pharma/Biotech	Medicine	Residential
Healthcare	Manufacturing (process)	Construction	Academic/ research	Manufacturing	Commercial
Education	Resource	Manufacturing	Agri genomic	Energy	Utilities

- The manufacturing sector has used frontier technologies mostly for predictive maintenance, quality control and human-robot combined working activities.
- Finance companies have used these technologies, for example, for credit decisions, risk management, fraud prevention, trading, personalized banking and process automation.

Source: UNCTAD 2021, Krungsri Research

Frontier technologies will be combined to create new technology trends that will affect all sectors, but their impact varies by industry

Estimated Effects of 7 Cross-technology Trends across Selected Sectors

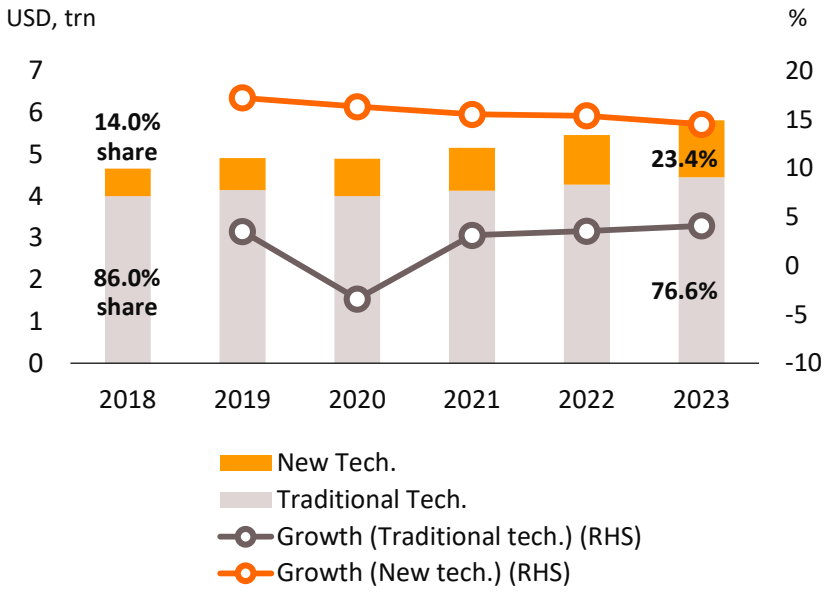
New Technology	Sectors								
	Automotive	Transport/ Logistics	Electronics	Aerospace/ Smart device	Chemicals	Healthcare	Pharma-ceuticals	Telecom-munication	Info. services
IT/Robotic/3D/ Drone									
AI									
5G/IoT									
Big data/Cloud									
Blockchain									
Gene editing /BioTech									
NanoTech									

Major influence Moderate influence Limited influence

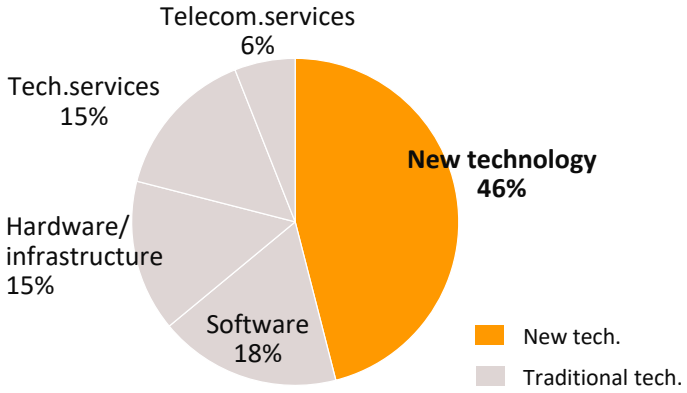
Source: McKinsey 2021, Krungsri Research

New technology spending will continue to record a strong growth momentum and contribute almost half of the revenue growth in global industry in 2023

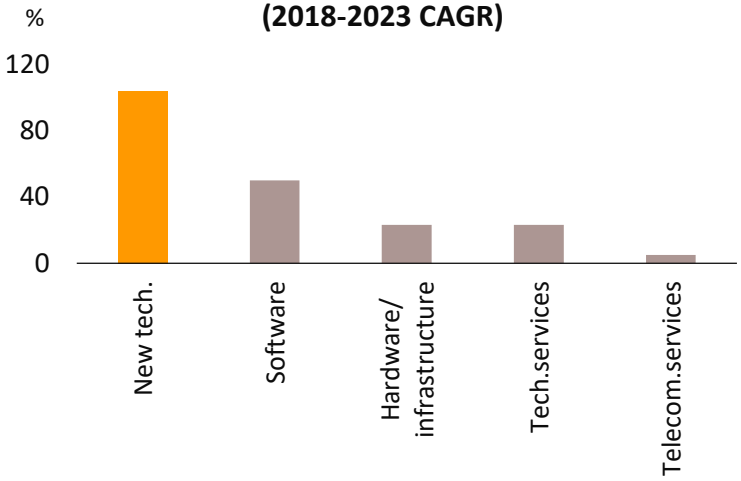
Global Technology Spending



Estimated Contribution of Technology to Revenue Growth In Global Industry in 2023



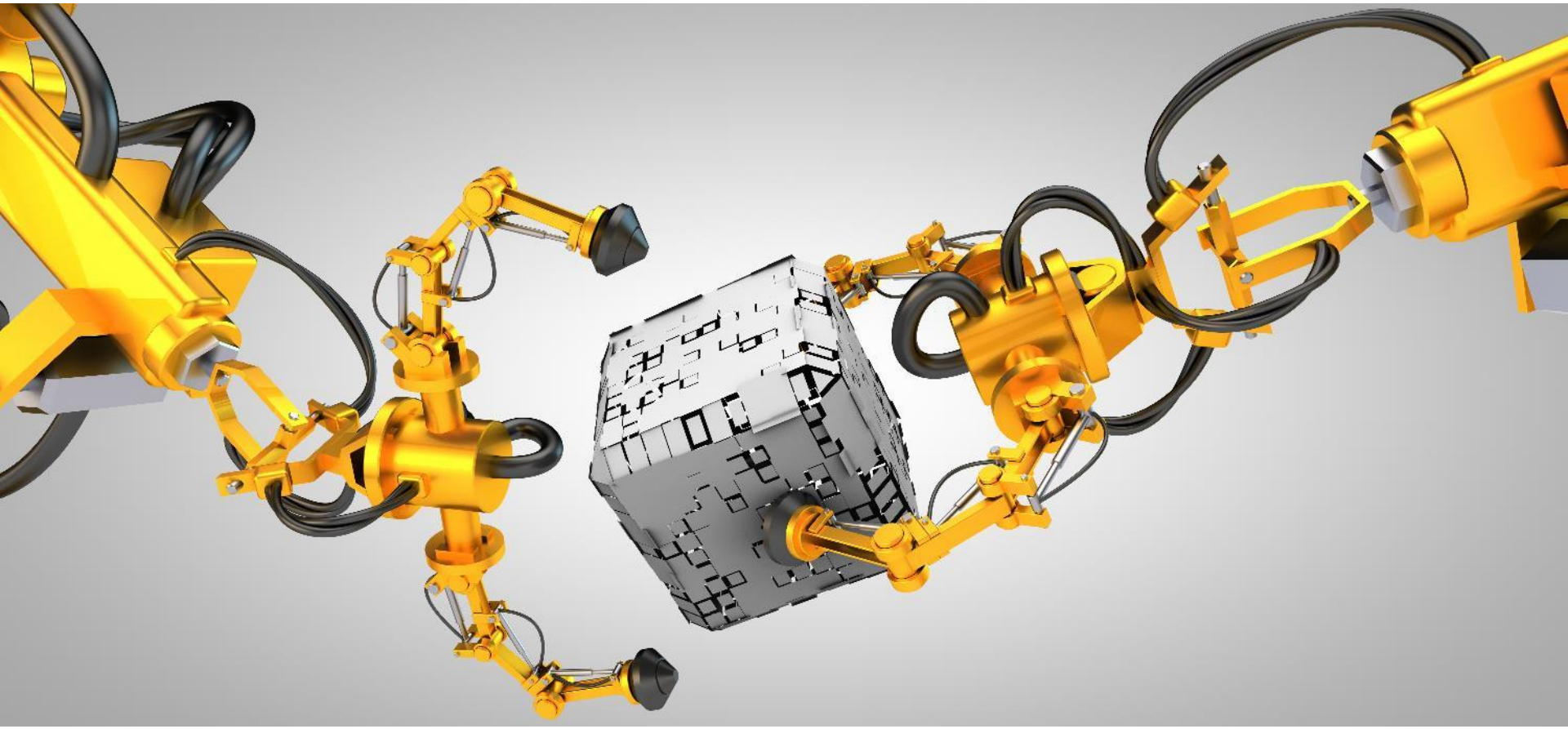
Growth of Revenue Contributed by Technology (2018-2023 CAGR)



According to IDC Corporate USA, businesses in emerging markets have already moved quickly to focus on rapid adoption of new technologies which deliver rapid return on industrial investment

Source: IDC Corporate USA, Krungsri Reserach

New Technologies
in Global Targeted Industrial Use Cases



Automobile: *IoT adopted for system integration in connected production plants*

- **Current applications:** Global major OEMs are now moving towards connected production plants with IoT ecosystem. The variety of IoT devices in connected factories is critical for monitoring equipment health, product quality, and workers' performance. IoT can integrate manufacturing systems into a central command center. Main functions of IoT in the auto connected factories include:
  - **System integrations**: IoT provides frameworks to integrate systems already existing in auto plants and build communication between a production line and back office. IoT platform is used to control the data flow between the sources (production lines, hardware, databases), and recipients (managers, displays, end users). This solution help car makers to gain easier access to information.
  - **Design/Prototyping:** IoT solutions can support the production of a virtual prototype and process design to reduce production cost of new car models.
  - **Predictive maintenance:** IoT can be utilized to collect information of problems during production process to analyze the most proper ways of maintenance in case of malfunctions.(nano-di.com, ttpsc.com)

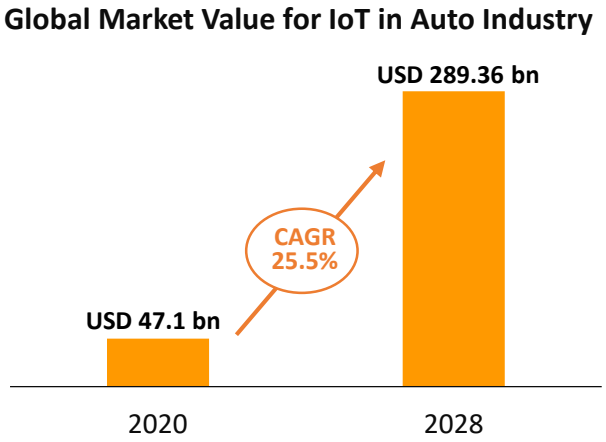
  Toyota Motors (Japan), for example, established an AI-based mechanism in 2020 for detecting signs of faults from manufacturing equipment data and returning the optimal parameters. **Isuzu (Tochigi, Japan)** also developed smart factories by using IoT in 2018.





Source: verifiedmarketresearch.com, ttpsc.com., nano-di.com, customers.microsoft.com, E Info chips (an Arrow company), Krungsri Research

Automobile: *IoT adopted for system integration…*





- **Commercial benefits:** Smart factories connected with IoT technology help **streamline manufacturing processes and benefit supply chain optimization**. Thus, IoT adoption can generate cost savings and productivity throughout the automotive supply chain. Besides production efficiency gains, data insights prediction is other commercial benefit generated from IoT adoption:
  - **Toyota Motors (Japan)** built a company-wide, standardized IoT platform as part of its industry-leading initiatives to accelerate data use in factories. It can use a variety of data generated at manufacturing sites to improve the efficiency of manufacturing processes and yield rates.
  - **Isuzu (Japan)** adopted IoT platform at new smart factory to quickly detect and solve a problem and cut the losses by half.
  - **Honda (Alabama, US)** uses IoT technology for predictive analytics. Higher predictive capabilities have transformed the plant's approach towards problem-solving and innovation development for more value creation.
- **Limitations:** In many countries, it is not yet possible to develop smart factory with IoT network due to constraints of infrastructure development especially for 5G networks.
- **Market value:** IoT in global auto industry is projected to reach USD 289.36 bn by 2028, growing at a CAGR of 25.5% from 2020 to 2028. North America dominated market value owing to its advanced economy and high buying capacity. The Asia Pacific is expected to grow at a rapid pace in the forecast period, with most contributions coming from India, China, Japan, and Taiwan. The global major players such as Thales SA, Intel, IBM, Cisco System, Microsoft, and AT&T.(Source: verifiedmarketresearch.com).

Source: verifiedmarketresearch.com, ttpsc.com., nano-di.com, customers.microsoft.com, E Info chips (an Arrow company), Krungsri Research

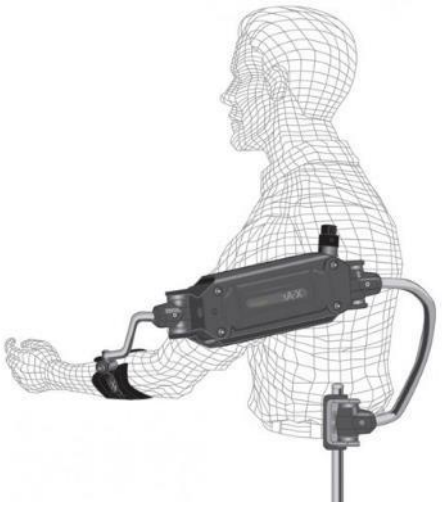
Automobile: *Robotics used for checking assembly works and distribute parts to assembly lines*

- **Current applications:** Compared to human workers, robots are capable of much more accurate work, and so to cut labor costs and to enable more precise engineering, auto manufacturers use robotic systems in the assembly of car bodies and the mass production of their component parts. This also helps to increase safety levels. Areas where robots tend to be used include checking assembly work, distributing parts to assembly lines, undertaking processes that involve high temperatures or the use of dangerous chemicals, and manufacturing electronic components, much of which involves processes that are not visible to the naked eye.
- **Commercial benefits:** Robots help to build value in the automotive sector as important contributors to the creation of value in production processes include the following:
  - **Collaborative Robotics** – These are robots that work together as a team in the assembly of a car body. For example, robots in the Chinese Great Wall Motors factory are able to assemble and connect 4,000 parts in just 86 seconds, while BMW uses robots in the final stage of door assembly to install seals that protect against sound and water.
  - **Robotic Hand** – It help to cut labor costs for processes such as installing electronics and fitting wheels. For example, the American company Equipois has developed an exoskeletal arm support, called the x-Ar, that increases workers' lifting power by up to 10 pounds. These systems are modeled on human nerves and muscles, and work as virtual limbs amplifying the abilities of the human operator wearing the device.

Great Wall Motor factory production line



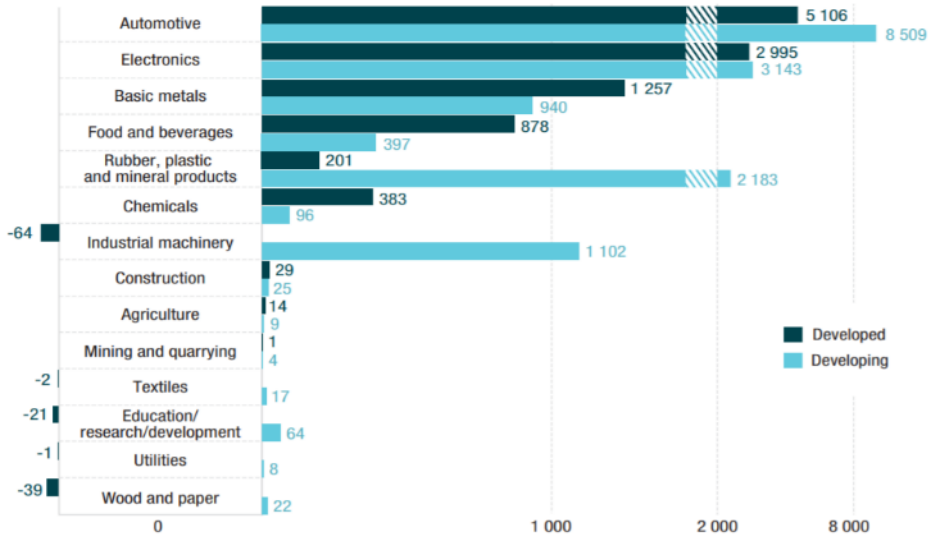
Robotic Hand (X-Ar Exoskeleton Arm Support)



Source: UNCTAD based on data from Carbonero et al. (2018), Great Wall Motor, roboticgizmos ; X-Ar , Krungsri Research.

Automobile: *Robotics used for checking assembly works…*

Average Change in Robot Density, by industry 2008-2014
(per 10,000 workers)



Robotic Painting



- **Robotic Vision** – Some robots are equipped with laser-powered eyes distributed across various parts to produce more tightly packed components.
- **Robotic Painting** – Robots are used to paint component parts, and help minimize problems with a shortage of skilled labor. In addition, because robotic painting systems are able to control the application of paint better than humans, this also cuts costs arising from the unnecessarily thick application of the paint.

- **Limitations:** (i) There is a shortage of experts able to work with robotic systems (ii) Upfront investment costs are high, placing this out of reach of small operators.
- **Market value:** In 2018, the market for automotive robotics had a value of USD 32 billion, but this is expected to increase to USD 499 billion by 2025, partly thanks to the fact that use of robotics is more widespread in the automotive sector than in other parts of the economy (source: UNCTAD, Technology and innovation report 2021).

Source: UNCTAD based on data from Carbonero et al. (2018), RoboDK Painting, Krungsri Research.

Automobile: *AI helps manage supply chain and inspect production process*

- **Current applications:** AI improves production process to enhance productivity for auto sectors in many ways as follows; .
  - **Developing inspection system: Honda'**s affiliate company (Musashi Seimitsu Corp.) recently developed new AI-powered prototype to create new efficiency and agility in manufacturing processes.
  - **Managing supply chain: Audi** and the **Volkswagen group** uses AI to manage complex operations in their supply chain system
  - **Streamlining manufacturing process: Hyundai** and **Kia Motors** developed AI-controlled co-bots working with human to move materials, perform tests, package products and help workers avoid injuries.
  - **Reducing production waste: Porsche** and **Audi** adopted AI to detect damaged parts and control quality of car bodies.
- **Commercial benefits:** : At many steps in the manufacturing process, AI will yield commercial results based on its ability to understand its environment, analyze data, draw conclusions, and learn from experience to achieve continuous improvements. According to McKinsey, AI has potential impacts on car manufacturers;
  - **Reducing cost:** AI-based algorithms can digest masses of data to diagnose production problems leading to ***25% and 10% reduction in inspection costs and annual maintenance costs respectively***.
  - **Increasing productivity:** AI has inspection system to improve production process for machined parts, painted car bodies, textured metal surfaces etc. ***Productivity increases in visual quality inspection of up to 50%*** are possible.

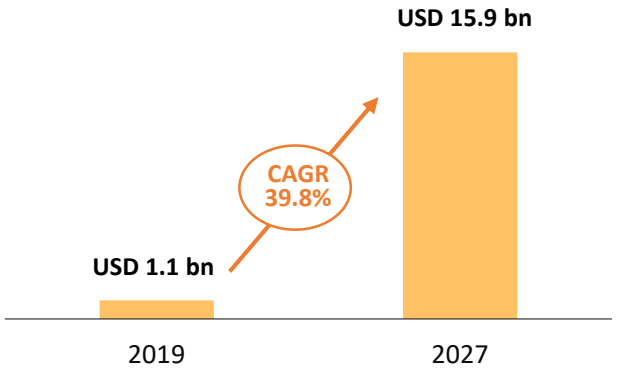




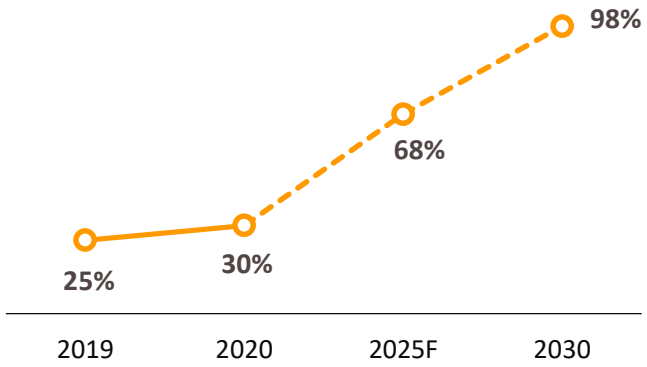
Source: Market world report., usmsystems.com, McKinsey (Dec 2020), Siemens, Toshiba-clip, Krungsri Research.

Automobile: *AI helps manage supply chain…*

Global Market Value for AI in Auto Industry



Deployment of AI in Global Automotive Industry



- **Minimizing forecasting errors:** Using AI machine learning, data analytics derived from supply chain are used for forecasting system. AI techniques developed by Blue Yonder, US, can reduce forecasting errors on auto demand by 30-50%. Thus, ***AI could reduce auto inventories by approximately 20-50%.***

- **Limitations:** Lack of infrastructure coupled with the high procurement operating cost is expected to challenge the market growth of the AI in automotive industry

- **Market value:** The global market for AI in automotive industry is expected to grow at a CAGR of 39.8% from 2019 to reach $15.9 billion by 2027, supported by 1) growing investments in AI technology for improved productivity and 2) increasing demand for connected systems with smart convenient features in vehicles. By 2030, 98% of global auto industry will deploy AI in production process, compared to just 25% in 2019.

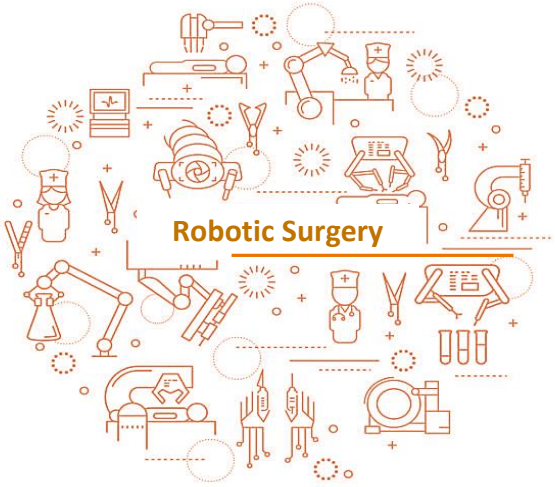
  - Asia-Pacific region is projected to grow at the highest CAGR during the forecast period thanks to growing adoption of intelligent solutions and increasing digitalization investments by the major players in this region.

  - Some of the key players operating in the global AI in automotive market are Google LLC (U.S.), IBM Corporation (U.S.), Intel Corporation (U.S.), Microsoft Corporation (U.S.), Tesla, Inc. (U.S.), Xilinx, Inc. (U.S.), Ford Motor Company (U.S.), General Motors Company (U.S.), Honda Motor Co., Ltd. (Japan), Audi AG (Germany).(Meticulous Market Research Pvt. Ltd., usmsystems.com)

Source: Market world report., usmsystems.com, McKinsey (Dec 2020), Krungsri Research.

Healthcare: *Robotics mostly utilized for surgical procedure entering necessary parts*

- **Current applications:** Robots are mostly utilized for performing surgical procedures to enter the body parts that are impossible to reach with human hands. The arms of the robot can rotate around 280 degrees and reach the necessary part. Some examples of these uses include:
  - **The Da Vinci Surgical System** has been developed by the US company Intuitive Surgical and this is used to assist with obstetrics procedures, and with operations on the urinary system and on the head and throat.
  - **The Mako Smart Robot,** produced by the US Stryker Corporation, is used to operate on knees and hips, as well as other areas that are difficult to access. The precision cutting tools fitted to the robot allow surgeons to carry out much more accurate surgery than was possible in the past.
- **Commercial benefits:** Healthcare robotics systems provide a number of benefits to hospitals:
  - Operations are more precise, the scale of interventions is lowered, scarring is reduced and patients recover more quickly, allowing for shorter hospital stays.
  - Some robots help prevent doctors and medical professionals from being infected especially with coronavirus and to serve food and medication to infected patients.
  - Robots also provide external support and muscle training for rehabilitation.



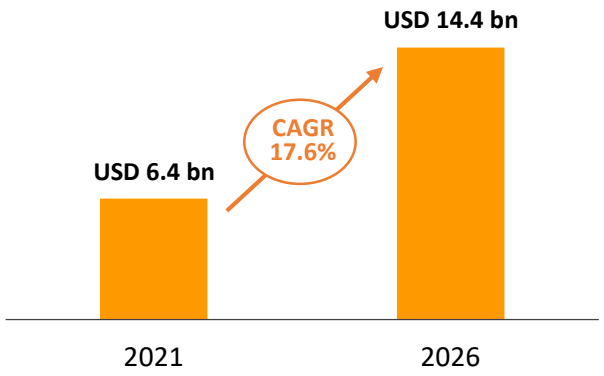
Robots help prevent doctors



Source: MarketsandMarkets Research (May 2021), Healthcarebusinessclub.com, Krungsri Research

Healthcare: *Robotics mostly utilized for surgical procedure…*

Global Market Value for Surgical Robots, 2021-2026



Robots in Healthcare



- **Limitations:** Although robotic surgery systems are marketed as a safer alternative to traditional surgeries, there are various risks associated with robotic systems, including mechanical errors and malfunction as the robotic systems have multiple components. However, technological advancements in the future would help in reducing those errors.
- **Market value:** The global surgical robots market in healthcare business is projected to reach USD 14.4 billion by 2026 from USD 6.4 billion in 2021, at a CAGR of 17.6%. North America dominated the global market with a revenue share of over 52% in 2020. Asia Pacific is anticipated to be the fastest-growing regional market. (MarketsandMarkets Research). Global large producers include Intuitive Surgical (US), Stryker Corporation (US), Medtronic (Ireland), Smith & Nephew (UK). At present, diagnostic robots are largely still at the R&D/prototype development stage.

Source: MarketsandMarkets Research (May 2021), Healthcarebusinessclub.com, Krungsri Research

Healthcare: *AI adopted for rapid diagnosis and following-up the infection*

- **Current applications:** AI has found many uses in diagnostic applications, including: (i) ZhiWei Information Technology's Morphogo bone marrow diagnostic system; (ii) analysis of blood circulation (carried out in combination with 3D modeling); and (iii) the diagnosis and identification of early-stage cancer. Since the outbreak of Covid-19, AI applications have also been developed to help with the rapid diagnosis of the disease and the follow up of infected individuals.
- **Commercial benefits:** AI can help by significantly speeding up testing or screening for conditions (especially in their early stages) and then assessing their severity. The improvements offered by AI are equally applicable to communicable and non-communicable diseases (NCDs).
  - **NCDs:** One example of testing for NCDs is that of analyzing bone marrow. In the past, testing took 5-10 days but AI tests can be completed in a single day, and so leukemia can now be diagnosed and treatments begun much more quickly.
  - **Communicable diseases:** Examples of using AI to test for communicable diseases can be found in China, where many hospitals are using AI to look for signs of disease outbreaks. Testing for Covid-19 may now be done using CT scans, which are fed into an AI application that can then distinguish between patients infected with Covid-19 and those with other types of respiratory illness. This has then cut the time between testing and diagnosis significantly and through this, Covid-19 fatality rates have fallen. Most recently, the Chinese tech giant Alibaba has developed a way of using CT chest scans to test for Covid-19 that has a 96% accuracy rate, and perhaps more importantly, this system can test 5,000 people in 20 seconds, compared to the 15 minutes per scan when swab testing is carried out.

AI helps diagnose diseases



Image from itchronicles.com

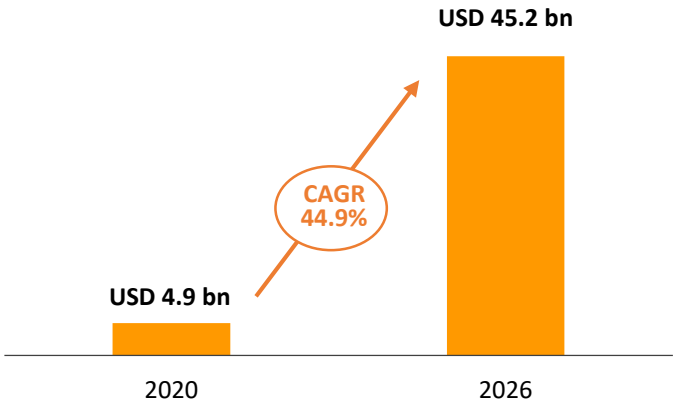
AI steps up in battle against Covid-19



Source: MarketsandMarkets Research (May 2021), Theeleader.com, BBC News, Forbes, Krungsri Research

Healthcare: *AI adopted for rapid diagnosis…*

Global Market Value for Healthcare AI



Artificial Intelligence in Healthcare



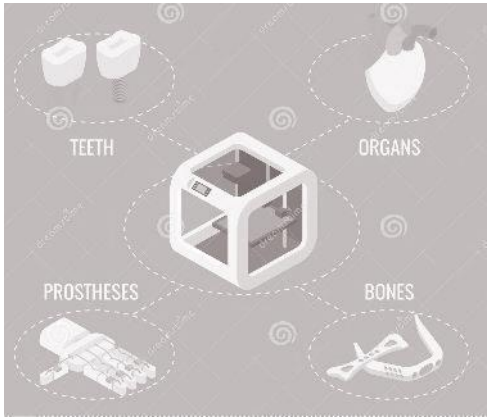
- **Limitations:** (i) There is a shortage of individuals with the highly specialized skills and knowledge required to build AI systems that are integrated into medical equipment. (ii) The rules and regulations governing the use of AI-powered healthcare equipment remain uncertain.
- **Market value:** The global AI in healthcare market size is expected to grow from USD 4.9 billion in 2020 and reach USD 45.2 billion by 2026; it is projected to grow at a CAGR of 44.9% during the forecast period. World major companies that successfully integrated an AI engine in their medical device artificial intelligence products include Heartflow (US), Freenome (US), OrCam Technologies (Israel), Paige (US), and Sight Diagnostics (Israel).

Source: MarketsandMarkets Research (May 2021), Theeleader.com, BBC News, Forbes, Krungsri Research

Healthcare: *3D printing implemented for producing dental products and surgical devices*

- **Current applications:** Most healthcare 3D printing is used to produce medical devices, of which the following are the most important.
  - **Orthodontic and dental products** such as false teeth may now be produced using 3D Systems' NextDent 5100 or Arcam's EBM (electron beam melting) technology. Clear aligners are also now commonly manufactured using 3D printing.
  - **Surgical tools and devices** that are produced by 3D printers include surgical guides, prosthetics and implants, tissue-engineered products, tourniquets, handles for scalpels, hearing aids, wearable medical devices and organ models. Development of these processes has been helped by the ability of 3D printers to use durable materials such as ultem, PEEK, nylon, stainless steel, nickel and titanium.
- **Commercial benefits:** 3D printing technology is facilitating the work of surgical teams both inside the operating theatre (e.g., with surgical tools) and outside it (e.g., with anatomical models). 3D printing is also being used to create dental products cheaper and faster than is possible with traditional technologies. For example, NextDent, a Dutch company, creates dentures and other types of implants using 3D printing technologies that are faster than older methods and that generate savings of up to 90%. In 2021, a German medical device company also deployed 3D printing to develop a surgical tool for use in hip cup removal.

Medical 3D Printing



3D printing technology boosts hospital efficiency

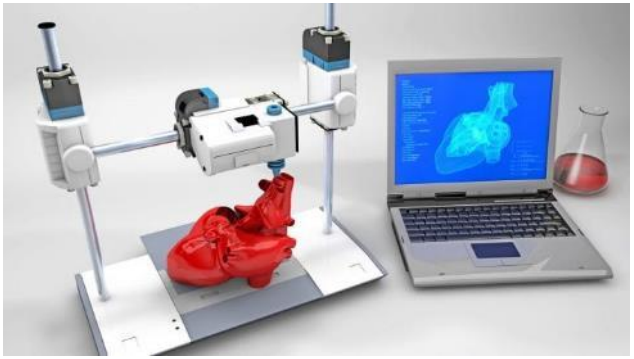
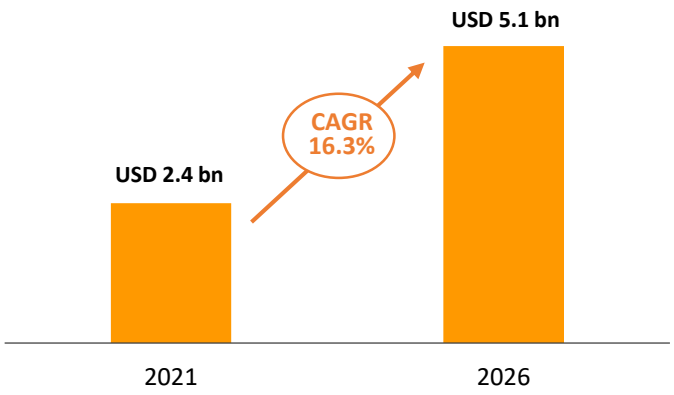


Image from healtheuropa.eu

Source: MarketsandMarkets Research (May 2021), Frost.com, Krungsri Research

Healthcare: *3D printing implemented for producing dental products…*

Global Market Value for 3D Healthcare Printing, 2021-2026, (Medical Devices Market)



Dental 3D Printing



Image from 3Dsourced.com

- **Limitations:** (i) The limited availability of specialized training in additive manufacturing means that there is a shortage of skilled workers. (ii) The industry is saddled with high capital investment and operating costs. (iii) Regulatory frameworks governing the use of 3D printing for the production of medical and dental devices remain unclear.
- **Market value:** The majority of 3D printing in the healthcare sector is connected to the production of medical devices. Over 2021 to 2026, this segment is expected to see annual growth of 16.3% (CAGR), which will take the industry's value from USD 2.4 billion in 2021 to USD 5.1 billion by 2026. Global leaders in the area of 3D printing include Stratasys Ltd. (US & Israel), 3D Systems Corporation (US), GE Additive (US), Materialise NV (Belgium), Renishaw PLC (UK), Organovo Holdings, Inc. (US), EOS (Electro Optical Systems) GmbH (Germany), and Biomedical Modeling, Inc. (US).

Source: MarketsandMarkets Research (May 2021), Frost.com, Krungsri Research

Real estate: *AI - Virtual Reality (VR)/ Augmented Reality (AR) allows project members working together from remote areas*

- **Current applications:**
  - The real estate industry is embracing AI through the use of Virtual reality (VR) that replaces reality with a completely new 3D digital environment and Augmented reality (AR) that overlays digital content on top of the real world.
  - VR is being used to develop platforms that coordinate the work of developers, architects, interior designers and clients. VR allows these different team members, who may be working on other sides of the planet, to simultaneously enter a digital built environment simply by slipping on a headset and carry out direct peer-to-peer collaboration. Moreover, by allowing buyers to experience a space from the comfort of their home, VR also makes it possible for real estate companies to market projects to clients before construction completed.
- **Commercial benefits:**
  - Cuts the cost of building and maintaining sales offices – Using AR or VR requires nothing more complicated than an empty room, but by putting on a VR headset, clients are able to inspect all the details of a site easily as visiting it themselves.
  - Increases sales – since Covid-19 outbreak and the need to maintain social distancing, walk-in sales have declined but VR offers a solution to this problem.
  - Allows for real time peer-to-peer collaboration, which then helps to shorten project completion times.

3 ways to conduct a VR real estate tour (smart phone/tablets, PC/laptop, headset)

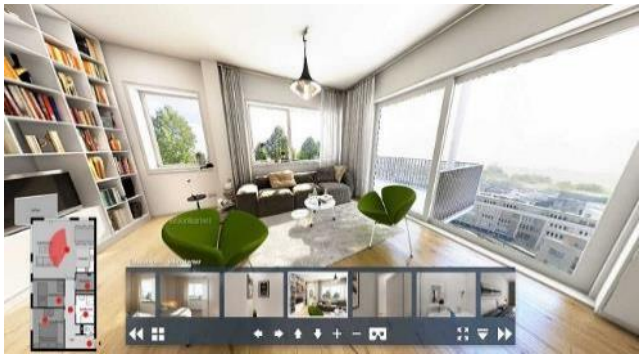


Image from www.wear-studio.com

Join with stakeholders in real time review sessions



Image from www.kalloctech.com

Source: Goldman Sachs Global Investment Research, Krungsri Research

Real estate: *AI - Virtual Reality (VR)/ Augmented Reality (AR) allows project members…*

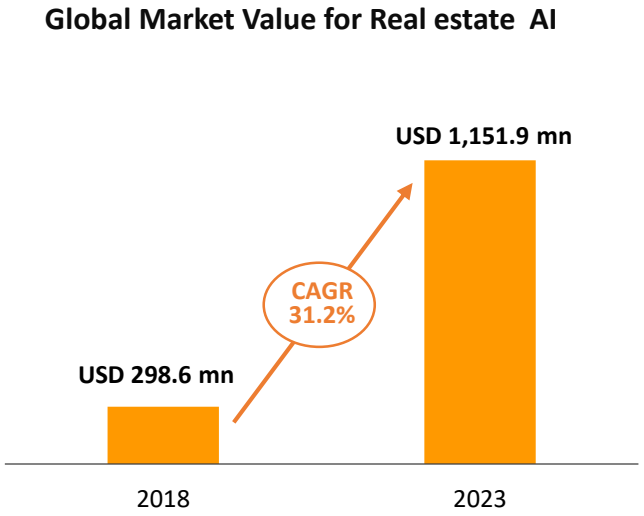




Image from www.therealestatemarketingmasters.com

For example, the Californian company Kalloc Studios uses VR to meet with 100 other companies in its otherwise cramped offices. These real time design meetings take place every week, and the result has been that a steady stream of new developments have been rapidly released to the market.

- **Limitations:** Using AR and VR in connection with smaller, lower value developments may not be cost effective.
- **Market value:** Research from AllTheResearch and Goldman Sachs estimates that the global AR VR in real estate market was valued at USD 298.6 mn in 2018 and expected to reach USD 1,151.9 mn in 2023, expanding at a CAGR of 31.2%. In 2021, 130,000 real estate agents is estimated to use VR to show housing projects (10% growth compared to the previous year).

Source: Goldman Sachs Global Investment Research, Krungsri Research

Real estate: *3D printing mostly used with robotic arms to complete construction process*

- **Current applications:** 3D printing can be used for all stages of construction, from floors, through walls to roofs. During the construction process, the printing head lays down layers of the construction material in a way that is similar to how concrete is poured using more traditional techniques, and this is then repeated layer by layer until the building has been completed. There are many different 3D printing technologies used in construction but generally, these use robotic arms or gantry systems to complete the printing process.
- **Commercial benefits:** 3D printing is gaining favor with property developers because compared to traditional methods, this technology allows construction to be completed more rapidly and at lower cost. Cost reductions come from both lower labor overheads and the ability of the technology to more accurately assess the quantity of cement/concrete that will be required for a particular build, and so overall, 3D printing allows for cost savings of as much as 30-55%.

  For example, the Russian Apis Cor and America's ICON have shown that they can complete construction of a small house (including its roof) in just 24 hours and do so with savings of respectively USD 10,000 and USD 4,000.

Gantry system



Image from www.newatlas.com.

Robotic arm

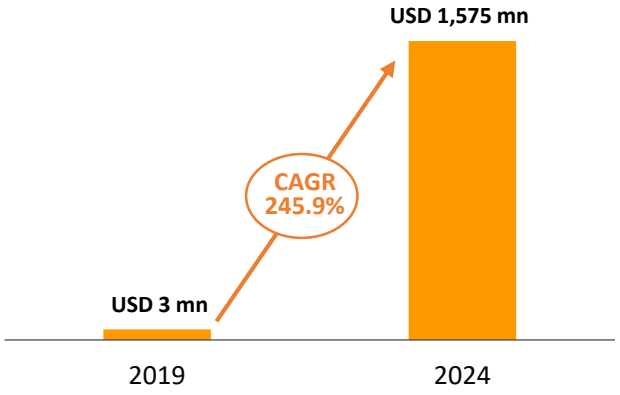


Image from www.apis-cor.com

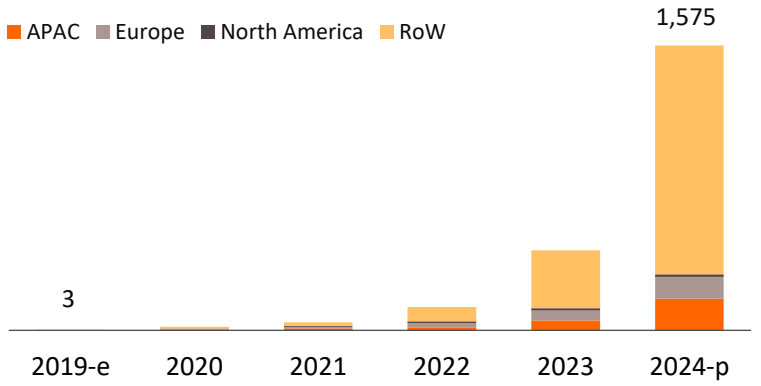
Source: GlobalNewswire, Krungsri Research

Real estate: *3D printing mostly used with robotic arms…*

Global Market Value for 3D Printing in Construction



Market for 3D Printers in Construction, by Region
(USD million)



- **Limitations:** (i) The upfront investment costs for using 3D printing are high (ii) The external finish is somewhat rough compared to that achieved by using prefabricated units and (iii) Regulations have generally not been updated to take account of the safety considerations arising from the use of 3D printing in construction.
- **Market value:** The 3D printing construction market size is estimated to be USD 3 mn in 2019 and is projected to reach USD 1,575 mn by 2024.The market is growing due to the high demand from the building and infrastructure sectors. Some of the key players in global 3D printing construction market are Yingchuang Building Technique (China), XtreeE (France), Apis Cor (Russia), Monolite UK (UK), CSP s.r.l. (Italy), CyBe Construction (Netherlands), Sika (Switzerland), MX3D (Netherlands), Contour Crafting (California), and ICON (Texas).

Source: GlobalNewswire, marketsandmarkets.com, Krungsri Research

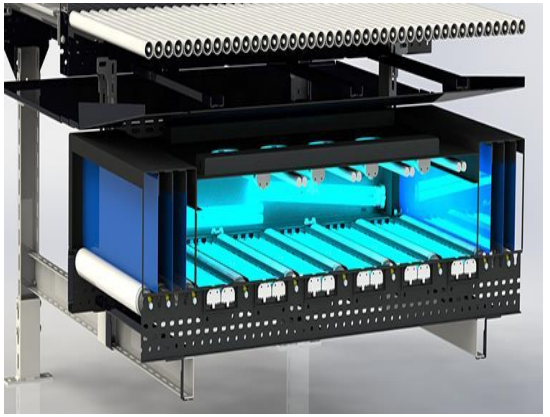
Air transport: *Robotics (Disinfection Robots) minimize the spread of viruses and reduce interaction between passengers and staff*

- **Current applications:** An interesting example of a UV disinfection robot is Honeywell's UV cabin system, which uses UV-C light to kill 99.99% of bacteria, yeast, spores, Covid-19 and H1N1 viruses, etc. within 5 minutes. Airports and airlines around the world are now using mobile robots to minimize the spread of viruses and to reduce interaction between passengers and staff. For example, during the Covid-19 pandemic, Qatar Airways has deployed disinfecting robots on domestic aircraft and the next step will be to operate these onboard all aircraft turnarounds at Hamad International Airport (HIA).
- **Commercial benefits:** Disinfection robots have come to prominence during the Covid-19 crisis thanks to their role supporting hygiene and sanitization measures in airplanes and airports that have helped to restore passenger confidence. Like other robots, these overcome problems with labor shortages and can work rapidly and ceaselessly. Thus, disinfection robots can cover an area of 18,000 sq. m. within an airport in just 2.5 hours (nesarobotics.com). Examples of applications of disinfection robots include the following.
  - **Hamad International Airport (Qatar)** uses robots inside the airport to sterilize against Covid-19 every 10-15 minutes, and boarding gates and bus counters are all cleaned after every flight.

Heathrow Airport's UV cleaning robot



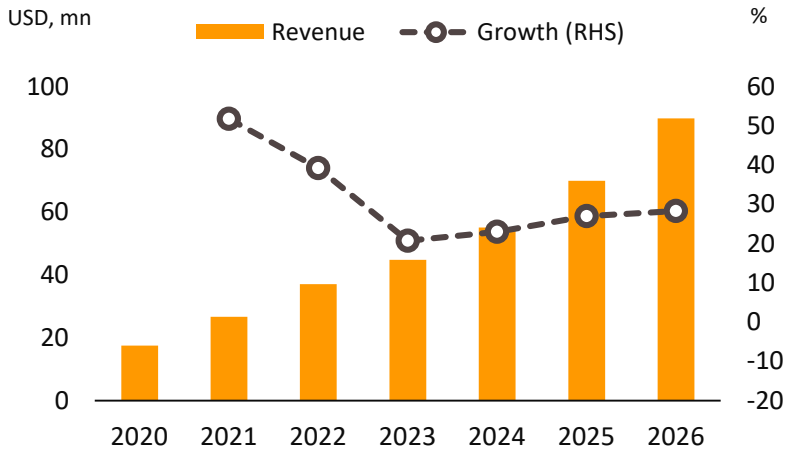
UV-tunnel scans every tray immediately before Each passenger uses it at Gatwick airport



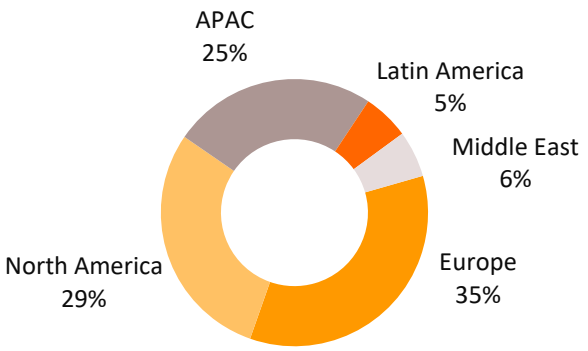
Source: EMIS/Arizton advisory & intelligence, / www.airport-business.com/ Heathrow Photo Library / Krungsri Research

Air transport: *Robotics (Disinfection Robots) minimize the spread of viruses…*

Market for Global Transport Disinfection Robots



Share by Region



- **Heathrow airport (UK)** deploys UV cleaning robots to ensure continuous disinfection of the moving handrails within the airport. These robots are supplied by the Danish Company UVD Robots.
- **Gatwick airport (UK) and Helsinki Airport (Finland)** use UV disinfection robots on eight security lanes at their north terminals.

- **Limitations:** Robots require supporting infrastructure including internet access, power supplies, and maintenance, which makes the equipment expensive to buy and maintain
- **Market value:** Global transport disinfection robots were valued at USD 17.57 mn in 2020 and estimated to grow by 51.8% at USD 26.7 mn in 2021. The market value is expected to reach USD 89.88 mn in 2026, growing at a CAGR of 27.5% during 2021-2026. More than half of those market value come form Europe and North America. The largest segment is UV disinfection robot with more than 80% of global market share, followed by disinfection spray robot and combined system robot. (Arizton)

Source: EMIS/Arizton advisory & intelligence, / www.airport-business.com/ Heathrow Photo Library / Krungsri Research

Air transport: *AI (AI Robots) responds to customers as digital human concierges*

- **Current applications:** AI robots will be increasingly used in airports in customer facing roles. Continuing technological advances (most especially with AI and machine learning) are making it possible for robots or 'digital human concierges' to respond to customers through speech in a manner that closely resembles interactions with human staff. This includes providing reasons and justifications for their real-time decision-making processes. An example of this can be seen in the new terminal at **the Beijing Daxing International Airport in China**, where over 10 AI robots are on hand to respond to passenger queries.
- **Commercial benefits:** Many airports are introducing AI robots as they look to manage the large number of travelers passing through their sites simultaneously. Robots can respond to passengers individually and to give personalized information in the traveler's preferred language, and to do this around the clock. This then provides a number of benefits for businesses involved in air transport, including:

  1) The expansion in the range and size of services on offer, which generates economies of scale.

  2) The use of robotic assistants helps build more in-depth consumer profiles, which then helps airports better predict future demand for services

FRAnny is an expert concierge at Frankfurt airport



Image from https://www.passengerselfservice.com/

Airstar robots at Incheon International airport

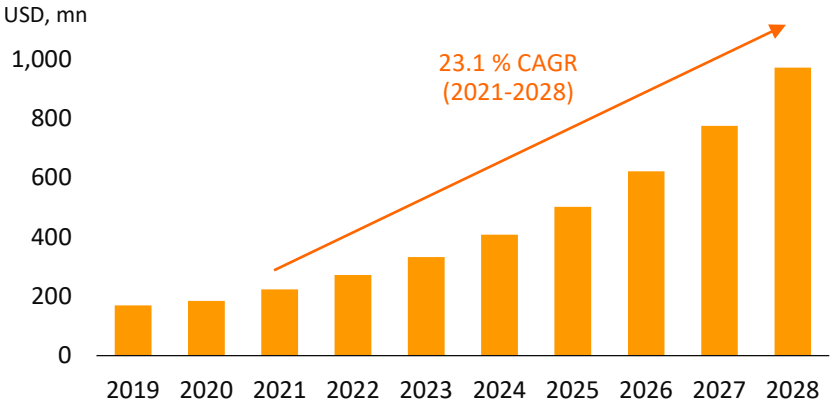


Image from http://koreabizwire.com/

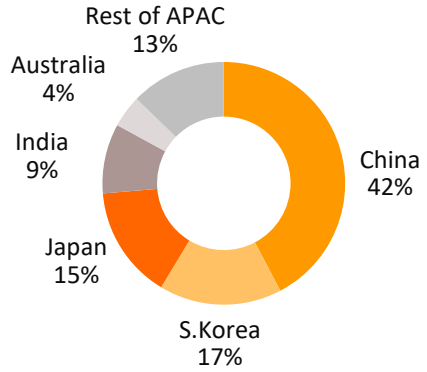
Source: EMIS/The Insight Partners Analysis, Krungsri Research

Air transport: *AI (AI Robots) responds to customers…*

Market for Airport AI Robots in the Asia-Pacific



Share by Region



Examples of uses of robot/digital human concierges include the following:

- **Frankfurt Airport** uses a robotic concierge service called 'Franny'. This provides travelers with information on how to use the airport facilities, which gate they should go to, how to connect to the airport's wi-fi; and responds to individual queries and gives out advice on particular topics.
- **Incheon International Airport** in South Korea employs 14 robotic AI concierges to give out travel information, including information on arrivals and departures, advice on how to check in, how to use airport facilities, and other recommendations.

- **Limitations:** (i) Database infrastructure needs to be developed to serve AI system (ii) it can not replace human safety systems with robotic equivalents.

- **Market value:** Demand for airport AI robots in the Asia-pacific (APAC) has been driven by the need to protect against the spread of Covid-19, and this has helped to accelerate growth from 8.9% in 2020 to 21.2% in 2021, which then generated income of USD 223.5 million. Within the APAC region, China has a 42.3% share by value, making this the most important market. Over 2021-2028, the market for airport AI robots in the APAC region as a whole is forecast to expand by over 20% annually (The Insight Partners).

Source: EMIS/The Insight Partners Analysis, Krungsri Research

Hospitality: *AI (VR & AI Robots) can welcome visitors and remember guests' face*

- **Current applications:** Most AI hotel applications combine VR with robotics. For example.
  - **VR** can be used to give guests a preview of their hotel accommodation. Thus, Hilton Waikiki Beach uses VR on its own website, and the Shangri La Hotel and Resort sends 360° VR images to business partners and visitors.
  - **Robotics** used by **the Marriot Group** in the form of **'Mario'**, a robot that speaks 19 languages and that can welcome visitors, take orders, help visitors check in and check out, and even sing and dance with guests. In Belgium, Ghent Marriott's Mario provides visitors with detailed information on the city, earning the robot fame as a local celebrity. Meanwhile, Alibaba has developed a robot butler called 'Space Egg' that is used in a hotel in Hangzhou as a robot butler much as any other member of staff, while **Henn Na hotel in Nagasaki** employs micro robots that can remember guests' faces. These serve in guests' rooms and allow guests in and out of their room without their having to use a key.
  - **AI smart rooms** allow guests to control the room's electrical appliances from a single controller or via voice. In 2018, **Intercontinental Hotel Group** joined with Baidu (China's leading AI company) to install 100 AI smart rooms in Intercontinental rooms in cities popular with tourists across China.

Mario Robot at Mariott Hotel



Image from www.hospitalityupgrade.com

Henn Na hotel in Nagasaki

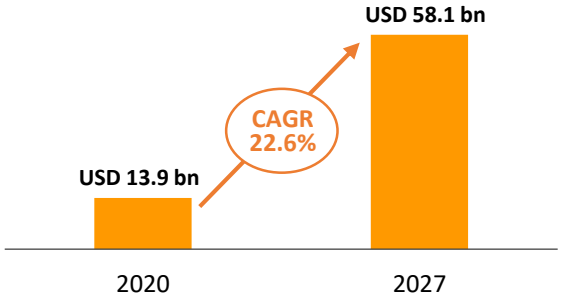


Image from allabout-japan.com.

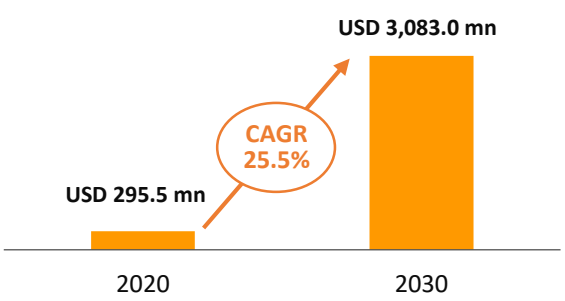
Source: Research and Markets, c3-marketing.de, Krungsri Research

Hospitality: *AI (VR & AI Robots) can welcome visitors…*

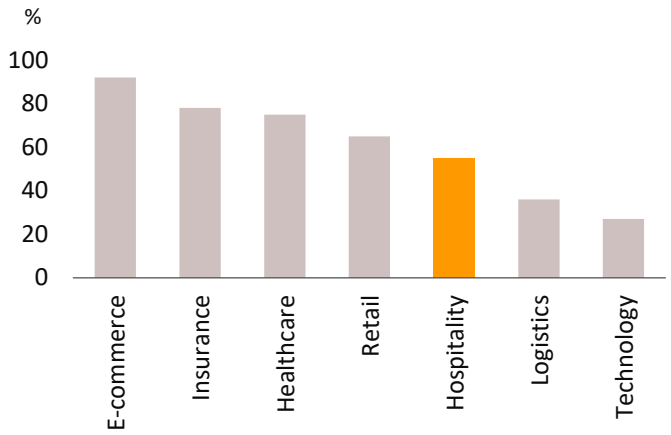
Global Market for Smart Hospitality



Global Market Hospitality Robots



Industries Benefiting from Chatbots



- **Commercial benefits:** Using AI robots to provide services to visitors helps to build benefits for hotel operators in two main ways.
  - Robots can respond directly to customer needs and answer tourists' and travelers' questions, especially when interacting with Gen Y and Gen Z travelers since these groups are often more at ease with technology. Robots also provide an easy way to maintain social distancing.
  - Because they work 24 hours per day, robots may also provide operators with cost savings. For example, Chatbot Magazine estimates that using chatbots in hotels could save up to 30% on the day-to-day costs of providing customer service (https://thenextweb.com).
- **Limitations:** Using robots in hotels incurs significant investment costs. Operators also need to build trust with their guests by investing in secure software systems to ensure that visitors' privacy is respected. Therefore, use of robots is limited to large hotel chains.
- **Market value:** Market value of AI used in the travel and hospitality is estimated to surpass USD 1.2 bn by 2026 growing 9.7% CAGR during 2021 to 2026 as AI can assist most hotels and resorts to deliver excellent customer services by improving personalization, guaranteeing fast response times, even in the absence of staff. Global market for smart hospitality is forecast to record a promising growth of 22.6% CAGR during 2020-2027 (Industryarc.com, Research and markets).

Source: Research and Markets, c3-marketing.de, Krungsri Research

Agriculture: *The use of Robotics help overcome problems with labor shortages, save time, and raise production standards*

- **Current applications:** Robots are beginning to find a wide range of uses in the agricultural sector, including in arable farming, livestock management and fishing. Smart farmers in Canada and New Zealand use fully automated milking parlors, in Germany, France and Spain, robots that can distinguish commercial crops from other plants are used for weed control when growing beans, and beetroot, and in Britain, self-driving tractors are beginning to be used during the harvest.

- **Commercial benefits:** By using robots, farmers are able to overcome problems with labor shortages. Robots also save time, improve the quality of the produce and raise production standards. Some interesting examples of robotics applications include;

  - Over 80% of Canadian dairy farmers have installed automated milking parlors that can rapidly check for illness and infection in commercial herds, in the US, farmers using automated parlors report a 10%-14% increase in per milker yields. While in New Zealand, automated milking parlors are widespread and this has raised yields by 16%-50%, depending on the type of farming that is practiced.

  - Germany: Robotic weed suppression has led to a cut in overheads and a 90% fall in the use of herbicides. Robots also offer farmers the advantages of running on solar power, being able to operate 24 hours per day, and increasing efficiency 6.7-fold relative to human labor, thus generating further cost advantages for operators.

Automatic Milking Systems



Image from www.lely.com

Weeding Robot

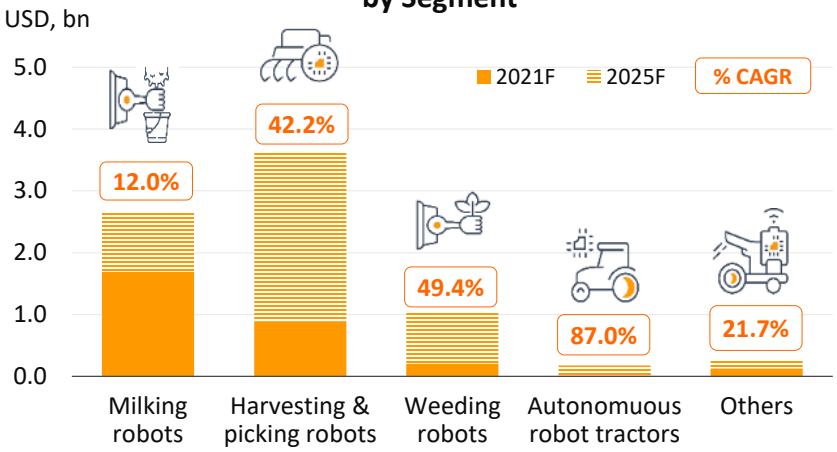


Image from www.futurefarming.com

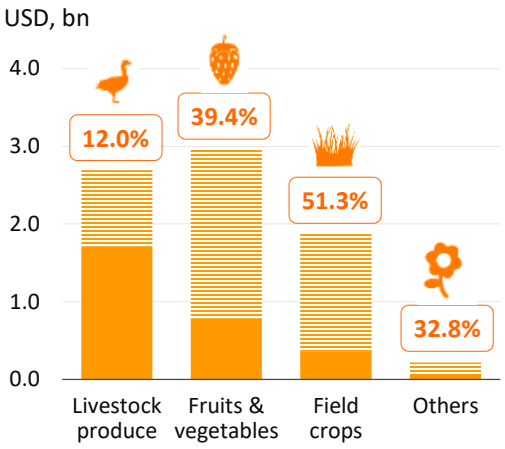
Source: BIS Research, GSMA, The impact of Robotic Milking System, ecoRobotix, Lely, Krungsri Research

Agriculture: *The use of Robotics help overcome problems…*

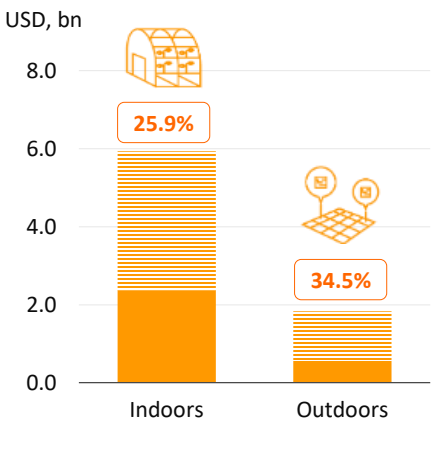
Global Agriculture Robotics Market, by Segment



By Farm Product



By Farming Environment



- Australia: Farmers are using small autonomous robots equipped with intelligent sensors that can distinguish desirable from undesirable plants to locate and to suppress weeds, whether by spraying with herbicides or by physically removing them. Use of these robots results in 90% of weeds being eliminated and a 75% reduction in herbicide use compared to other weed-control techniques.

- **Limitations:** (i) Using robots imposes high purchase, and maintenance costs, and (ii) currently, agricultural robots are only available for some on-farm tasks.

- **Market value:** As of 2021, sales of agricultural robotics are valued at around USD 2.9 billion (+23.7%), with the main markets found in Europe, the US, China and Japan. The most valuable segments are milking, and harvesting and picking robots, but although the markets for autonomous robot tractors and weeding robots are currently somewhat limited, these are forecast to see growth of respectively 87.0% and 49.4% (CAGR) over the period 2021-2025.

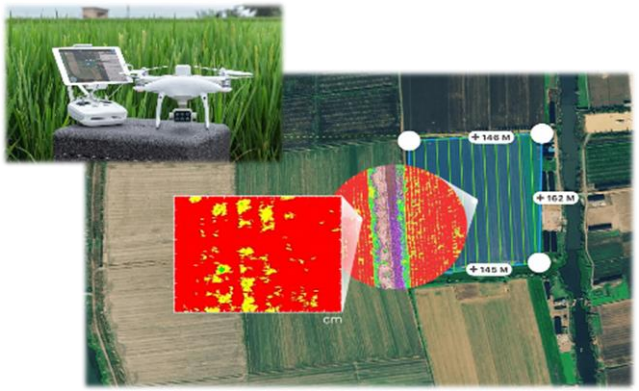
Source: BIS Research, GSMA, The impact of Robotic Milking System, ecoRobotix, Lely, Krungsri Research

Agriculture: *Drone helps farmers to check crop health and livestock movements*

- **Current applications:** Drones are used in almost all on-farm parts of agricultural supply chains, including: (i) soil analysis; (ii) crop spraying; (iii) planting; (iv) weather monitoring; (v) crop scouting; and (vi) irrigation. Smart farmers in the US and Canada are using drones to check crop health and to track the movements of livestock, while in Brazil drones are used to check for the presence of weeds in large soy fields (over 3000 rai/500 hectares).
- **Commercial benefits:** Drones generate time and labor savings for farmers, increase the accuracy of inspections and checks, and reduce the use of herbicides, thus also generating health benefits for farmers. The use of drones may also be extended by linking these to other technologies (e.g., advanced sensors, IoT, AI, robotics, etc.), which then helps to raise regular farm operations to the level of 'precision agriculture' and this therefore boosts yield quantity and quality. Some examples of how agricultural drones are used are given below.
  - **Arable farming:** Large smart farmers in the US, and Europe that use drones to deliver insecticides have recorded task completion times that are up to 40-times quicker than when using human systems, while using drones to check for soil moisture levels has led to over 90% reductions in demand for irrigation water. In Brazil, smart farmers using drones to check for weeds to reduce the amount of herbicide they use by up to 52%.
  - **Livestock farming:** Farmers in Scotland use drones to check the health of sheep and cows that range freely over large areas. This cuts the time taken to complete the task 3-4-fold, while also saving on the costs incurred in cross-country driving looking for the herds.

Agriculture Drone

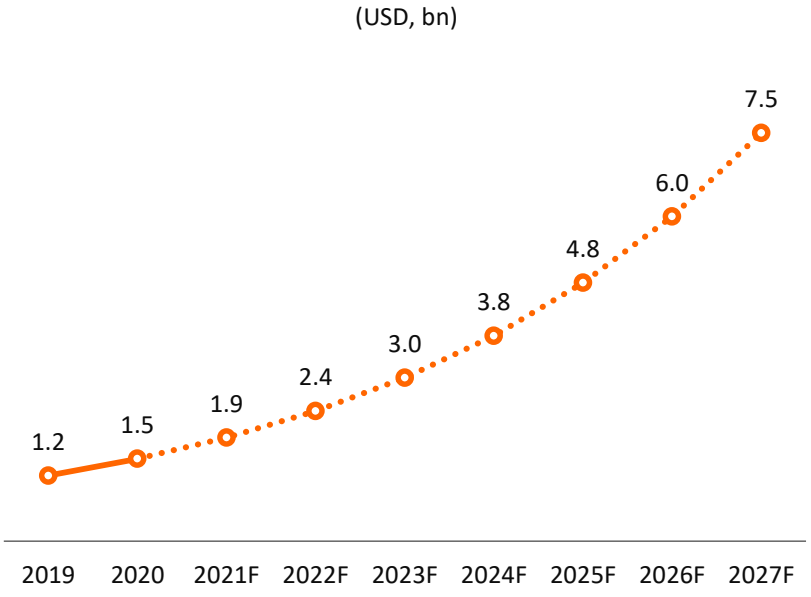




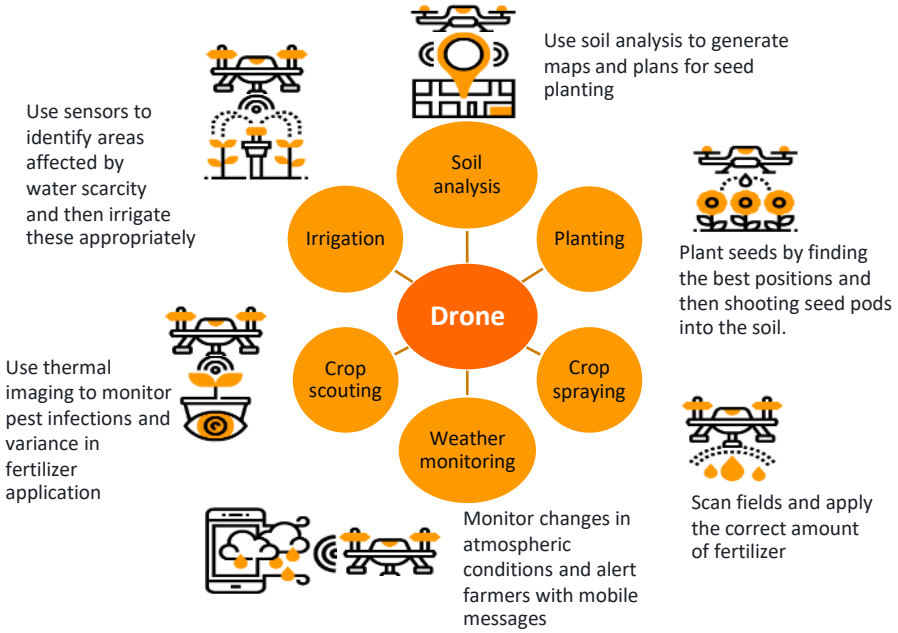
Source: BIS Research, Farm Advisory Service, Riis LLC, Croptracker, ag.dji.com, Krungsri Research

Agriculture: *Drone helps farmers…*

Global Market Value of Agriculture Drones



How Smart Farmers in Major Economies Use Drones



- **Limitations:** (i) Knowledge of agricultural applications for drones remains somewhat limited; and (ii) purchase, maintenance and repair costs can be prohibitive. Local government organizations, agricultural cooperatives and other stakeholders thus have a role to play in developing a sharing economy-type infrastructure that would help support greater investment in and use of drones in the agricultural sector
- **Market value:** The market for agricultural drones is valued at USD 1.9bn in 2021 (+25.7%). This is forecast to grow to USD 3.8bn by 2024 and then to USD 7.5bn by 2027. The US comprises the largest market for agricultural drones, followed by Europe and the Asia Pacific region (BIS research, 2021).

Source: BIS Research, Farm Advisory Service, Riis LLC, Croptracker, Krungsri Research

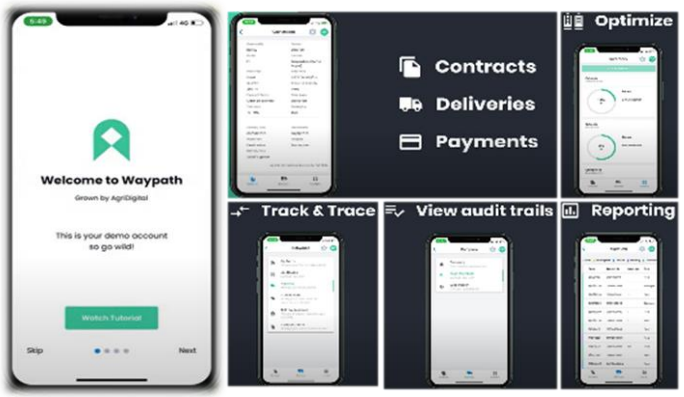
Agriculture: *Blockchain used for supply chain tracking and data management*

- **Current applications:** Global agricultural leaders have found a number of interesting applications for blockchain technology, some examples of which are given below.
  - **Supply chain tracking:** Walmart uses blockchain to check the provenance and history of Chinese pork and Central American mangos. This cuts inspection time from the earlier 6 days to just 2.2 seconds and allows the company to instantly check for the presence of impurities, thus cutting the time and costs involved in returning or recalling substandard goods and reducing the risk of any damage to the company image that might arise from selling poor quality products.
  - **Data and Finance Management:** It is popular in many countries for companies to develop blockchain-based platforms that facilitate near-instant peer-to-peer payments between farmers and buyers of agricultural products (thus side-stepping the need to interact with any 3rd parties, such as banks). These applications link farmers, buyers, and middlemen that undertake a range of tasks including distributing agricultural goods and confirming payments.
  - **Land & Property Ownership:** In Africa, blockchains are used to store land registry details, which can then be leveraged as collateral when applying for loans.
- **Commercial benefits:** Blockchains are benefitting agricultural supply chains worldwide, though their use is concentrated in the US, where they help to reduce overheads related to recalls. The Food Marketing Institute and the Association of Food Manufacturers (USA) has estimated that the cost of these runs to around USD 10 million per year. Other examples of agricultural blockchain applications include:

Agrichain Platform

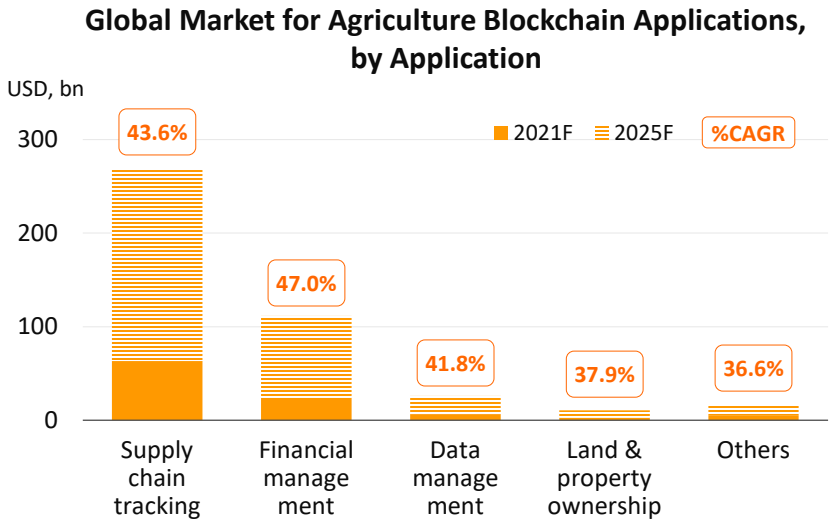


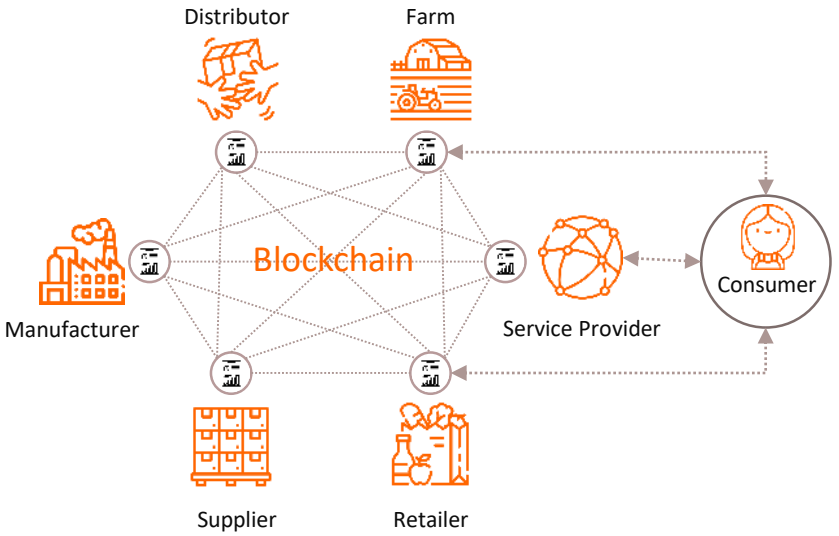
AgriDigital Platform



Source: BIS Research, Agrichain Technologies Pvt Ltd, Blockchainfarm (Nguyen Thi Thuy),epam, Krungsri Research

Agriculture: *Blockchain used for supply chain tracking…*





- **Malaysia:** Agrichain Technologies Pvt Ltd., a Malaysian agri-tech company, believes that within the Malaysian agricultural sector, blockchains help cut the cost of micro financial transactions, which may account for up to 25% of total transaction values. Blockchains also have the potential to reduce procurement costs by up to USD 200 billion, cut food waste by 30 mllion tonnes, and increase income through blockchain-mediated sales by USD 300 billion.
- **Australia:** The major agro-processor AgriDigital has developed a platform to enable the sourcing of inputs from 1,300 farmers, and the latter now supply over 1.6 million tonnes of goods through this. Using the platform has helped to generate total savings for farmers of USD 268.5 million and cut payment times from 1-4 weeks to just 1-2 days

- **Limitations:** (i) The legal framework governing the use of blockchains remains unclear. (ii) Most farmers remain unaware of the benefits from this technology.
- **Market value:** The market is valued at USD 101 billion (+36.1%) as of 2021. Over 70% of the market is accounted for by North America, followed by Europe and Asia. The most important agricultural blockchain are for supply chain tracking, especially for checking compliance with health standards, and financial management, and these two segments are forecast to see growth of 43.6% and 47.0% (CAGR) respectively over 2021-2025).

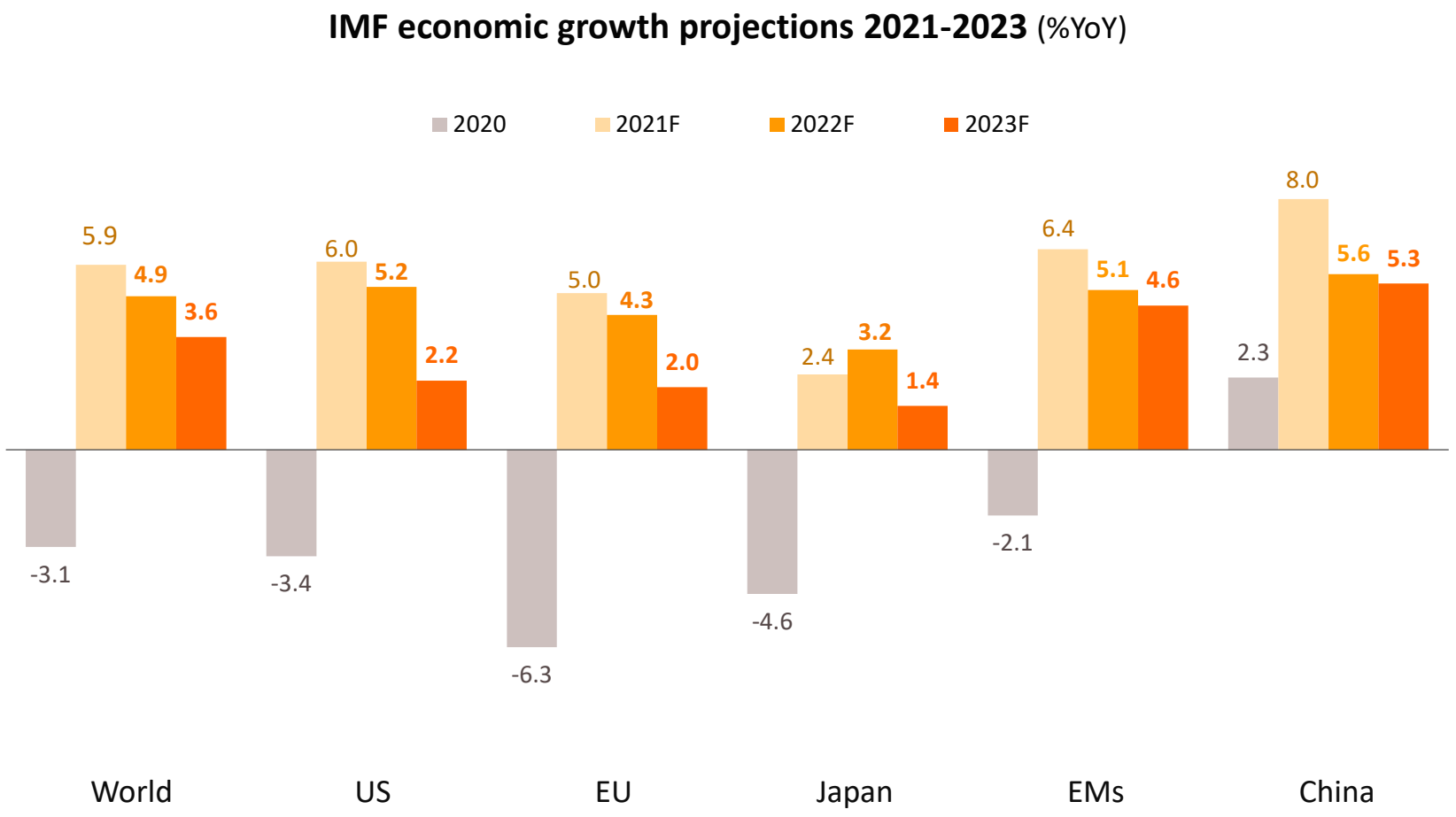
Source: BIS Research, Agrichain Technologies Pvt Ltd, Blockchainfarm (Nguyen Thi Thuy),epam, Krungsri Research



01 TECHNOLOGY TRANSFORMATION (GLOBAL)

02 INDUSTRY OUTLOOK

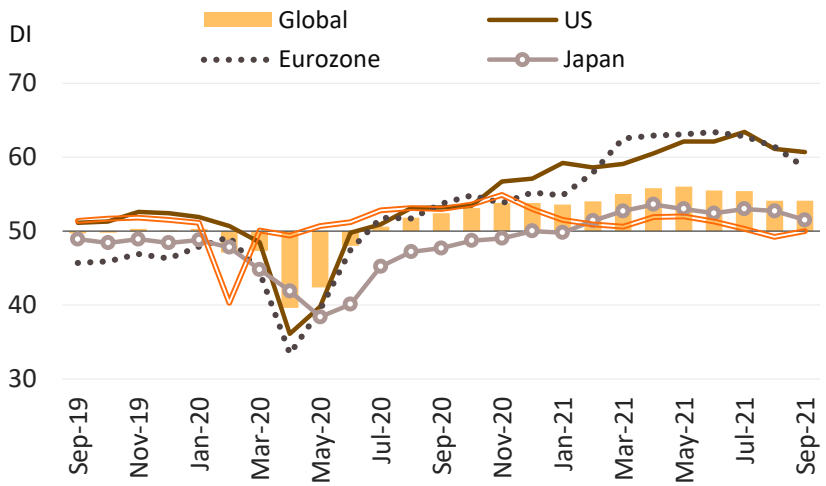
Global: Growth boosted by huge policy supports and major economies' reopening in 2021 but could moderate on policy normalization in 2022-23



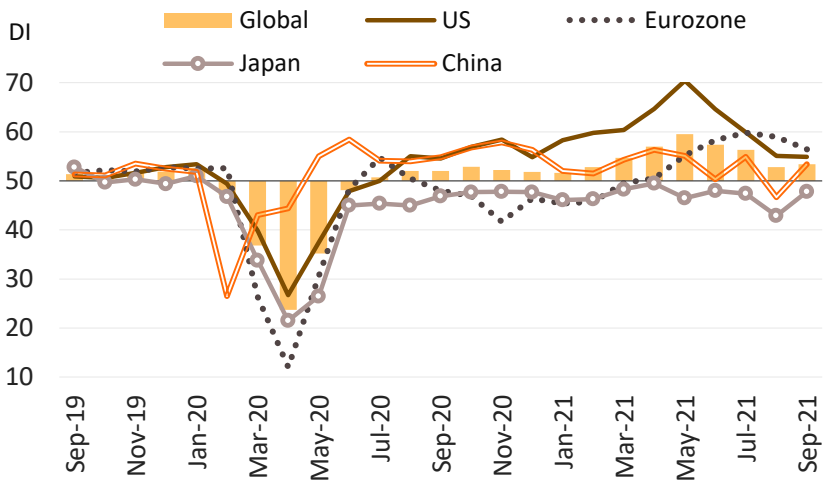
Source: IMF World Economic Outlook as of October 2021, Krungsri Research

Recent supply disruption and rising price pressures weigh on manufacturing sector but easing COVID-19 situation is a tailwind

Manufacturing PMI for Major countries



Services PMI for Major Countries



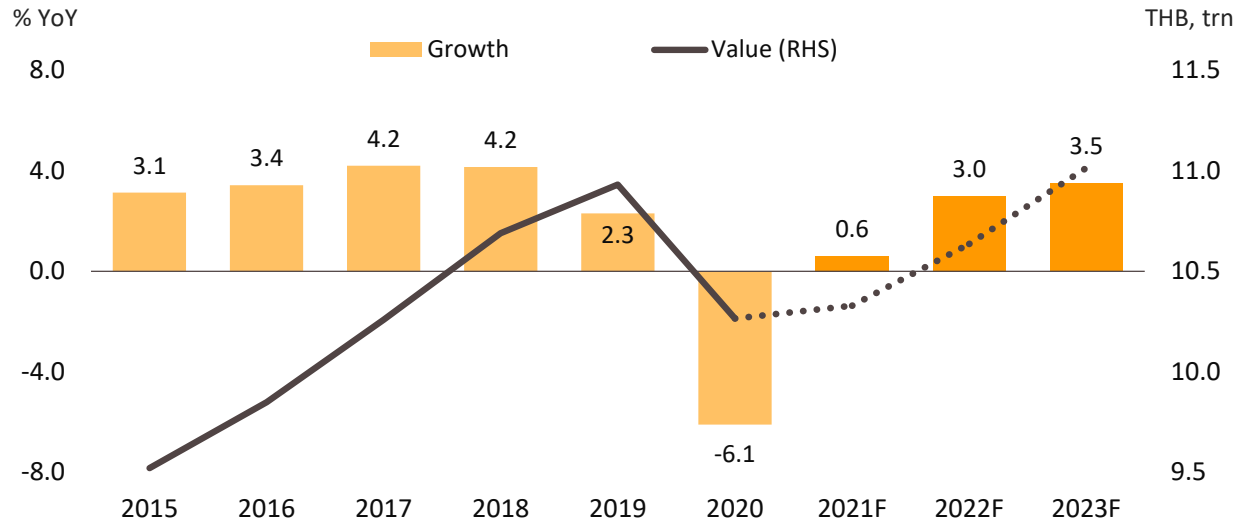
Economic activity is expected to recover gradually given improving COVID-19 situation, large policy supports and increasing adaptability to the new normal although supply bottleneck and rising energy prices could limit the upside of global growth, particularly in manufacturing sector.

- **Global Manufacturing PMI was stable at 54.1 in September,** with rising concern over price pressures and supply disruption. Most key countries saw slower manufacturing growth except China where manufacturing activity picked up because of fewer daily cases and easing restrictions.
- **Global Services PMI rose to 53.4 in September,** led by a rebound in activities in China and Japan given the improving COVID-19 situation.
- Overall, despite threats to growth and inflation, **the global economy continue to improve** as global Manufacturing and Services PMI data remained well above pre-pandemic levels of 50.1 and 51.9 in December 2019, respectively.

Source: Markit, Bloomberg, Our World in Data, Krungsri Research

Thailand: Economy likely to grow only 0.6% in 2021, hit by more severe outbreak; After reopening, growth would improve in 2022-23 but at a gradual pace given lingering economic scars

2021-2023 Thai GDP growth projection

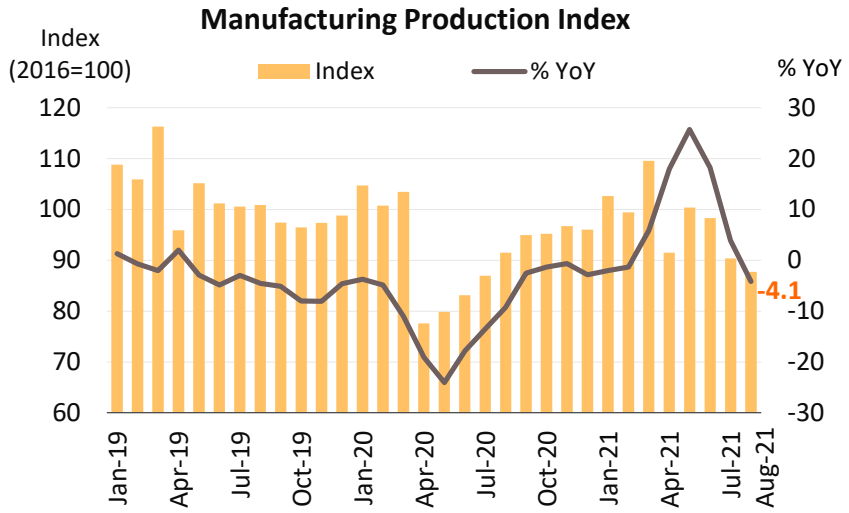


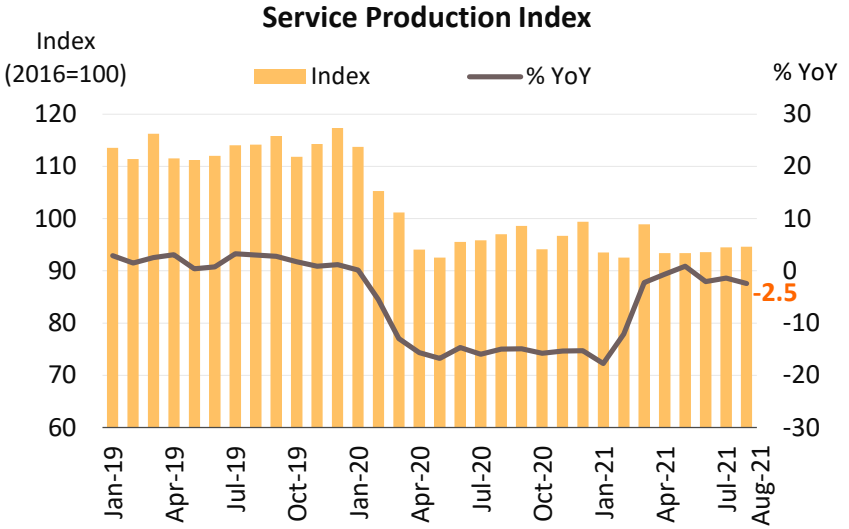
2021: GDP growth is projected at only 0.6%. More-severe-than expected third wave of COVID-19 and strict containment measures in 3Q21 have caused supply disruption, lower income, demand shock, and weaker tourism. While the labor shortage in some sectors hit production and exports in 3Q21, overall export growth this year would benefit from a further recovery in the global economy and a weaker baht. Flooding since September could be a headwind but with limited impact on the overall economy.

2022 and 2023: The Thai economy would recover but at a gradual pace, with growth of 3.0% and 3.5%, respectively. Given Thailand to start reopening to vaccinated visitors amid the improving COVID-19 situation, this will help to underpin a revival in confidence and domestic economic activity. Global recovery would continue to support exports and manufacturing sector. However, economic scars creased by the outbreak coupled with uncertainties over pandemic dynamics and domestic political issues will curb the upside of this recovery.

Source: NESDC, Krungsri Research

Virus resurgence hit manufacturing production in Q3; Rising exports and easing containment measures will support growth ahead





Manufacturing production by industry

Manufacturing Production (%YoY)*	Weight	2020 J	F	M	A	M	J	J	A	S	O	N	D	2021 J	F	M	A	M	J	J	A
All industry	100.0%																				
Food & Beverages	20.3%																				
Automotive	13.8%																				
Petroleum	9.5%																				
Chemicals	9.1%																				
Rubbers & Plastics	8.8%																				
Cement & Construction	5.5%																				
IC & Semiconductors	5.5%																				
Electrical Appliances	3.8%																				
Textiles & Apparels	3.5%																				
HDD	3.4%																				

**Green > 0%, Red < 0% / Darker green (red) indicates stronger (weaker) momentum*

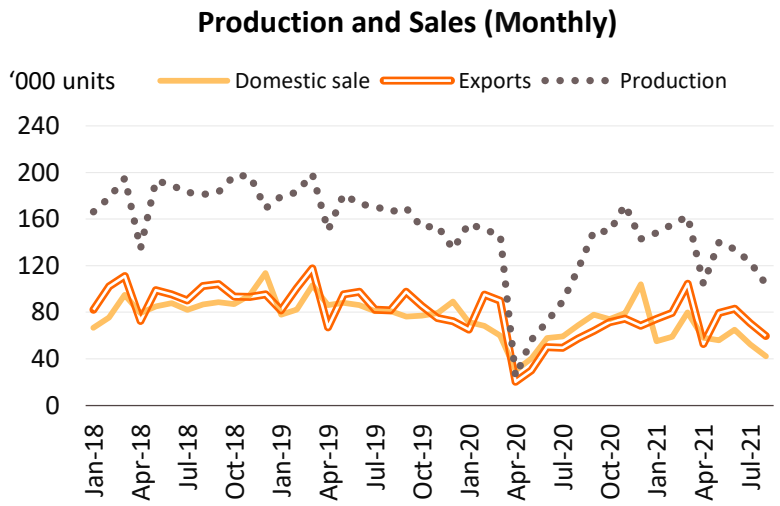
Source: BOT, Krungsri Research

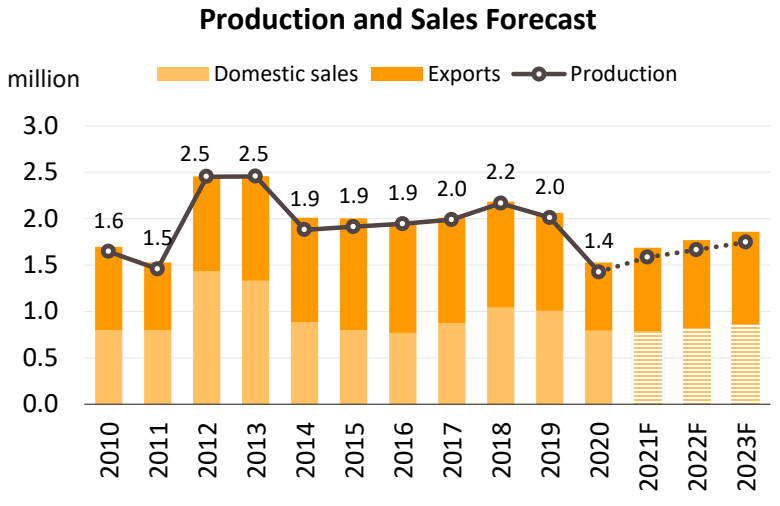
Domestic outbreaks and lockdown measures undermined economic activities in Q3.

- **Manufacturing Production Index (MPI) slowed down in Q3** due to lower demand, supply disruption and labor shortage. The hardest-hit sectors included (i) automobile due to weak purchasing power, supply shortage, and the outbreak in factories; (ii) food & beverage due to a ban on restaurant dine-in; (iii) chemicals due to less demand of construction sector and supply shortage in fertilizer industry; and (iv) electrical appliances due to chips shortage and severe outbreak in the factories. However, production in several industries were still higher than the same period last year.
- **Services Production Index weakened in Q3,** particularly in trading, passenger carriers, hotel and restaurant.

Looking forward, increasing external demand and recovering domestic demand after relaxing restriction and easing labor shortage should improve economic activities in the period ahead. However, global supply bottleneck and rising energy prices could cap growth in many sectors.

Automobile: Demand recovers on improving export markets. Supply disruption from chip shortages expected to ease in 2H22



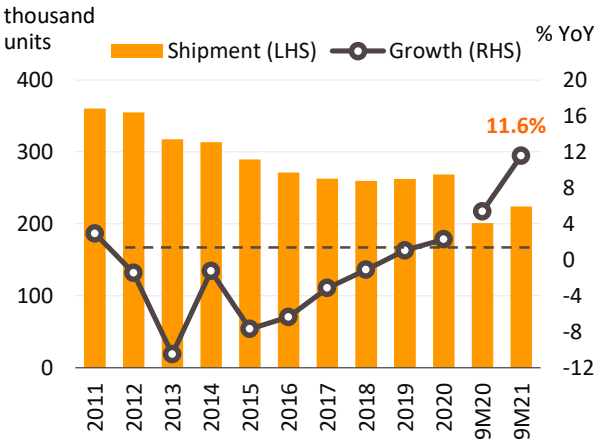


- **In 8M21,** output increased 31.9% YoY. **For all year, it is forecast to rise 10.0-12.0% driven mainly by exports to major markets**.
  - **Domestic sales rose 2.4% YoY**. Sales crashed 11.6% YoY in July and 38.8% YoY in August from earlier strong growth, as a result of (i) declining purchasing power undercut by the sharp rise in Covid-19 cases and (ii) tightened release of new auto loans. **For 2021**, **the growth is forecast to be in the range of -1.0% to 1.0% from continuing weakness in consumer spending power**.
  - **Exports jumped 31.9% YoY due to improving major trading partners' economies:**; Malaysia (229.5% YoY), New Zealand (107.1%), Vietnam (83.8%), Japan (69.7%), and Australia (58.2%) (a combined proportion of 50.7% of total value of auto exports). **Krungsri Research expects that ongoing recovery overseas would continue to support export growth to rise by 21.0-23.0% in 2021**, though the chip shortage will drag on output.
- **In 2022-23,** market growth would be supported by the rollout of vaccines and the easing of Covid-19 pandemic globally. Meanwhile, the chip shortage is forecast to persist until 2H22. **Output of autos is expected to increase by 4.0-6.0% annually**.
  - **Domestic sales are forecast to rise by 3.0-5.0% and 4.0-6.0% in 2022 and 2023 respectively**, supported by (i) improving consumer spending in accordance with economic recovery; and (ii) government's excise tax waive on battery electric vehicles (1 January 2020 to 31 December 2022). Commercial vehicle segment is forecast to be a main driver for growth on higher demand for use in construction, online retail and logistics.
  - **Overseas sales are predicted to increase by 5.0-7.0% and 4.0-6.0% in 2022 and 2023 respectively,** thanks to: (i) continued economic recovery of trading partners; and (ii) the gradual shutting of production facilities in the Philippines from 2019 onwards.

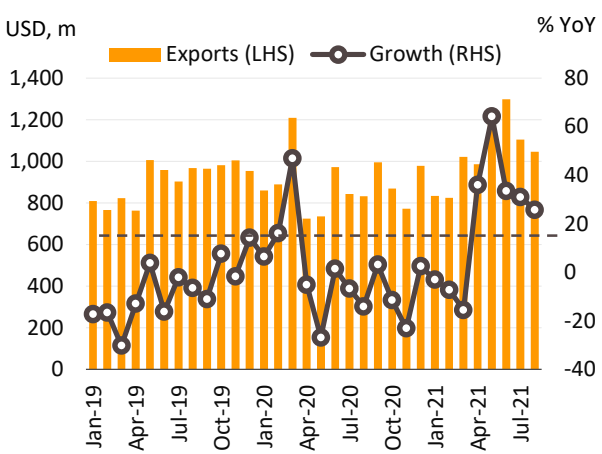
Source: The Federation of Thai Industries (FTI), Krungsri Research

HDD: Increasing demand for cloud computing services and big data storages will support export growth momentum

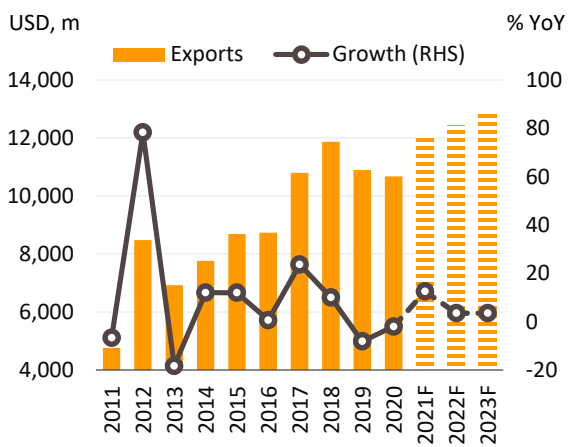
Worldwide PC Shipments



Exports Value (Monthly)



Exports Forecast

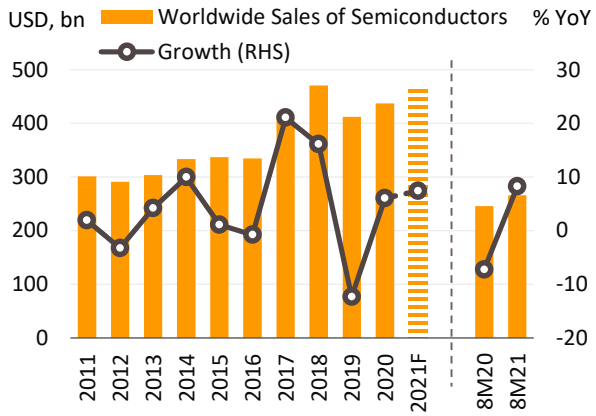


- **In 8M21, export value grew by 17.8% YoY**, mainly driven by shipment to ASEAN countries (+127.6% YoY) EU (+36.2%), Japan (+17.7%, and US (+5.5%), due to increasing demand for high capacity of HDDs for cloud computing and data center services to process big data. Likewise, the world demand for PCs surged by 11.6% in 9M21. For the rest of the year, export value is expected to grow slower due to supply disruption from chip shortage. Therefore, **in 2021, total export value is expected to grow by 13.0-14.0%.**
- **From 2022 to 2023, export value of HDDs will tend to rise by an average of 3.0-4.0% per year,** boosted by;
  - **Rising demand for high-capacity HDDs** that are used to store huge amounts of information on the expansion in working from home and distance learning.
  - **Cost reduction of HDD per storage unit following the development of new technology.** This should benefit Thai players' competitiveness and preserve their export market shares.
  - However, **demand for HDDs used in PC assembly would weaken globally** and HDD manufacturers will face greater competition from alternative products, most notably SSDs.

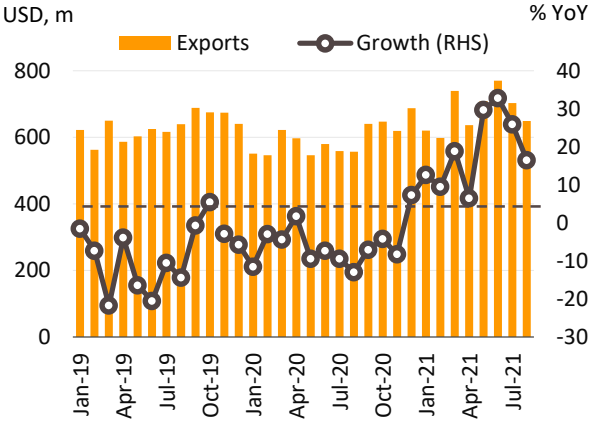
Source: Gartner, Ministry of Commerce (MOC), Krungsri Research

IC: Demand growth in electronics will continue to boost exports

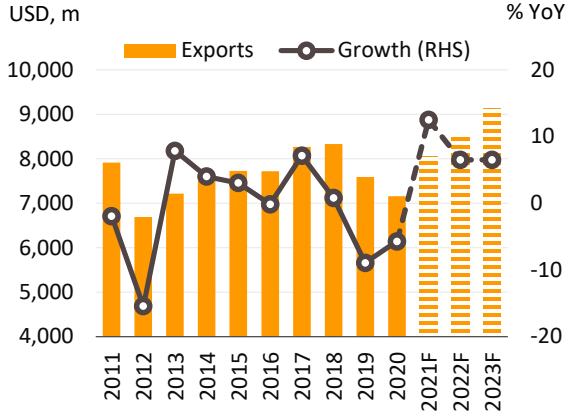
Worldwide Sales of Semiconductors and Forecast



Exports Value (Monthly)



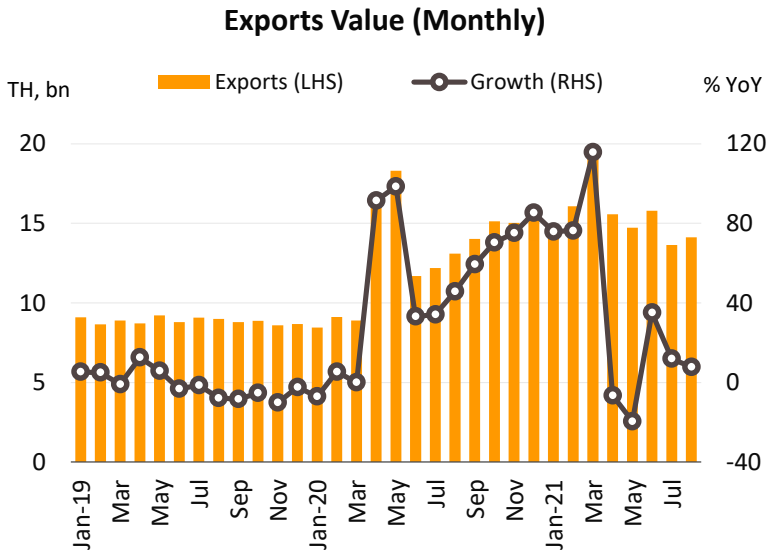
Exports Forecast

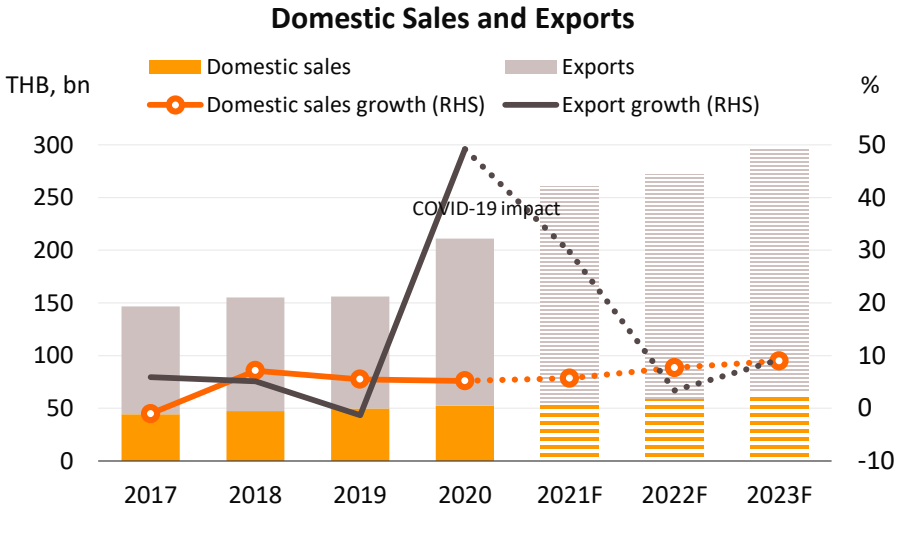


- **During 8M21, export value of ICs grew 19.0% YoY,** driven by accelerated demand to serve learning and working online amid multiple waves of the COVID-19 pandemic. Likewise, semiconductor sales in global market rose by 8.3% YoY. Shipments to ASEAN countries, the US and the EU had a combined proportion of 44.8% of total IC export value**.** In the rest of the year, exports are expected to grew at a slower pace due to chip shortage in Malaysia (major hub for chip testing and packaging). Therefore, **IC exports would grow at 13.0-14.0% in 2021**.
- **From 2022 to 2023, export value is expected to grow by 6.0-7.0% per year,** supported by:
  - **Ongoing trends of working and learning at home:** This will remain support demand for consumer electronics such as PCs, notebooks, tablets, game consoles and smartphones.
  - **Global technology megatrends:** (i) the development of auto technology, especially electric and autonomous vehicles, will require more ICs (up to 150 compared to about 40 in an ICE vehicle); and (ii) the new generation of 5G-compatible smartphones will use around 40% more ICs than 4G devices, especially to link with Internet of Thing (IoT), which will feed into stronger demand for ICs.
  - **Easing shortage of IC and chips in 2022:** IC manufacturers in several countries with substantial indigenous technology industries (e.g., China, Taiwan, the US, and Japan) plan to invest more to boost IC production capacity.

Source: Semiconductor Industry Association (SIA), Ministry of Commerce (MOC), Krungsri Research

Medical Devices: Exports would turn to grow at 8.0% p.a. in 2022-23 following accelerating growth in the previous 2 years



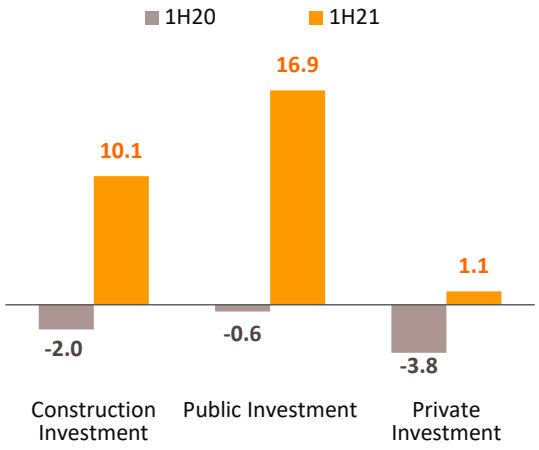


- **In 8M21, production rose significantly, and this was reflected in the 16.7% YoY jump in the index of medical and dental devices manufacturing output.** Exports (70% of all output by the industry) rose at 26.0% YoY, led by 30.3% YoY growth in disposable goods (92.8% of medical devices export by value), and 97.1% YoY increase in latex gloves (59.2%). However, exports of durable goods and of solutions and diagnostic kits slipped by respectively 12.0% YoY and 10.4% YoY. The gradual easing of control measures in Q4 will likely feed into stronger uptake of hospital services, lifting average use-rates for 2021, **and it is expected that for the year**, **the export value of medical devices would strengthen by 25-30% on demand for disposable PPE that is continuing to increase.**
- **During 2022 and 2023, growth in the export value of medical devices is forecast to slow at 8.0% p.a. in dissipation of Covid-19 with the global rollout of vaccines**. **Domestic sales are expected to increase at an annual average rate of 7.5% per year**, supported by: (i) economic recovery in export markets; (ii) demand boosted by a concern on personal health and well-being; (iii) the rising trends of NCDs (especially heart disease, strokes, cancer, and diabetes), and the aging society, which will together increase demand for modern diagnostic equipment; (iv) the return of foreign patients to Thai hospitals; and (v) investment by private-sector hospitals in the expansion of existing facilities and the opening of new branches. However, demand for disposable goods will weaken in the coming period after pandemic eases.

Source: Business Monitor International (BMI), FitchSolution, Medical Device Intelligence Unit (MeDIU), Krungsri Research

Contractors & Construction Materials: Spending on government megaprojects continues to be key driver of growth

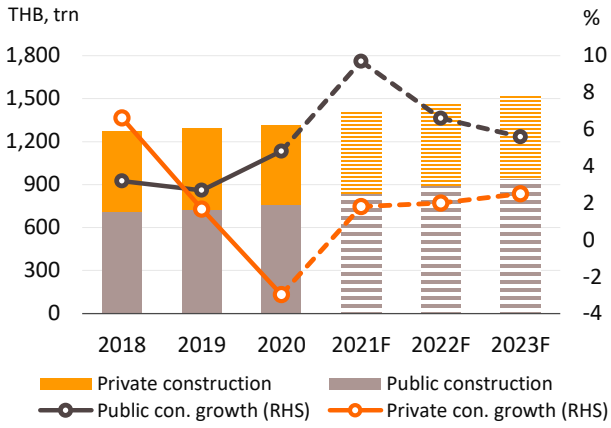
Construction Investment Growth *(%)*



Construction Materials Situation (1H21)

Product	Unit (mn)	Production	Domestic sales	Exports
Cement	Tonnes	20.6	18.7	1.8
% YoY		4.0	4.7	-18.6
Construction steel	Tonnes	2.0	2.1	0.3
% YoY		23.6	18.6	-7.0
Ceramic tiles	Sq.m.	72.0	86.5	10.6
% YoY		17.5	5.3	37.8
Sanitarywares	Pieces	3.8	1.6	2.4
% YoY		15.3	5.0	38.4

Construction Investment Forecast
(at Current Market Price)



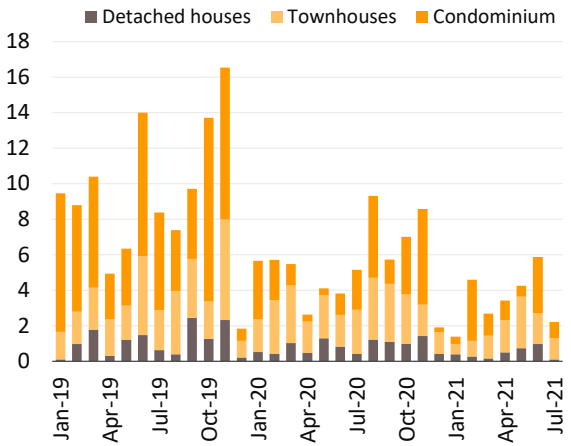
- **In 1H21, the construction sector grew by 10.1% YoY driven mainly by a 16.9% YoY rise in spending by the public sector**. Meanwhile, private-sector construction grew by just 1.1% YoY. This supported growth in domestic demand for construction materials. Sales of cement and construction steel rose by respectively 4.7% YoY and 18.6% YoY, while sales of tiles and sanitary wares were also up by 5.3% YoY and 5.0% YoY. However, the construction sector is likely to be lackluster in 3Q21 due to the decision by the authorities to lockdown the accommodation of migrant workers at construction site. **For 2021, spending on construction is now forecast to grow by 6.0-8.0%, mainly driven by public construction projects.**
- **Through 2022 and 2023**, **overall investment in construction will tend to rise by 4.0-6.0% annually**. The main driving force will come from **public construction investment** which are expected to rise by 6.0-7.0% per year on acceleration of megaprojects especially those connected to EEC (e.g., on phase 3 of the Map Ta Phut port development and the construction of the high-speed rail-link connecting the area's 3 airports). This will then attract additional **private construction investment**, which should grow by an annual average of 2.0-2.5%. The new investment of private sector would focus on residential projects near the new metro lines in Bangkok and in major provinces. With the increase in construction work, demand for building materials will naturally strengthen. In particular, sales of construction steel are expected to be boosted by the government's 'Made in Thailand' scheme, which requires contractors working on government-funded projects to use Thai-produced steel at least 90% of total value (or volume) of total steel used in the project.

Sources: Office of the National Economic and Social Development Council (NESDC), The Office of Industrial Economics (OIE), Krungsri Research

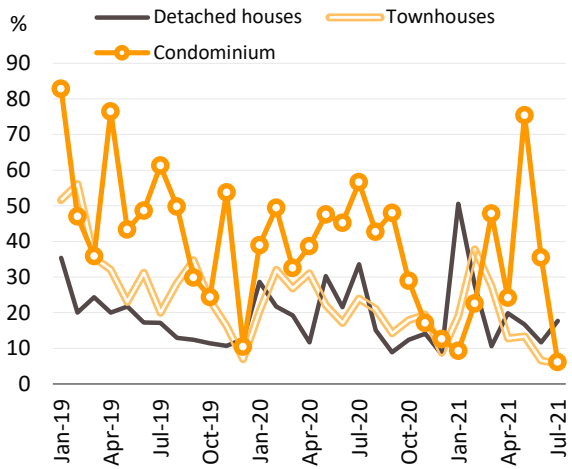
Housing in BMR: Demand would gradually recover in step with improving purchasing power

New Supply

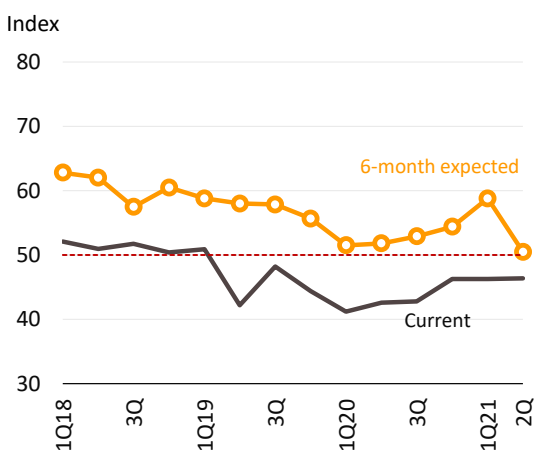
(Units, thousand)



Take-up Rate



Housing Developer's Sentiment Index (HDSI)

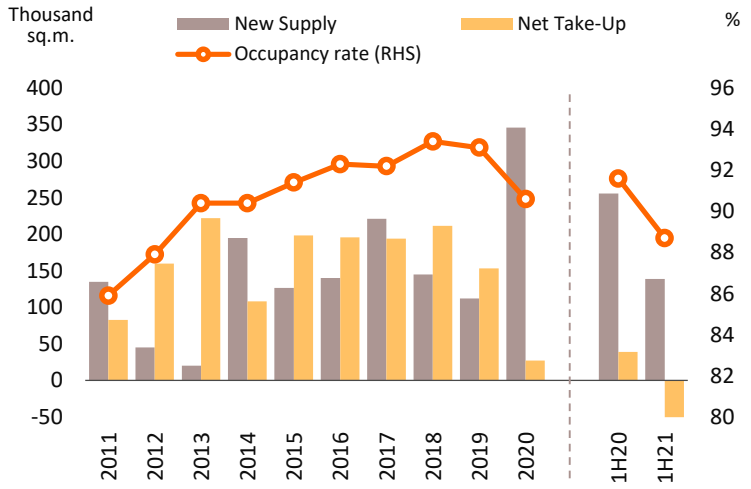


- **Through 7M21, new units launched fell 25.0% YoY to 24,383** as developers continued to hold off work on new projects and instead tried to sell off their stock of unsold properties. Demand has also softened, and this is reflected in a continuation of the weakening take up rate for new units across all segments. Thus, the take up rate stood at 31.6% for condominiums, 17.6% for townhouses and 22.1% for detached houses (compared to average rates for the 2017-2019 of respectively 54.6%, 23.1% and 31.9%). In the rest of 2021, weak purchasing power and high levels of household debt will continue to drag on the market and so **sales of new units in 2021 would be close to those in 2020 level**. Sales would mostly come from low-rise developments that have already been completed.
- **The market is likely to recover gradually in the next 2 years**, helped by a recovery of purchasing power in line with economic growth and the gradual reopening of the country to international visitors. **The supply of new housing is expected to rise by 6.0% per year**, with this split approximately equally between condominiums and low-rise developments. Supply of the latter will steadily rise as developers look to meet growing real demand, while investors will also tend to work on a more diverse range of project types that will include mixed-use developments, wellness residences, housing for the elderly, smart homes and leasehold properties.

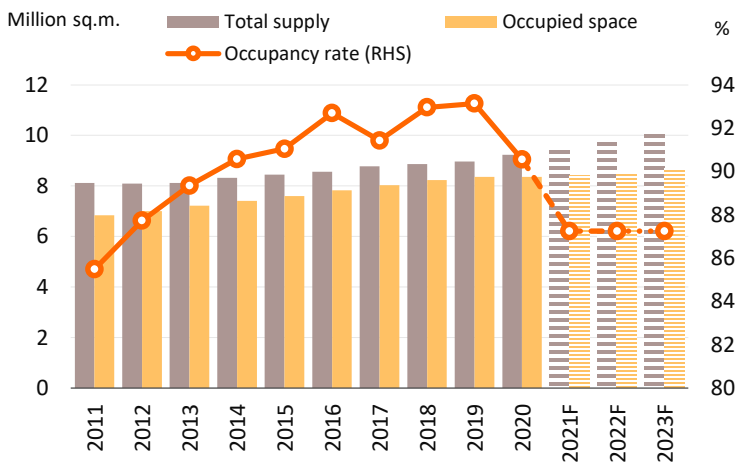
Source: Agency for Real Estate Affairs (AREA), Krungsri Research

Office Buildings: Huge supply and slow demand recovery will lead to a fall in the occupancy rate to multi-year lows

New Supply and Occupancy Rate



Office Space Forecast (BMR)

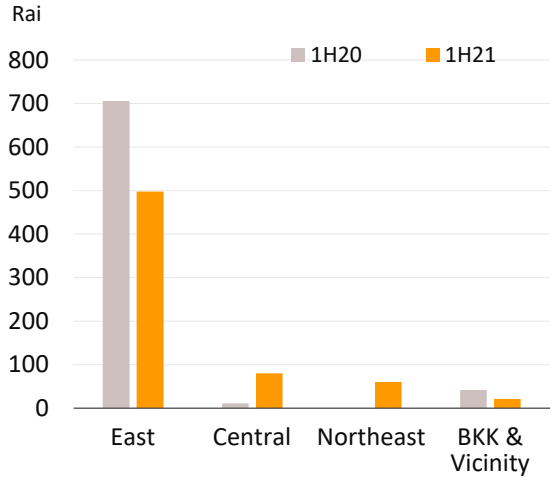


- **In 1H21, demand for space rental fell in the wake of business shutdown**. However, businesses still benefit from demand from e-commerce, technology and health-related businesses, and a rent reduction (to attract more leases). Hence, demand for space rental fell at just 0.6% YoY at 8.3 mn sq.m., while supply rose by 2.5% to 9.4 mn sq.m. The occupancy rate plunged at 88.7%. For the rest of the year, demand is expected to improve gradually in Q4 after a severe impact of lockdown measures in Q3. **For the whole 2021, occupied space is likely to record no growth** or a slight drop of 0.5% to a level of approximately 8.6 mn.sq.m. Meanwhile, **total supply is expected to increase to 9.7 mn.sq.m.** As a result, the occupancy rate would sink at 89% from 90.6% in 2020.
- **In 2022-2023, demand is projected to rise by an average of 1.4-2.1% per year,** compared to an annual average of 2.5% over 2015-2019. That is premised on a rise in purchasing power after the COVID-19 crisis eases. However, **new office space under construction and scheduled for completion is currently projected to add 770,000 sq.m, leading to 4.0% p.a. growth in total supply**. **This will pull down average occupancy rate to 85% in 2023** and make it difficult to increase rents.

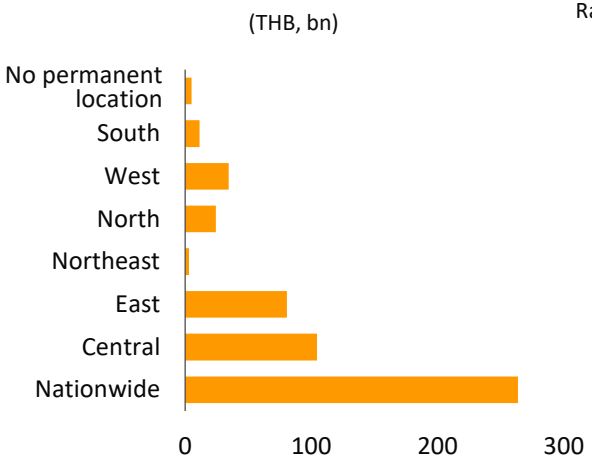
Source: CBRE Research, Krungsri Research

Industrial Estate: Investment tends to increase on acceleration of infrastructure projects focusing on EEC

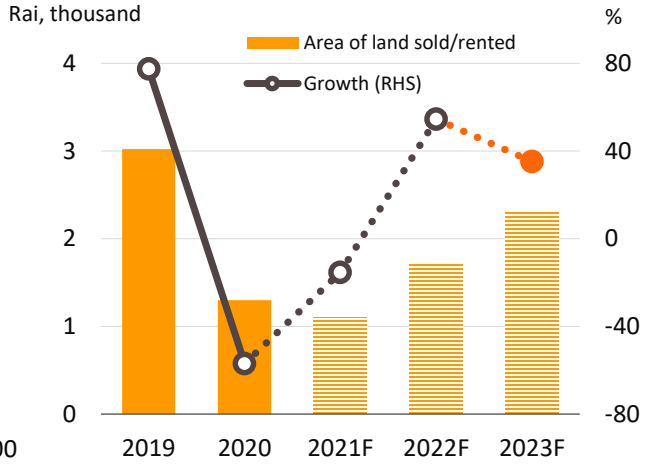
Sold/Rent of Industrial Estates (1H21)



Value of Applications Approved by Location (1H21)



Forecast Sales/Rentals on Industrial Estates

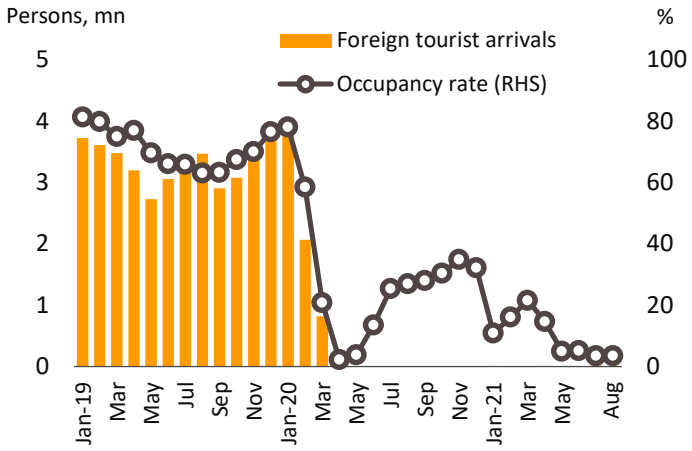


- **Sales and leases of land on industrial estates slumped 13.2% YoY in 1H21** to a total of just 659 rai on severe Covid-19 outbreaks that adversely affected investment plans and prevented foreign investors from coming to Thailand. In the East, a region that contributes 58% of all sales and leases of industrial land, sales recorded the deepest decline of 29.5% YoY (covering just 498 rai) while the value of projects approved for BOI investment also declined by 36.2% YoY. Conditions are expected to remain depressed through 2H21, and **so for 2021 overall, sales and leases of industrial land are forecast to drop 15.4% from their 2020 level to 1,100 rai.**
- **In 2022 and 2023, sales and leases of land are expected to see average growth of around 20% per year to 1,700 rai and 2,300 rai respectively**. These will be supported by: (i) a recovery in the world economy that will lift demand for Thai exports; (ii) progress on government infrastructure projects, leading to more demand for investment especially in EEC; and (iii) rising confidence among foreign investors that will move with a better economic outlook. Some developers are in the process of preparing demand by developing new estates equipped with modern industrial applications and communication system such as Smart Parks industrial estate (2021-2023), the Rojana Nong Yai industrial estate (Chonburi) and the Rayong Egco industrial estate.

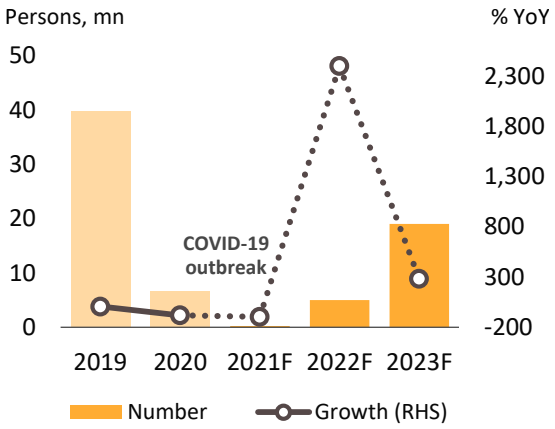
Sources: Real Estate Information Center (REIC), Board of Investment (BOI), Krungsri Research

Hotels: Foreign tourist arrivals would turn to a normal level in 2025

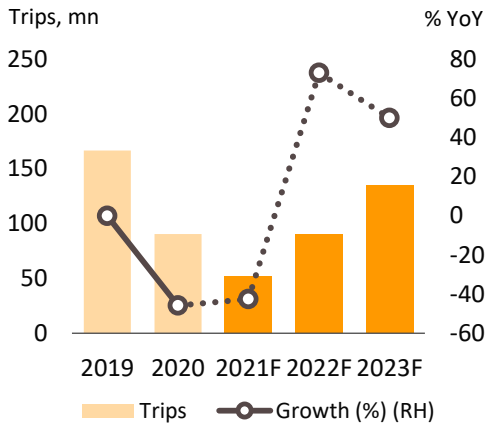
Foreign Tourist Arrivals & Occupancy Rate



Foreign Tourists Forecast



Thai Tourists Forecast

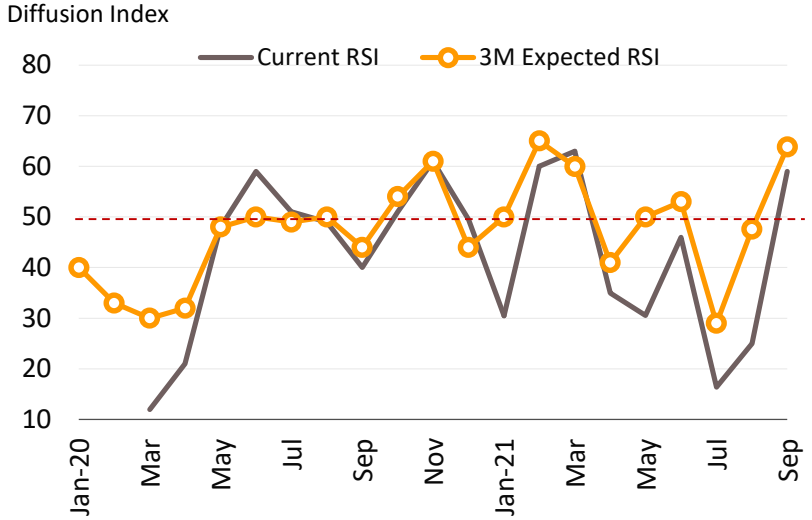


- **The 8M21, tourism has been severely disrupted** by (i) repeat waves of COVID-19; (ii) the slow progress of the vaccination program; (iii) Thailand's appearance on EU and US red lists for travelling; and (iv) the ban on outbound travel in the major markets of China, India, Japan and South Korea. Domestic tourists; thus, declined 42.7% YoY to 25.9 million trips. Meanwhile, foreign tourists collapsed 98.9% YoY to just 73,608 arrivals. Thus, hotel occupancy rate averaged just 10.0% YoY. However, in the rest of 2021, the acceleration in the rollout of vaccines and government tourism stimulus measures [including lifting curfews in 17 provinces including Bangkok (from Oct 31, 2021), reopening of Thailand to foreign visitors from 46 COVID-19 low-risk countries (effective from Nov1, 2021) and 'We Travel Together Phase 3' scheme to promote domestic tourism (open for registration on Sep 24,2021 – Jan 31,2022)] will help to support recovery . **For 2021, foreign arrivals are expected to reach 200,000 (-97.0%), while domestic tourists are projected to take 52.0 million trips (-42.5%). As such, the hotel occupancy rate should average 14.0-15.0%, compared to 29.5% in 2020**.
- **In 2022-2023, the hotel industry should see a recovery. Foreign arrivals are forecast to increase at 5.0 million in 2022 and 19.0 million in 2023. Domestic tourists are predicted to make respectively 90 million and 140 million trips respectively.** The main factors supporting: (i) progress with COVID-19 vaccination programs, which will help to reestablish confidence among tourists in many countries; (ii) the reopening of international travels and the relaxation of pandemic control measures as vaccinations are likely to achieve completion and herd immunity is reached; and (iii) strong pent-up demand that will be released in the post-pandemic environment. As a result, the occupancy rate may gradually rise at around 45% as at the end of 2023. Given a gradual recovery, the number of foreign tourist arrivals is expected to meet pre-COVID level in 2025.

Sources: Ministry of Tourism and Sports (MOTS), The Tourism Authority of Thailand (TAT), Krungsri Research

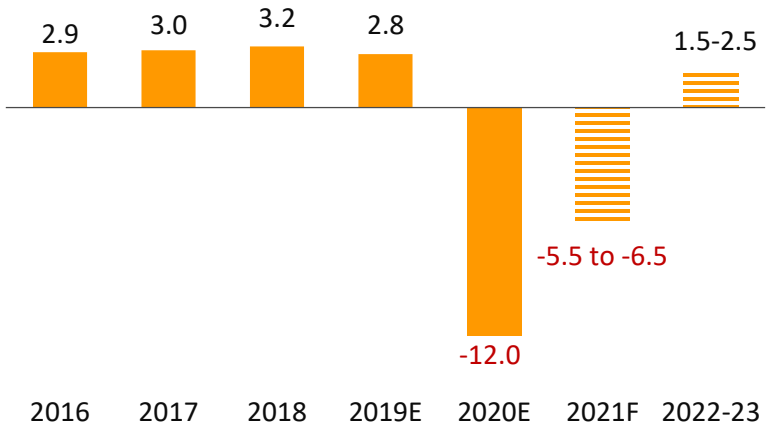
Modern Trade: Sales expected to improve on eased control measures and the return of tourists

Retail Sentiment Index (RSI)



Retail Business Growth

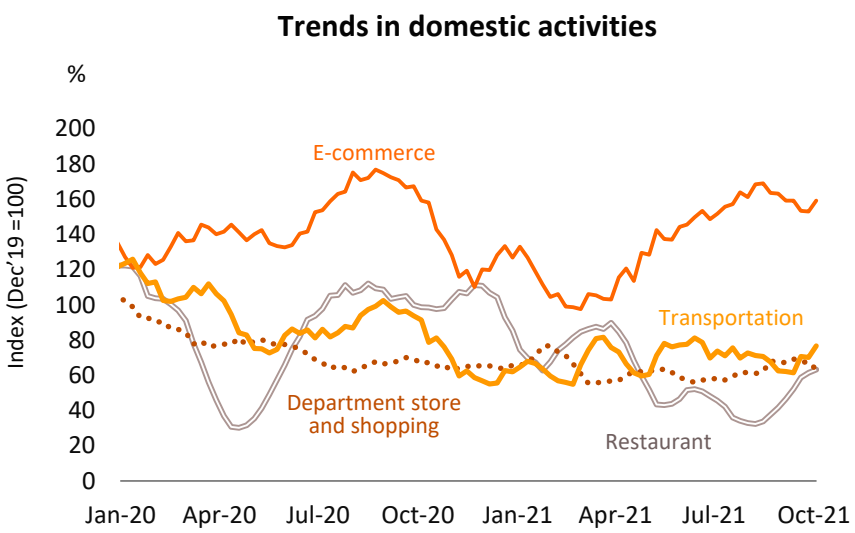
(% per annum)

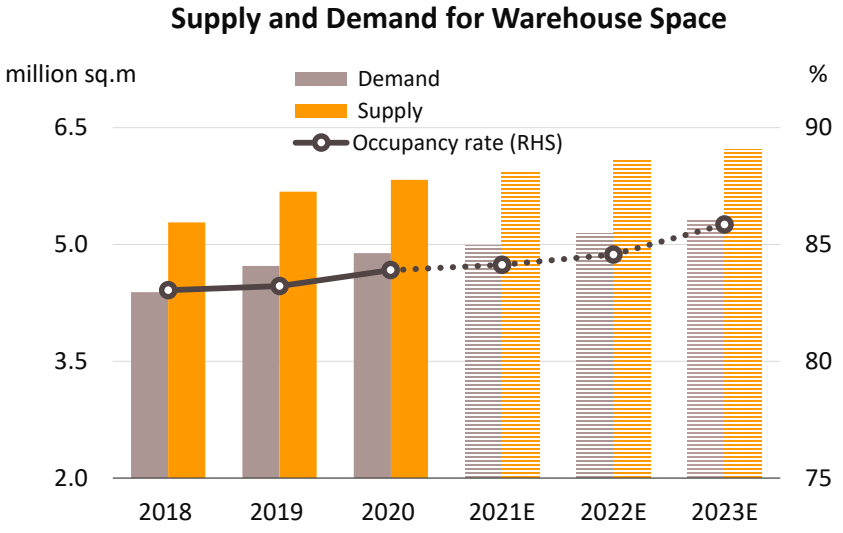


- In 9M21, retail trade was severely depressed on lockdown measures (curfews and temporary closure of shopping malls) to contain the spread of virus. However, for Q4, it is likely to somewhat improve boosted by (i) the easing of control measures that help improve economic activities and (ii) the reopening in popular tourist destinations that help stimulate tourist spending. Therefore, sales of convenience stores, discount stores, supermarkets and hypermarkets, that focus on consumer necessities, will gradually increase. Meanwhile, department stores will be affected by weakening demand for luxury goods. **For all of 2021**, **total sales are likely to contract by 5.5% and 6.5%, compared to a 12% contraction in 2020.**
- **For 2022 and 2023**, **sales are forecast to rise by 1.5-2.5% annually**, supported by: (i) somewhat economic recovery following the gradual lifting of control measures; (ii) an increase in the number of foreign arrivals that is forecast to reach 5 million in 2022 and 19.0 million in 2023 (from a 97.0% contraction or 200,000 tourists in 2021); (iii) progress on new infrastructure projects that will spur the expansion of adjacent communities and stimulate greater spending; and (iv) growth in the CLMV economies, which will stimulate stronger sales in border regions.

Source: Thai Retailers Association (TRA), Bank of Thailand of Thailand (BOT), Krungsri Research

Warehouse Space for Rent: Operators will benefit from a rebound in exports and e-commerce boom



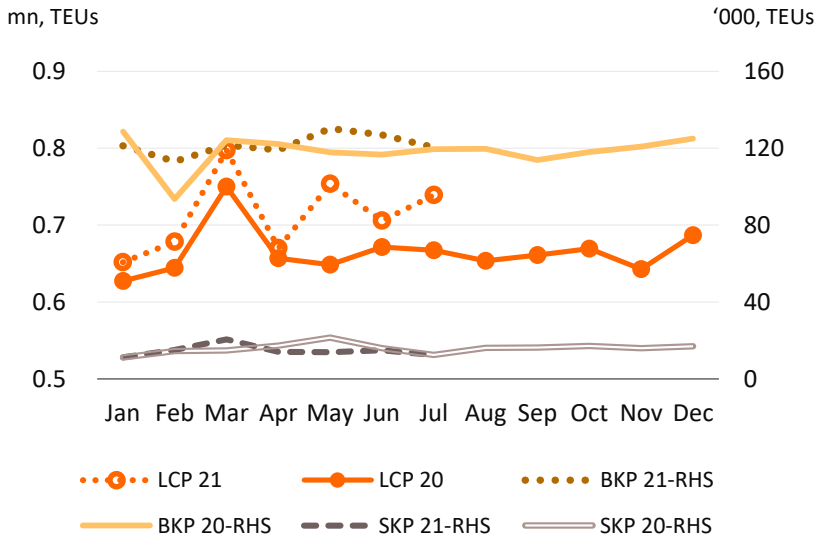


- **In 1H21, warehouses had new contact lease of more than 150,000 sq.m.** (source: Colliers). Growth in demand has come from (i) strong growth in e-commerce; (ii) a recovery in exports of many product groups including processed food, medical equipment and supplies, and packaging. In addition, the Covid-19 pandemic has also encouraged some businesses to delay investments in their own properties and instead to rent warehouse space. In the rest of the year, warehouse operators are expected to enjoy an improving business environment, especially for players offering built-to-suit units and modern warehouse spaces. **For 2021 overall, total demand for warehouse space is forecast to come to 5.05 million sq.m. (+3.4%), with supply running at 5.96 million sq.m. (+2.3%). Consequently, the occupancy rate would edge up slightly to 84.7% from 83.9% in 2020**.
- **For 2022 and 2023, demand is expected to escalate by an average of 3.5% per year**, helped by: (i) economic recovery that will feed into greater activity in manufacturing and sales; (ii) spending on government megaprojects, which will stimulate demand for warehouse space in new areas; and (iii) an increasing preference among consumers for the 'new normal' of shopping online, which will encourage players to take on more warehouse space. Given these tailwinds, **the area of warehouse space rented out will rise by some 2.7% per year, while the occupancy rate is expected to climb to an average of 85.6%**. Major new entrants to the market will tend to develop 'built to suit' properties to meet rising demand in the coming period.

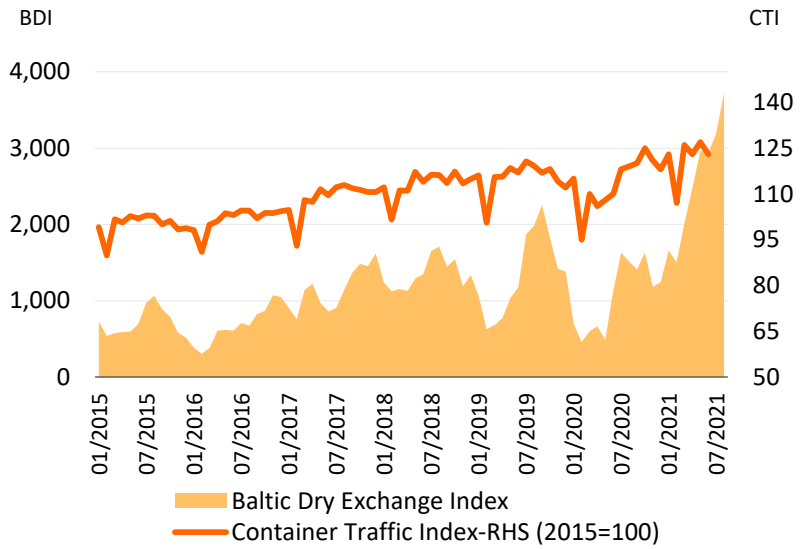
Source: WHA Premium Growth Real Estate Investment Trust (WHART),Google, Krungsri Research

Sea freight services: Income boosted by global economic recovery and still-high freight rate

Container Throughput Volume By 3 major ports (Monthly)



Freight Rate Index

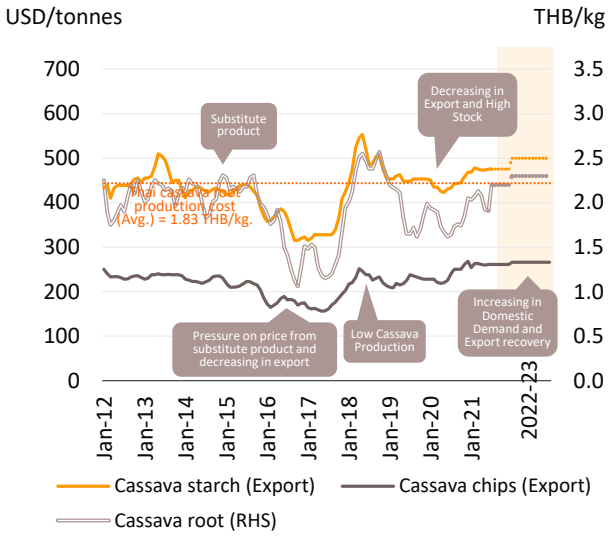


- **Through 8M21, sea freight operators benefited from recovery in the world trade and high freight charge**. The spread of COVID-19 pandemic and strict containment measures causes logistics to take longer period and shortage of vessels and containers. On a yearly basis, the BDI rose by 183% while 20-foot and 40-foot containers, prices jumped by an average of 205% and 188% for Thai-US (West coast) shipping, by 726% and 709% for Thai-European shipping, and 110% and 147% for Thai-China shipping**. These shortages are likely to persist for the rest of the year and this will then help to support a continuation of these strong price increases.**
- **In 2022 and 2023, sea freight companies will benefit from a number of positive factors**. (i) The WTO predicts global trade would average 6.2% per year, which will then support greater demand for exports. (ii) Investment in utilities and infrastructure will pick up across Asia, especially water transport (e.g., for canals/transportation channels and dry and deep-sea ports). **The shortage of container and shipping is expected to ease in the second half of 2022.** However, some point of concerns include rising costs due to higher oil prices and the additional overheads entailed in meeting IMO standards.

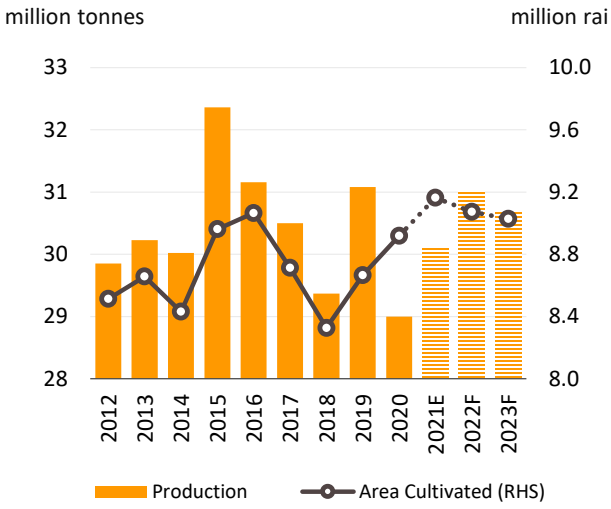
Note: IMO= International Marine Organization
Source: Ministry of Commerce (MOC), Krungsri Research

Cassava: Strong demand from China continues to support export growth

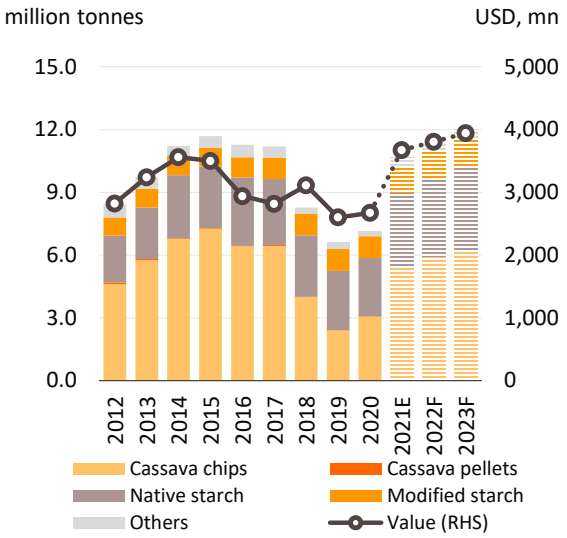
Thai Cassava Price



Cassava Root Production



Cassava Product Exports

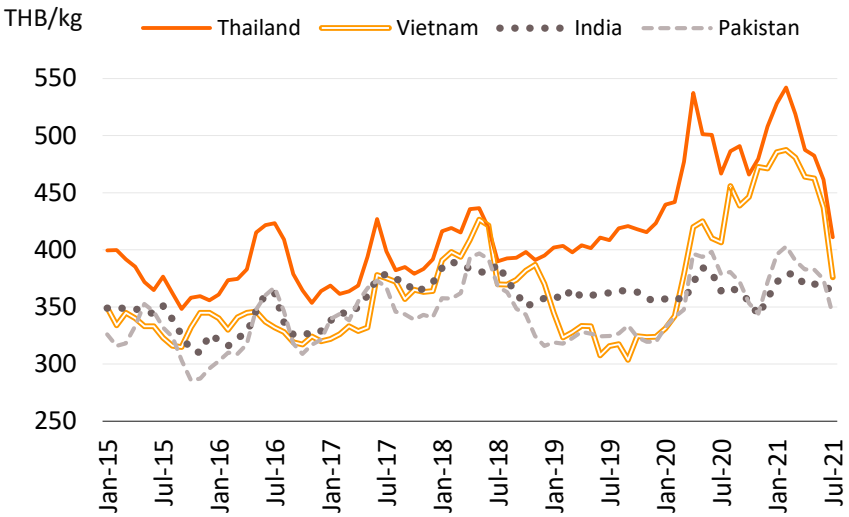


- **In 8M21, the export volume jumped 44.1% YoY while export prices of cassava chip and cassava native starch rose by 16.6% and 9.2% YoY, respectively.** The market was buoyed by stronger demand from China used in place of corn to produce alcohol, and for use as an input into food processing and the production of animal feed, sweeteners and citric acid. During the remaining 4 months of 2021, demand from China would continue to grow robustly. Therefore, **overall export volume for 2021 is forecast to grow by 48.9%.**
- **In 2022 and 2023, export volume is forecast to climb by an average of 5.0-6.0% on continuing strong demand from China**; prices for corn are forecast to stay high and cassava will thus be used as a lower cost input into the production of alcohol. **Outputs of fresh cassava are forecast to increase by an average of 1.0-2.0% annually,** helped by (i) an expansion in the total area cultivated; (ii) better water management; (iii) control of outbreaks of leaf mosaic disease; and (iv) a more favorable long-term weather forecast. In addition, the likely strong price of cassava in 2021 and income guarantee scheme for farmers will attract farmers to expand their production. However, stiff competition from suppliers in Cambodia and Lao PDR (which enjoy lower production costs) will remain a point of concerns.

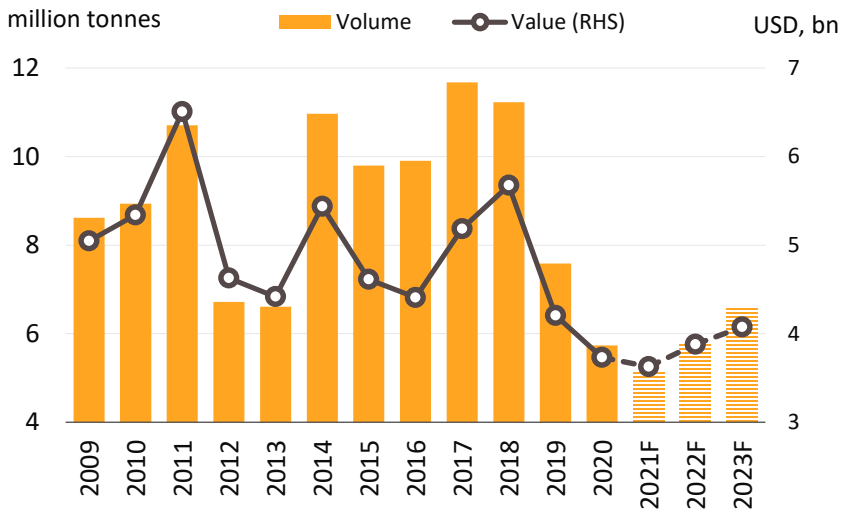
Source: U.S. Department of Agriculture (USDA), Office of Agricultural Economics (OAE), MOC, Tapiocathai, Krungsri Research

Rice: Exports expected to improve on lower prices and government stimulus measures

World White Rice 25% Prices (F.O.B.)



Thai Rice Exports Forecast



- **In 7M21, exports of Thai rice crashed 22.4% YoY** due to: (i) export prices that were higher than those of Vietnamese, Indian and Pakistani products; (ii) a shortage of container capacity, which then delayed exports; and (iii) a switch among trade partners to buying soft rice from Vietnam, rather than Thailand. However, yields should increase in Q4 thanks to heavier rainfall, and this will help to bring prices back to a level that makes Thai rice competitive with other major exporters. In addition, Thai rice exports also benefit from ongoing demand in some markets such as Africa, the Middle East and Asia. **For 2021 as a whole, exports should slightly decline to a total of 5.1-5.3 million tonnes (compared to 5.7 mn tonnes in 2020).**
- **For 2022 and 2023, rice exports are expected to rise to 5.8-6.3 million tonnes**. Factors supporting this outlook include: (i) improving purchasing power in trading partner countries; (ii) government help for farmers (e.g., income guarantee schemes for rice growers) and better access to water, which will boost yields and pull down prices to more competitive levels; (iii) stronger demand from hotels and restaurants as the Covid-19 crisis abates; and (iv) additional government assistance that will include moves to open up new G2G markets (with Indonesia and Bangladesh).

Source: Food and Agriculture Organization (FAO), MOC, Trademap, Krungsri Research

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