Photonics
For Advanced
Manufacturing Plus
by PIMAP+ partnership

D2.3 Market trends analysis in Asia

January 2021

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PIMAP+ PROJECT

The PIMAP+ consortium has been set up to support 6 leading European clusters, their SMEs and regional ecosystem actors to strengthen cross-sectoral cooperation in the fields of photonics, advanced manufacturing, metalworking and aerospace industry.
The PIMAP+ project is a follow-up of the successful activities implemented in the PIMAP Partnership Strand 1 project funded under the COSME programme. After two years of action-oriented project implementation and a solid internationalisation strategy, the partners seek to move to another level and accelerate access to international markets for SMEs and to support the development of business agreements and B2B cooperation.
In addition to the United-States and Canada, already targeted in the first stage, the consortium will also address the Asian market through one business mission in China and one in Japan.

The specific objectives of PIMAP+ are:

- To support cross-sectoral cooperation among cluster organisations and SMEs
- To foster SME engagement and SME internationalisation
- To establish cooperation agreements with international business and research intermediaries in countries beyond Europe
- To create a European identity and explore the possibility to establish a metacluster
- To monitor the achievements of the PIMAP+ project and its SMEs via a set of indicators
- To develop a long-term exit strategy ensuring the sustainability of the PIMAP+ project

PIMAP+ partners:

Number	Name	Short name	Country
1 (Coordinator)	ALPHA-Route des Lasers et des Hyperfréquences	ALPHA-RLH	France
2	TRIPLE STEELIX	TRIPLE STEELIX	Sweden
3	PRODUTECH	PRODUTECH	Portugal
4	MORAVIAN AEROSPACE CLUSTER	MAC	Czech Republic
5	AFIL	AFIL	Italy
6	BUISNESS JOENSUU	BJOE	Finland

EXECUTIVE SUMMARY

In a report[1] published in May 2020 and addressing the role of SMEs in extra-EU exports, the European Directorate General for Trade suggests that more than 700 000 EU27 companies sold goods outside of the European Union in 2017. Out of all these companies, around 615 000 were small and medium-sized. These SMEs exported goods account for 28% of extra-EU exports, worth 476 billion euros this year. They conclude that EU exporting SMEs support over 13 million jobs in Europe, with goods and services exports having a comparable contribution.

Today, the European Photonics industry, comprised of mainly SMEs, is fast-growing and thriving: there are an estimated 5000 companies that have created more than 300,000 highly skilled jobs in this sector alone with an annual turnover in excess of 60 billion euros. With a compound annual growth rate (CAGR[2]) of 6.2%, the European photonics industry is growing four times faster than the European GDP (Figure 1).
Photonics is the science and technology of generating, controlling, and detecting photons, which are particles of light. Photonics underpins technologies of daily life from smartphones to laptops to the Internet to medical instruments to lighting technology. Even if we cannot see the entire electromagnetic spectrum, visible and invisible light waves are parts of our everyday life. Photonics is everywhere (Figure 2); in consumer electronics (barcode scanners, DVD players, remote TV control), telecommunications (internet), health (eye surgery, medical instruments), manufacturing industry (laser cutting and machining), defense and security (infrared camera, remote sensing), entertainment (holography, laser shows), etc.

Europe is one of the leading players in the global photonics market, ranking only second after China. Photonics technologies are key enablers for future mega-markets such as Internet of Things (IoT), cybersecurity, quantum technologies, healthcare and additive manufacturing among others. Photonics technologies will become increasingly embedded in future products and services because they are often the only means of achieving specific performance requirements; but even where there are competing technologies, the photonics solutions tend to be faster, more accurate or precise and use radically less energy. The advantages of photonic solutions mean that they are used to drive innovation in almost every sectors.

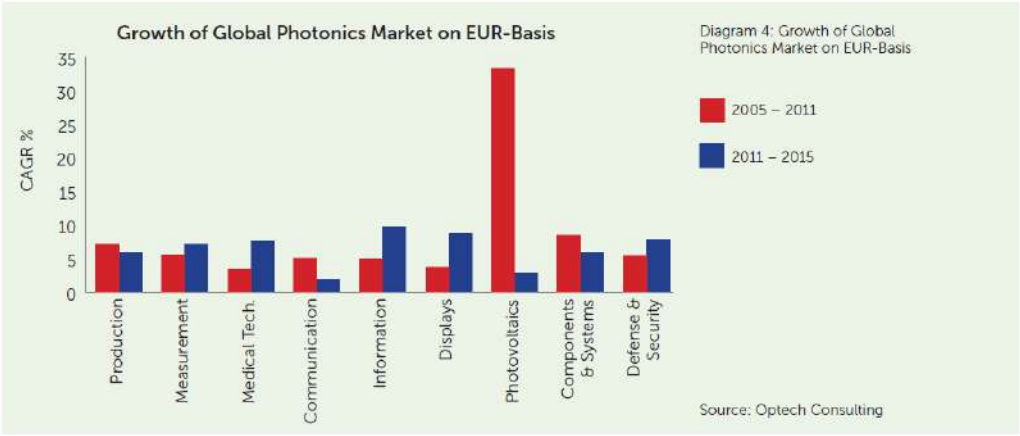


Figure 1: Growth of Global Photonics Market

[1] The role of SMEs in extra EU exports: key performance indicators, DG Grow: chief economist note, May 2020. https://trade.ec.europa.eu/doclib/docs/2020/june/tradoc_158778.pdf

[2] Compound annual growth rate (CAGR) is the rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each year of the investment's lifespan.

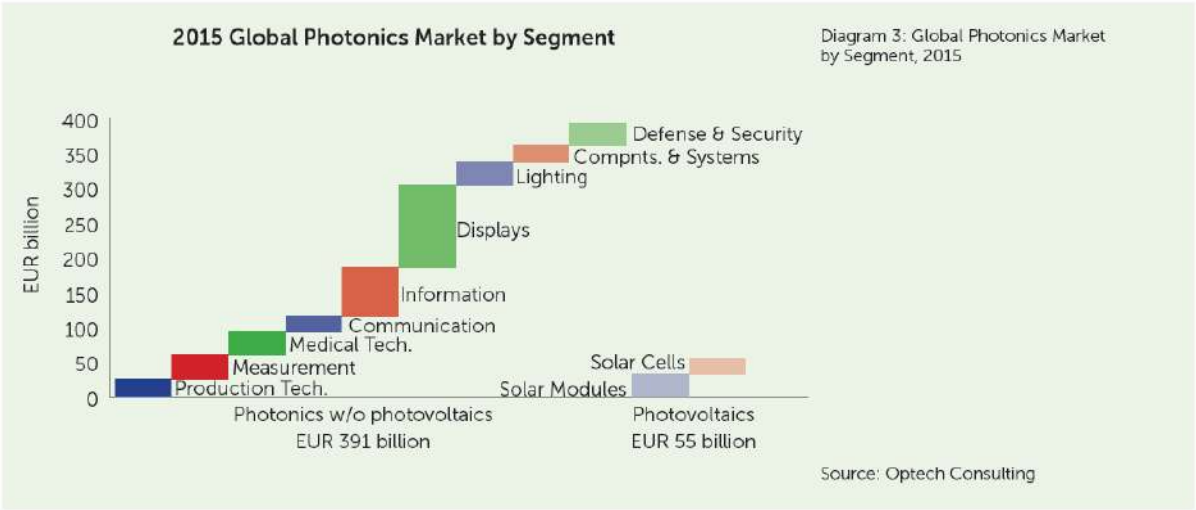


Figure 2: 2015 Global Photonics Market by Segment

PIMAP+ partners intend to provide in this document an accurate market analysis to facilitate the approach and the understanding of European companies, and in particular SMEs, of Japanese and Chinese exports markets. These markets are offering interesting opportunities for foreign companies and should be evaluated when a company is looking to expand its business at the international level.
This analysis is based on the most recent and various documentation available. The photonics market evolves fast and it is hard to follow all the ongoing developments and activities occurring in export market, but we provide here a first basis. You will find key information on the four fields addressed by PIMAP+ project: photonics, advanced manufacturing, metalworking and aerospace industry.

Photonics:

Asia became the Photonics key market leader in the world. For the last decade, the production has been constantly increasing and is expecting to carry on in the next ten years. The two biggest producers of the region are China and Japan with respectively 26.5% and 15.4% of the world's shares. If counting the overseas production, Japan comes first with 30% of global market share in 2015. The Chinese strong political attention in the photonic market demonstrates the shift toward a more value-add driven center of high technology. The country is a leader market for photovoltaics, displays and information technology.

Japan is facing a growing competition from emerging Asian countries that justifies its losing market share in the recent years. Japan is looking to look for new application industries to counter its biggest rival, being China. Information technology and displays contribute to the largest parts of the photonic production volume in the country.

Steel:

The significant growth of crude steel production in China is due to the high demand for raw materials during the industrialization and urbanization of the country. China now accounts for around 45% of global steel production, which is significantly higher than its share of 15 per cent at the start of the decade. The construction industry in the largest consumer of Chinese steel products.
On the other hand, steel production in Japan has been slowing down since 2018 due to the decline in residential construction and the Korean weak demand for car production. The country maintains its world third place of steel production behind China and India.

Advanced manufacturing:

Integrating digitalization and automation will shift the industrial sector toward a smarter and more efficient production. ASEAN region is by far the region counting the more operational stock of industrial robots and is expected to boost productivity up to US600 million by 2025. China is today the world's largest manufacturing economy which accounts for 40% of the national GDP. The country emphasizes technological innovation through its policy “Made in China 2025” which aims to create long term economic growth by pushing the following sectors: robotics, information technology and clear energy.

Japan is still among the most highly advanced and innovative industries in the world. Japan is leader in both production and technological advancement in the fields on electronics and automotive sectors. However, Japan ageing population appears as the biggest challenge for the country that could potentially drop its overall competitiveness for the manufacturing sector.

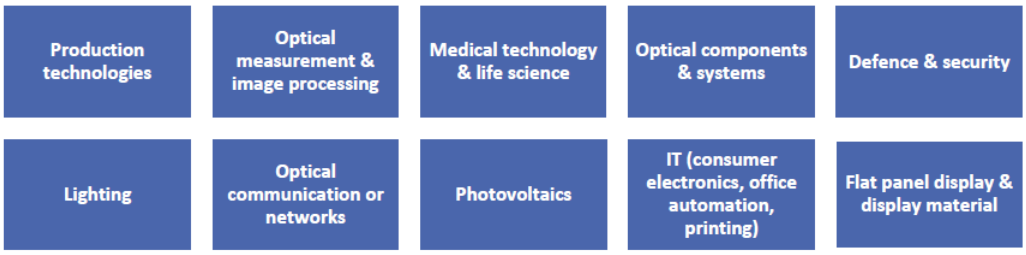
Aerospace:

China experienced a tremendous growth of international air transportation from the past two decades and is expecting to replace the US as the world’s largest aviation market by 2024. The formation of the COMAC (the Commercial Aircraft Corporation of China) and the “Made in China 2025” reinforce the Chinese long terms strategic plans to strengthen the aviation market, especially with the production of the C919 aircraft.

The Japan Aerospace and Defense Market is expected to grow by 4% annually until 2025. Japan’s aerospace production is relatively low compared to other region of the world but is the largest market in Asia, mainly providing aircraft components for commercial and defense aircraft for overseas customers. Previously, Japan’s aircraft production relied heavily on demand from the defense sector however this trend is changing, though, due to considerable sales expansion in civil aircraft production.

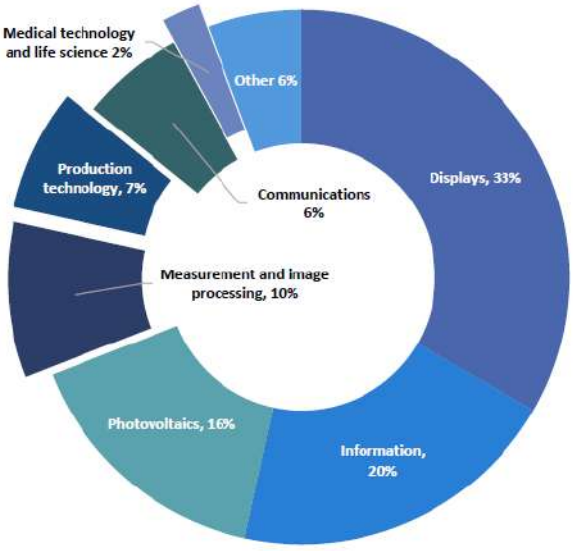
1. Introduction

Like electronics, photonics products are being used in many different applications and a wide range of sectors. Photonics21, the European association representing photonics industries and relevant R&D stakeholders with more than 2500 members, summarizes the applications in ten segments shown in Figure 3 and their respective share in the global market in Figure 4. Under productions technology segment, there are laser materials processing systems, lithography systems, laser for production technology and objective lenses for wafer steppers. Under measurement and image processing – machine vision, spectrometers and modules, binary sensors and various measuring systems. In the medical technology & life science segment the following products – lens for eyeglasses and contact lenses (not included in the further overview about Japanese industry), laser systems for medical therapy and aesthetics, endoscopes, microscopes, medical imaging, ophthalmic and other diagnostics systems for pharmacy and biotech R&D. Data related photonics technologies (information, communication and displays) are dominating the world photonics industry. The two last segments of importance are Defence & Security and Photovoltaics (16% of the market).



Source: Photonics21

Figure 3: Segments of the photonics industry as defined by Photonics 21



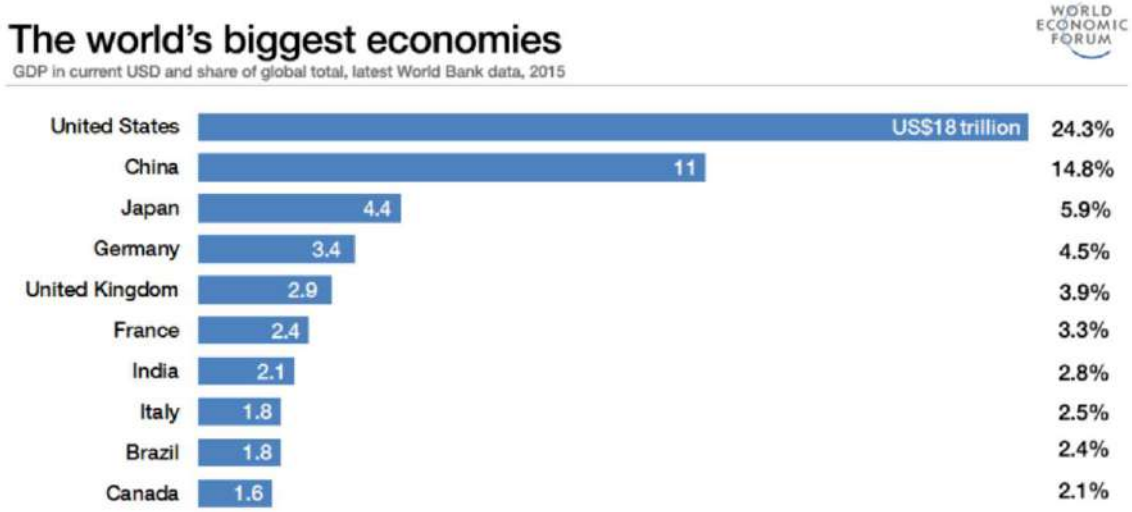
Source: Photonics21

Figure 4: Global market for photonics, totaling 447 billion Euros in 2015

2. Region Report: Asia

3.1 General Overview

Asia is the world area with the greatest number of emerging markets, and they grow around twice as fast as advanced economies on average. As a result, six of the seven largest economies in the world are projected to be emerging economies in 2050 led by China (1st), India (2nd) and Indonesia (4th). Today, China is still ranked as the second largest economy in the world while Japan is the third (Figure 5).



Source: World Bank and Visual Capitalist, 2015

Figure 5: The world biggest economies (GDP in current USD)

3.2 Focus on Photonics

The global market for photonics products in 2015 accounted for 447 billion euros. The market grew at a compound annual growth rate (CAGR) of 6.2% between 2011 and 2015[3]. Photonics production is mainly located in Asia. Nearly 70% are accounted for by China, Japan, Korea, Taiwan, and a few other Asian countries including the Philippines, Malaysia, Singapore, Thailand and India. Europe and North America account for 15.5% and 13.6%, respectively (Figure 6). Other photonics producing countries include Israel, Turkey, Australia, South Africa, and Brazil.

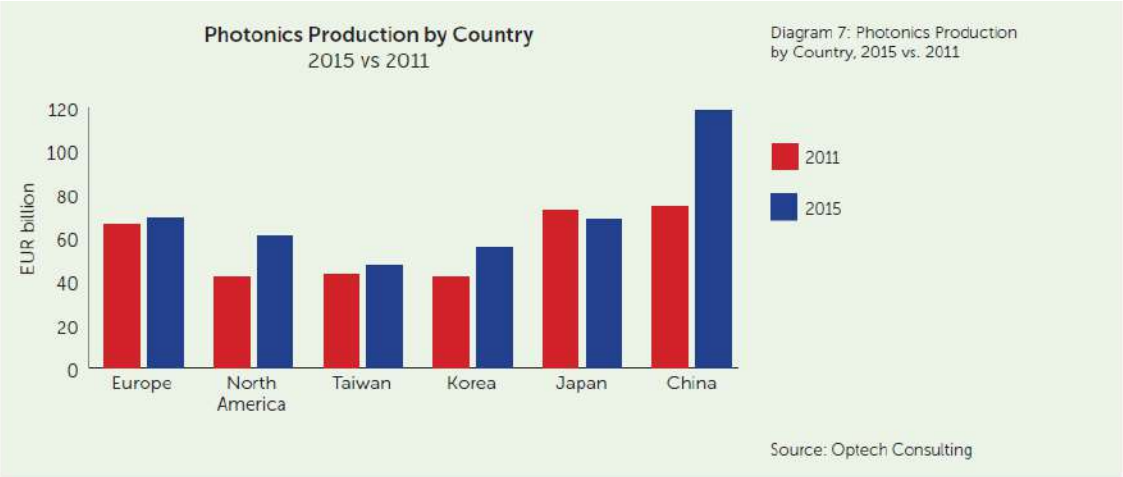


Figure 6: Photonics production by country 2015 vs 2011

China is the leading producer with a share of 26.5%, well ahead of Japan (15.4%), Europe (15.4%), North America (13.6%), Korea (12.5%), and Taiwan (10.6%). These production shares are valid for the market by origin of product, but the production shares are very different when the country of the company headquarters is used to allocate revenues. Then, Japan clearly is the leading producer with a share of nearly 30%. Nearly half of the photonics production of Japan headquartered companies is located outside Japan, mainly in China which explains the figures.

By the origin of products, China now is the clear leader in photonics (Figure 7). The success of the Chinese photonics industry is based on five segments: photovoltaics, information technology, lighting, displays, and communication.

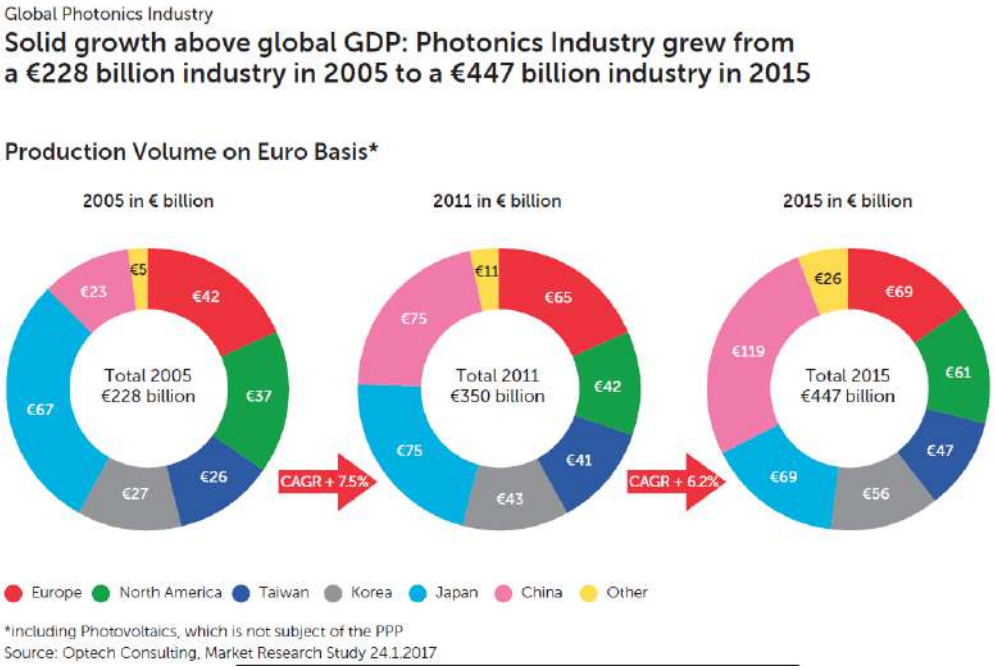


Figure 7: Photonics production volume by country between 2005 and 2015

The photonics sector is expected to continuously grow and to follow the same tendency that the ten past years according to Figure 8.

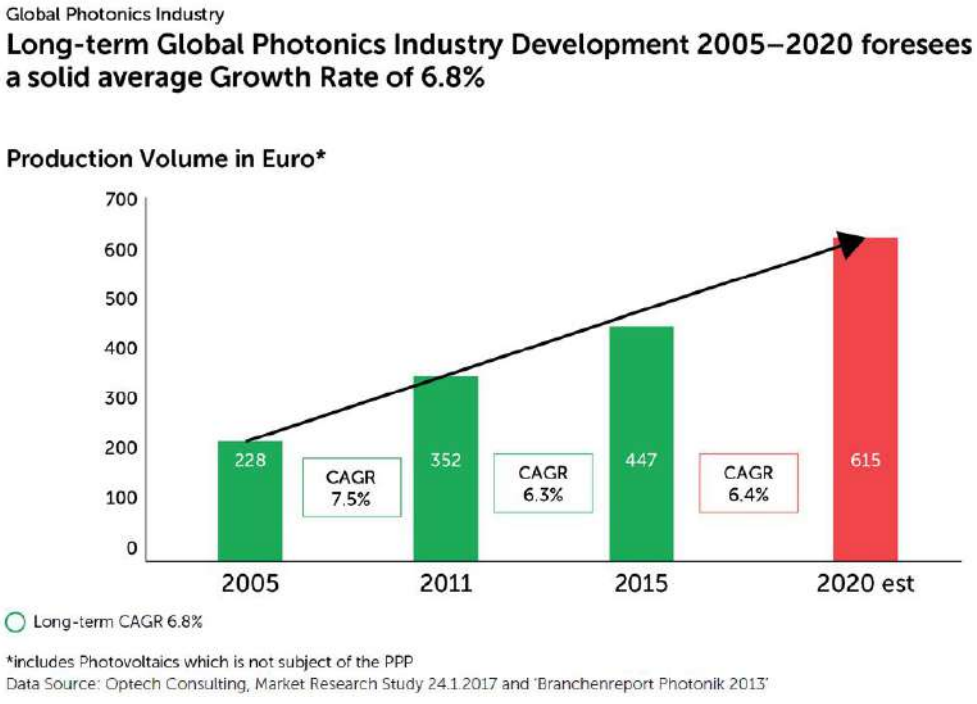
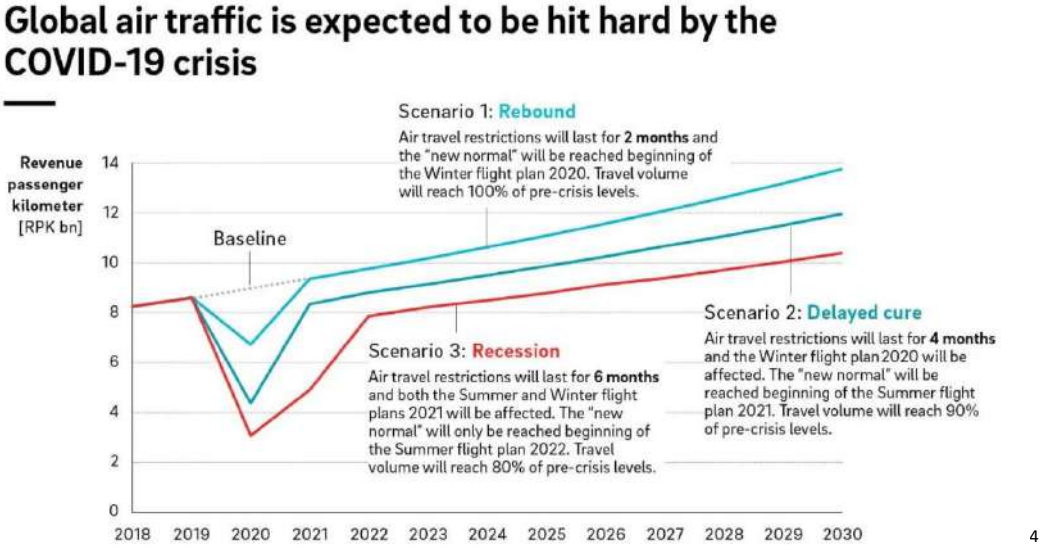


Figure 8: Photonics production volume between 2005 and 2020

3.3 Focus on Aerospace

In 2020, experts are forecasted -60% decline in global air traffic. The challenges facing airlines have a direct effect on the global aircraft industry by the postpone of new plane deliveries, if not cancellations, depending on the type of aircraft. Covid-19 crisis has hit demand for twin-aisle aircraft more than single-aisle ones since long international travel has suffered the most. In this context, aircraft

manufacturers have had no choice but to slow down their production-rates which has a direct impact on the wide aircraft supply chain, affecting from original equipment manufacturer and consequently their Tier-1 to all companies related to this key sector. This situation had a great impact on aerospace related jobs, where major companies had to stop to hire new people and stop ongoing contracts, though impacting very much some areas in terms of economic development. Several scenarios of recovery are possible and presented in the below Figure 9.



Source: Roland Berger, COVID-19 – HOW WE WILL NEED TO RETHINK THE AEROSPACE INDUSTRY, April 2020

Figure 9: Air traffic scenarios post covid-19 crisis

3.4 Focus on Steel

The October 2019 forecast by the World Steel Association pointed to steel demand in the Asia and Oceania region growing by 1.8% in 2020[5]. India and ASEAN are likely to be the drivers of growth in steel used for construction, due to robust investment activity in the infrastructure sector. Admittedly, the impacts of the recent coronavirus outbreak, which, at the time of writing are still uncertain, could weaken steel demand prospects even further. Forecasts announce that Chinese steel demand will decrease by 0.6% in 2020 compared to 2019. Although steel demand in the energy, white goods, and rail infrastructure sectors would increase in 2020, demand in the construction, automotive and shipbuilding sectors are forecast to decrease. According to the China Association of Automobile Manufacturers, total automobiles sales (including passenger and commercial vehicles) in China dropped by 8.2% in 2019, to a level of 25.8 million vehicles.

3.5 Focus on Advanced manufacturing

Manufacturing has increased prosperity for nations by creating both direct and indirect jobs. Industry accounts for nearly a quarter of total global employment, and the multiplier effect of manufacturing jobs often results in the creation of several indirect jobs.

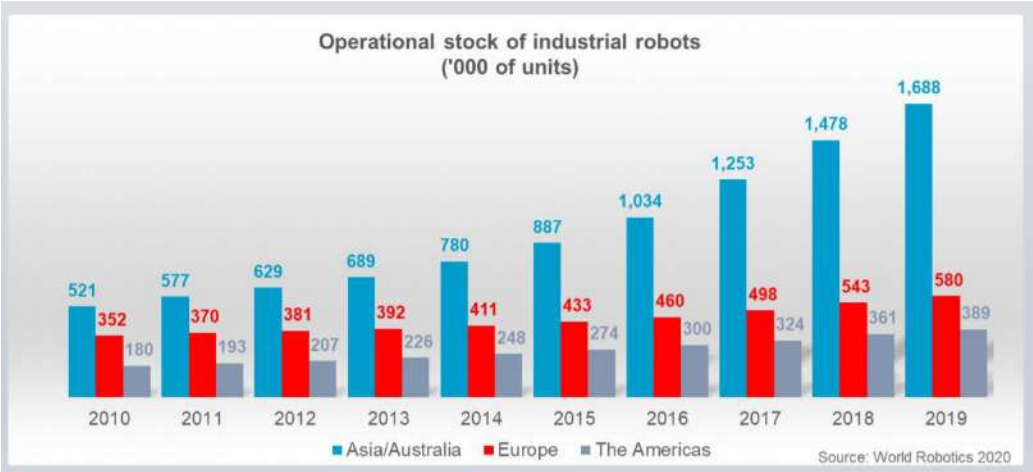


Figure 10: Operational stock of industrial robots

The past decades have seen the industrial sector drastically transformed by technology, globalization, and the rise of Asia. The stable, export-oriented manufacturing of basic products that sustained regional growth is changing. Faced with competition from low-cost manufacturing markets in South Asia and Africa, countries across the region now face the challenge of retooling to facilitate a shift into smarter production incorporating digitalization and automation. The McKinsey report estimated that embracing Industry 4.0 measures—the adoption of smart, data-driven systems and technologies to improve storage and computing capacities—could boost ASEAN's regional productivity by up to US$600 billion by 2025. As an example, we can see in the above graph Figure 10 that Asia is by far the first region in terms of operational stock of industrial robots. Indeed, the development of artificial intelligence and robotics are one of the twelve key emerging technologies identified by the World Economic Forum (Figure 11).

Table 1.1: Twelve Key Emerging Technologies

Technology	Description
Artificial intelligence and robotics	Development of machines that can substitute for humans, increasingly in tasks associated with thinking, multitasking and fine motor skills.
Ubiquitous linked sensors	Also known as the "Internet of Things." The use of networked sensors to remotely connect, track and manage products, systems and grids.
Virtual and augmented realities	Next-step interfaces between humans and computers involving immersive environments, holographic readouts and digitally produced overlays for mixed-reality experiences.
Additive manufacturing	Advances in additive manufacturing, using a widening range of materials and methods. Innovations include 3D bioprinting of organic tissues.
Blockchain and distributed ledger technology	Distributed ledger technology based on cryptographic systems that manage, verify and publicly record transaction data; the basis of "cryptocurrencies" such as bitcoin.
Advanced materials and nanomaterials	Creation of new materials and nanostructures for the development of beneficial material properties, such as thermoelectric efficiency, shape retention and new functionality.
Energy capture, storage and transmission	Breakthroughs in battery and fuel cell efficiency; renewable energy through solar, wind, and tidal technologies; energy distribution through smart grid systems; wireless energy transfer; and more.
New computing technologies	New architectures for computing hardware, such as quantum computing, biological computing or neural network processing, as well as innovative expansion of current computing technologies.
Biotechnologies	Innovations in genetic engineering, sequencing and therapeutics, as well as biological computational interfaces and synthetic biology.
Geoengineering	Technological intervention in planetary systems, typically to mitigate effects of climate change by removing carbon dioxide or managing solar radiation.
Neurotechnology	Innovations such as smart drugs, neuroimaging and bioelectronic interfaces that allow for reading, communicating and influencing human brain activity.
Space technologies	Developments allowing for greater access to and exploration of space, including microsatellites, advanced telescopes, reusable rockets and integrated rocket-jet engines.

Source: *World Economic Forum Handbook on the Fourth Industrial Revolution and World Economic Forum Global Risks Report 2017.*

Figure 11: 12 Key emerging technologies, World Economic Forum 2017

After surpassing the United States in 2010, China's manufacturing sector is the largest in the world, representing approximately one-quarter of global Manufacturing Value Added[6]. While China performs very well on the scale of its production base, it still can improve on the complexity component, as it is the 26th most complex economy in the world. Over the last two decades China has evolved its capabilities from producing low-cost goods to more advanced products. However, due to its size, the levels of modernization within its manufacturing sector vary greatly. China will need to continue to strengthen the capabilities of its labour force to develop the skills required in the future and improve the levels of innovation within companies.

Source: Deloitte

Figure 12: Rankings of major countries in each industry based on R&D leadership[7]

Japan's manufacturing sector is currently the 3rd-largest in the world, representing nearly 9% of global Manufacturing Value Added. Across the drivers of production, Japan performs particularly well on demand environment, due to a sophisticated consumer base, robust corporate activity and large market size. Japan also ranks in the top 20 on technology & innovation and institutional framework. In 2016, the government launched Society 5.0, as a strategy to use emerging technology to not only transform production, but all the society. In addition, the government added connected industries in 2017 to support Japanese industries including manufacturing and other sectors that create new added value through connecting things, people, technologies, organizations and other societal elements. In terms of leadership by industry and R&D, you can see in Figure 12, the ranking of China and Japan compared to Germany, the US and the UK. Even if the US has a leading position in many industries,

[6] Advanced Technologies Initiative: Manufacturing & Innovation, Deloitte, 2015. https://www.nist.gov/system/files/documents/mep/data/us-indprod-deloitte-and-council-on-competitiveness-advanced-tech-report.pdf

Japan and China have developed their own areas of expertise and represent serious competitors for example in motor vehicles, Japan ranks first before the US, and China is in third position.

3. Country Report: China

3.1 General overview

Key data:

- GDP 2019: 14 093 million USD (21 million for the US)
- GDP per capita: 10 261 (65 000 for the US)
- Annual growth in 2019: 6,1%
- Second world largest economy in the world after the US
- Ranks 1 in the list of countries by population (1,441,949,083 people, 18% of the total world population)
- 9,56 millions de km², 146 inhabitants/km²
- The median age in China is 38.4 years

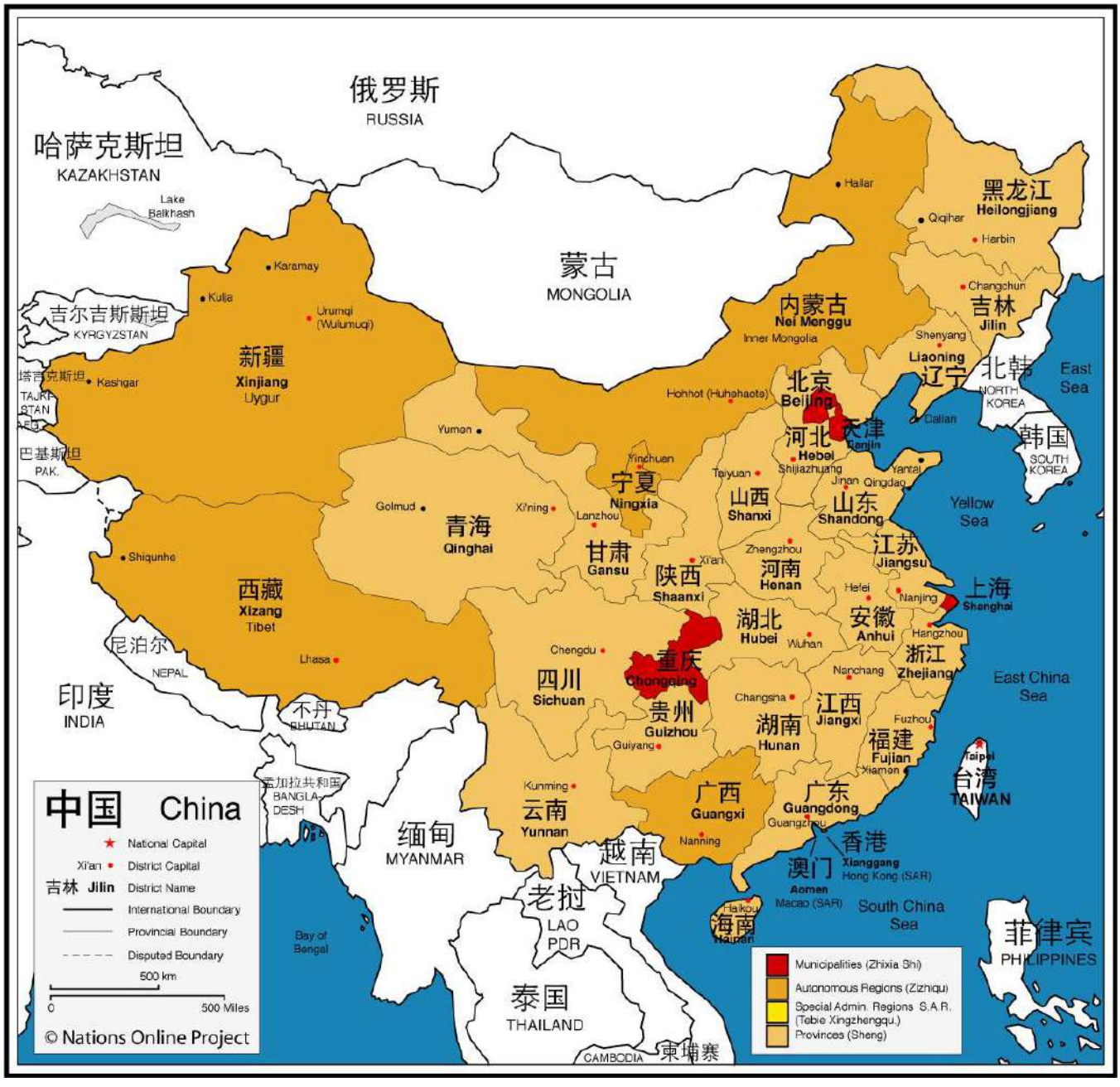


Figure 13: Administrative map of China

Despite being the second largest economy in the world and probably soon the first one, China is still facing many challenges: an ageing population and shrinking workforce, the lack of openness of its political system and issues of competitiveness in an economy dependent on high capital spending and the expansion of credit. A large gap remains between the living standard of the cities and the countryside, between urban zones on the Chinese coast and the interior and western parts of the country, as well as between the urban middle classes and those who have not been able to benefit from the growth of recent decades. These inequalities are becoming increasingly worrisome for both Chinese authorities and investors, hence Xi Jinping's vow to complete the eradication of rural poverty. The unemployment rate slightly decreased from 3.8% to 3.6% in 2019, the IMF expects however this trend to be slightly affected by the negative economic impact of the COVID-19 pandemic. Around 43 million people continue to live on less than USD 1 per day, which is the poverty line set by the government.

GDP growth is expected to slow down to 5.7% in 2020 and to 5.5% in 2021. Public infrastructure investment is expected to be strong, with new large-scale projects being approved for roads, railways, telecommunications and energy, and project financing in general is expected to benefit from relaxed banking requirements.

China has a highly diversified economy, dominated by the manufacturing and agricultural sectors. China is one of the largest producers and consumers of agricultural products. The agricultural sector is estimated to employ 24.7% of the active population in 2020 and accounts for 7.1% of GDP. China is the leading global producer of cereals, rice, cotton, potatoes and tea. A series of plans have been aimed at transforming, modernising and diversifying agriculture to increase productivity. Additionally, the country is rich in natural resources, China is the world leader in the production of certain ores (tin, iron, gold, phosphates, zinc and titanium) and the fifth biggest oil producer in the world.

The industry sector contributes to approximately 40% of China's GDP and employs 28.2% of the population in 2020. China has become one of the most preferred destinations for the outsourcing of global manufacturing units thanks to its cheap labour market, despite an increase in labour costs in recent years. China’s economic development has coincided primarily with the development of a competitive and outward-oriented manufacturing sector. More than half of the Chinese exports are made by companies with foreign capital.

The services sector's share in the GDP is approximately 54% and it employs around 47.1% of the workforce in 2020. Even though the sector's GDP share has been growing in recent years, the service sector as a whole, encumbered by public monopolies and restrictive regulations, has not progressed. The development of the sector has been constrained by the country’s focus on manufactured exports and the substantial barriers to investment in the sector. However, the Chinese government has been focusing more on the services sectors lately, particularly in sub-sectors such as finance, logistics, education, healthcare and it is also aiming to rank among the top exporters for transport, tourism and construction.

In 2015, Prime Minister Li Keqiang launched “Made in China” (MIC), an initiative which sets to modernize China’s industrial capability. This 10-year, comprehensive strategy focuses heavily on intelligent manufacturing in 10 strategic sectors (Figure 14). There is a strong emphasis on its domestic manufacturing process where it wishes to increase production, not only on the essential components, but on the final product as well.
MIC 2025 is an initiative which strives to secure China's position a global powerhouse in high-tech industries. The aim is to reduce China’s reliance on foreign technology imports and invest heavily in its own innovations in order to create Chinese companies that can compete both domestically and

globally. China sees MIC 2025 as a chance to fully integrate into the global manufacturing chain and more effectively cooperate with industrialized economies.

Source: Institute for development and security policy, Made in China 2025, June 2018

Figure 14: The ten Key Sectors in China

3.2 Research and Development in China

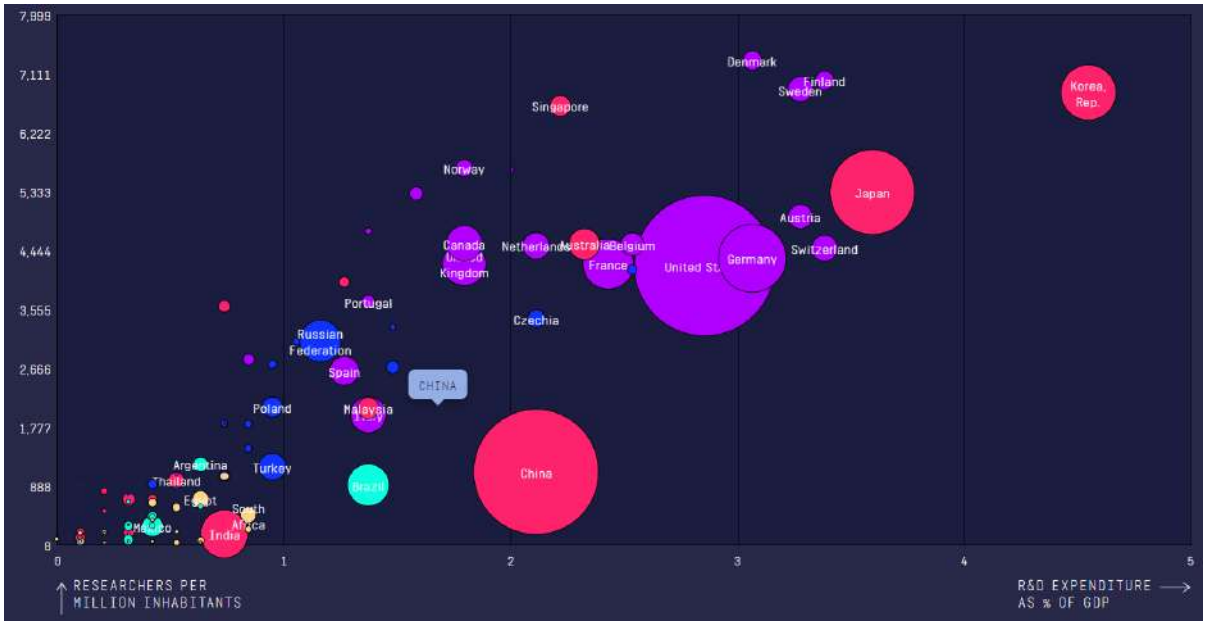
Gradually stepping away from its previous stage of growth and mass production, modern China faces several societal changes that directly impact the development of the local photonics industry:

- Industrial reformation and upgrades in quality and efficiency
- Aging society- senior population of age 65+ is growing at 3.28% annually
- Call for action on environmentally sustainable development

Source: UNESCO

Figure 15: R&D spending in China

The Chinese government, in response to these impending societal changes, is aiming to increase its annual R&D spending to 2.5% of GDP by 2020 in order to better meet the needs of enhancing local competitiveness as well as reducing reliance on foreign technology (Figure 15).
To foster research and innovation and to upgrade the competitiveness of the local industry, China has established three umbrella research programs. All three programs are initiated and supervised by the Chinese Ministry of Science and Technology (MOST) and can be characterized by strongly governmental-driven research structures, all of which are executed top-down.
Among the research topics, high power and intensity laser is one of the highest emphasis areas from the Chinese government, along with 3D imaging and industrial robots, all of which are in line with the long-term technological strategy of the Chinese government.
China aims to become world leader in science and innovation by 2050. "Made in China 2025" announced in 2015, outlines China's strategy to become a world leader in a number of high-tech industries, such as robotics, aerospace equipment, medical devices, and more. In 2017, China's R&D spending was about $280 billion, accounting for 2.12% of the country's GDP and representing 20% of total world R&D expenditure, second to the $476.5 billion of the USA (Figure 16: circle size shows the R&D spending).



Source: UNESCO

Figure 16: R&D Spending by Country

The circles show the amounts countries are spending on R&D in PPP$ (Purchasing Power Parity Dollars). Countries farther to the right are spending relatively more in terms of their GDP. Those closer to the top have higher numbers of researchers per 1 million inhabitants

Based on its R&D and industry strategy, China has become competitor in fast growing high-tech sectors, like nuclear energy, new energy vehicles, wind and solar PV, Artificial Intelligence and some parts of advanced manufacturing and robotic (drones). Over the past 15 years, China has tripled its high-impact scientific efforts (as measured by its share of top 10% most-cited publications), reaching 14% – the second largest scientific powerhouse after the United States (that has 25%). Since 2016, China has had the most industrial robots in operation globally. Chinese scientific system is based on three pillars: academia, universities and companies. The main public financers are the MOST, Ministry of Science and Technology, the MOE, Ministry of Education and the MIIT, Ministry of Industry and Information Technology. Private companies finance more than 75% of the spending in research and development. About 4 million people are working in R&D in the country.

In photonics sector, CAS, China Academy of Sciences is the main public actor in terms of research and development with several research structures: one in Beijing, 2 in Shanghai, 1 in Changchun and 1 in Xi'an.

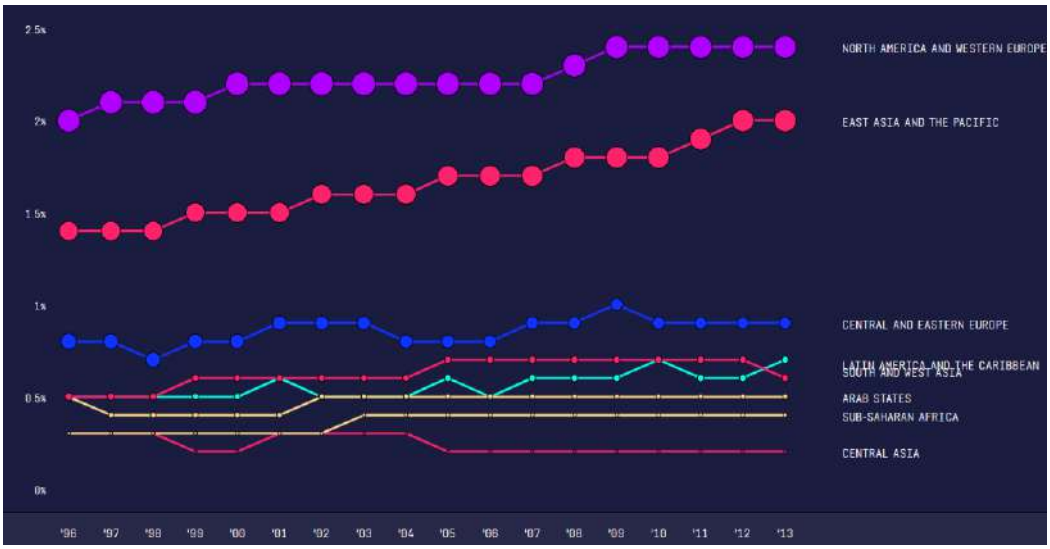


Figure 17: R&D Spending Regional Trends
Source: UNESCO

Both the private and public sectors have increased investments significantly in R&D. In 1991, a mere 39.2% of all R&D in China was conducted by business enterprises. By 2016, that number had soared to 77.5%, which was greater than that of both the US (71.2%) and the average for OECD economies (69.2%). This trend of companies investing in R&D was further illustrated when Alibaba and ZTE Corp, two of China's largest private sector companies, surpassed state-owned Petro China to become the country's top two publicly listed R&D spenders in 2016. Privately held companies like Huawei also play a vital role. In 2017, Huawei spent some US$ 14.3 billion on R&D –more than American firms like Apple and Johnson & Johnson[8]. The general trend is that Asia is slowly catching up the R&D spending of North America and Western countries as showed in Figure 17.

Research Institutes in optical component:

- Chinese Academy of Sciences
- Shanghai Institute of Optics and Fine Mechanics
- Changchun Institute of Optics, Fine Mechanics and Physics
- Fujian Institute of Research on the Structure of Matter

Research Institutes in fiber:

- Huazhoung University of Science and Technology
- Yanshan University
- Tianjin University
- Wuhan National Laboratory for Optoelectronics

Research Institutes in ultrafast laser:

- Beijing University of Technology Institute of Laser Engineering
- Pekin University State Key Laboratory of Advanced Optical Communication Systems and Networks
- Tianjin University Ulttrafast laser Lab of College of Precision Instrument and Opto-electronics Engineering
- Tsinghua University Dept. of Mechanical Engineering University
- East China Normal University State Key Laboratory of Precision Spectroscopy
- Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences
- Xi'an Institute of Optics and Precision Mechanics of CAS

Research Institutes in precision measurement:

- Tianjin University
- Beijing University of Technology Institute of Laser Engineering
- Huazhong University of Science and Technology
- Academy of Opto-electronics, Chinese Academy of Sciences
- National University of Defence Technologies

Research Institutes in biomedical photonics:

- Peking University, State key laboratory for artificial microstructure and mesoscopic physicis
- Tsingua University
- Tianjin University, Center for Terahertz Waves
- Fujian Normal University, key laboratory of medical photoelectric science and technology
- East China Normal University, State key laboratory of precision spectroscopy
- Huazhong University of Science and Technology

3.3 Focus on Photonics

China continued to be the winner of market shares in photonics during the last four years. Its production share in the global market increased from 10% in 2005 to 21% in 2011 and to 27% in 2015. The success of the Chinese Photonics industry is based on five segments: photovoltaics, information technology, lighting, displays, and communication.

Photonics production in China accounted for 118 billion euros (USD 130 billion) in 2015 (Figure 23). In euros the production volume increased from 2011 to 2015 at a CAGR of 12.4%. China continued to gain market share in photonics during the last years. The share of photonics made in China in the global market increased from 10% in 2005 to 21% in 2011 and to nearly 27% in 2015. China is still the first market for fiber optics in 2018 representing 58% of the global market as well as the global leader of photovoltaics manufacturing.

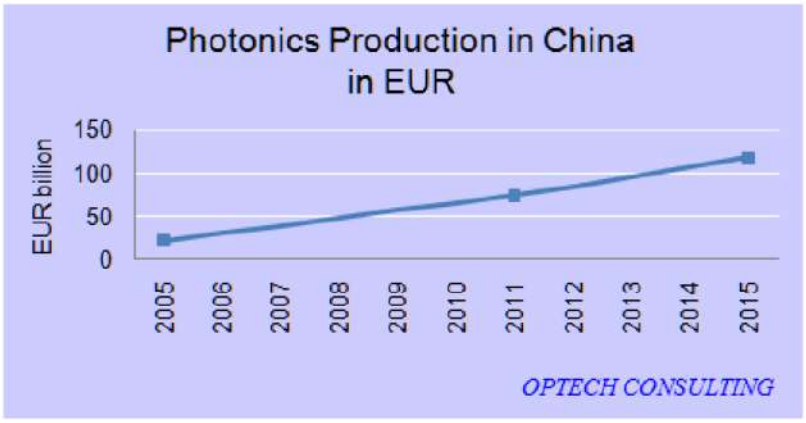
Photonics production in China comprises three major segments with a volume of more than 20 billion euros: photovoltaics, displays, and information technology.
Production technology has the highest strategic importance for the Chinese government. China's goal to upgrade its economy from the world's "work-bench" to a more value-add driven center of high-technology, as well as its remarkable growth in key application industries, such as semiconductors, displays and photovoltaic, are the reason for strong political attention. Laser production receives the biggest support from the Chinese government within the production technology segment. Chinese players in this segment have yet to reach global industry standards but are shortening the technological gap at a tremendous speed.

Medical technology in China's domestic market is currently dominated by foreign players. Due to the high level of research and innovation required in this specific segment, Chinese players have yet to make a noticeable impact. The usage of medical technology in China remains at a growing stage. Thus, the industry has not been standardized and has a low penetration level of advanced equipment.

Machine vision is a relatively new market segment in China. But due to its overarching application potential, machine vision is being approached from numerous industries and technologies, covering a wide range of topics ranging from traffic surveillance, to robotics and factory automation, to 3D printing and to sphere panorama vision.

Nearly half of the photonics production in China can be attributed to production plants of companies headquartered outside China, mainly in Japan, but also in Taiwan, Korea, North America, and Europe. However, the production share of locally owned companies has increased steadily. Locally owned manufacturing is especially important in photovoltaics, optical communication, solid state lighting, and flat panel displays, besides security & defence. Locally owned manufacturing also accounts for a rapidly increasing share in laser materials processing.

Diagram 11: Photonics Production in China in EUR



Source: Optech Consulting

Figure 18: Photonics Production in China (in Euros)

China has set up six industrial bases for optoelectronic achievements conversion (Beijing, Wuhan, Shanghai, Shijiazhuang, Shenzhen and Changchun).

Since 2000, optoelectronic technology industry development zones are set up in many places. There are 13 optoelectronic industrial bases. Optoelectronic industry in Shanghai, Wuhan, Shenzhen, Guangzhou, Changchun and Beijing reach certain scales (Figure 24).
11 state key optoelectronic laboratories and 5 key laboratories affiliated to the State Educational Bureau have been set up. 5 National Engineering Research Centers in laser and optoelectronic are built, including CD, laser processing, optical fiber communication and optoelectronic components. 4 NERTCs are set up, including solid-state lasers, optics instruments, specialty display and flat panel display engineering technologies.

China has built numbers of industrial enterprises in optoelectronic, including China North Industries Group Corporation, China South Industries Group Corporation, China Electronic Technologies Company, China Aerospace Science and Technology Corporation, etc. These group corporations all have several enterprises engaged in laser optoelectronic technology industry, such as the research institutes of CETC.
Others includes enterprises engaged in laser technology industry such as Wuhan Research Institute of Posts & Telecommunications, Yangtze Optical Fiber and Cable Company, Shenzhen Photon Technology Co., Ltd., Shenzhen Tianma Microelectronics Co., Ltd., Shenzhen Kaifa Technology Co., Ltd, Huawei Technologies Co., Ltd., WXZTE, Hi-Tech Optoelectronics Co., Ltd., Daheng Information Technology, Changchun Caijing, Changchun New Industries Optoelectronics Tech. Co., Ltd., Institute of Semiconductors of CAS, Shanghai Institute of Optics & Fine Mechanics of CAS, Shanghai Institute of Technical Physics of CAS, Kunming Institute of Physics, Xi'an Optics Application Institute, No. 41 Research Institute of CETC, Anhui Institute of Optics & Fine Mechanics of CAS, Xi'an Institute of Optics & Precision Mechanics of CAS, Peking University, Tsinghua University, Nankai University, Shanghai Jiao Tong University, Jilin University, Tianjin University, Southeast University and South China Normal University, etc.
In the past more than ten years, China's optoelectronic products market has developed dramatically, its average annual growing rate keeps double-digit. This is the outcome of reform and opening-up policies and effort to take full advantage of the investment environment and consumer market.

Key regions of optical expertise include Wuhan, Shanghai and Shenzhen.

Source: https://optics.org/article/23942

Figure 19: Regions of optical expertise in China

China is the largest trader of consumer electronics in the world, responsible for 31% of global consumer electronics exports and 46% of finished product exports in 2017, exceeding other major exporters in the region, including Vietnam, Thailand and Malaysia by a large margin. The primary product subsectors within the consumer electronics sector are computer hardware (PCs, notebooks, tablets), audio-visual (TVs, cameras, audio devices), and handsets (smartphones and non-smartphone devices). Increasing discretionary spending, household income expansion and rising demand for consumer electronics in China will facilitate continued domestic growth (Figure 25), however growth in key device categories is slowing due to market maturity and product cannibalisation. Finally, China is home to global consumer electronics leaders including Huawei, Lenovo, ZTE, TCL, Founder Technology and Xiaomi and has a well-developed domestic production base.

Source: BMI Research

Figure 20: China's consumer electronics sales, 2010-2017 (US$ billion)

- Photonics research actors

R&D

- Institute of Semiconductors of CAS
- Shanghai Institute of Optics and Fine Mechanics (SIOM)
- Shanghai Institute of Technical Physics of the Chinese Academy of Sciences (SITP)
- Shanghai Institute of Microsystem and Information Technology (SIMIT)
- Wuhan National Laboratory for Optoelectronics
- National Engineering Laboratory for Fiber Optic Sensing Technology
- Britton Chance Biomedical Photonics Research Centre (HUST)

- Some photonics optics components and lasers companies

- Some equipment manufacturers companies

- Various associations in photonics related fields

China Electronics Technology Group Corporation (CETC)
China Center of Information Industry Development (CCID)
China Semiconductor Industry Association (CSIA)

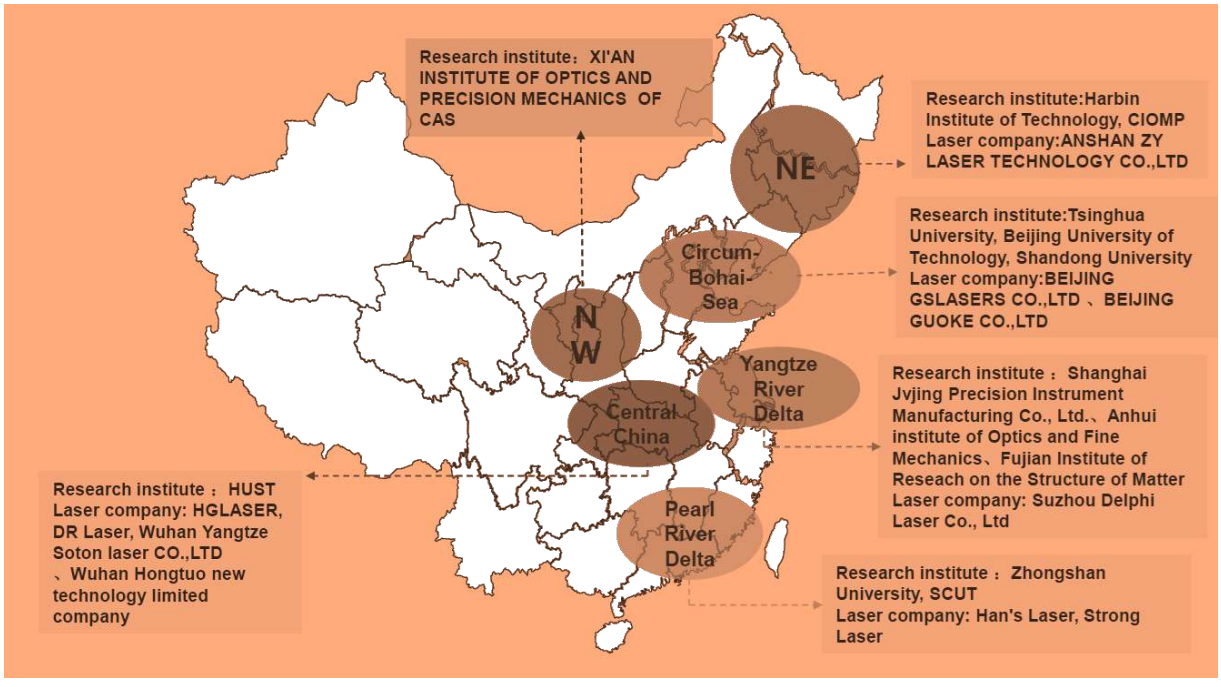


Figure 21: China Ultrafast laser industrial landscape

Figure 22: Ultrafast solid laser companies

State key laboratory for artificial microstructure and mesoscopic

Figure 23: Ultrafast fiber laser companies

China has become the largest consumer electronics market in the world and is beginning to act as the driving engine of global consumer electronics industry. Smartphone has become the most active part in consumer electronics market. According to estimates, global smartphone sales will reach 1.2 billion in 2014 euros.

Laser market trends

Figure 24: Wuhan Documentation and Information Center, CAS; Chinese Laser Press; The Chinese Optical Society

Although the laser market has grown in 2019, the growth rate has slowed down compared with the previous two years. The total market sales revenue of laser equipment (including imports) in the fields of industry, information, commerce, medicine, and scientific research was 65.8 billion yuan (8M€), a year-on-year increase of 8.8% compared with 2018.

In 2019, the sales revenue of laser equipment in the industrial field reached 38.66 billion yuan (4.9M€), followed by laser equipment in the information field, with sales revenue of 14.21 billion yuan (1.7M€).

Commercial equipment surpassed medical equipment to become the third largest market, with sales revenue of 5.48 billion yuan (640K). The sales revenue of laser equipment for medical and scientific research is ranked fourth and fifth respectively. The largest application in the industrial field is laser cutting, accounting for about 40% of revenue. In 2019, the sales revenue of laser equipment in the industrial field increased by only 1.9% year-on-year, the fastest commercial growth was 38%, and the scientific research field maintained a 20% growth.

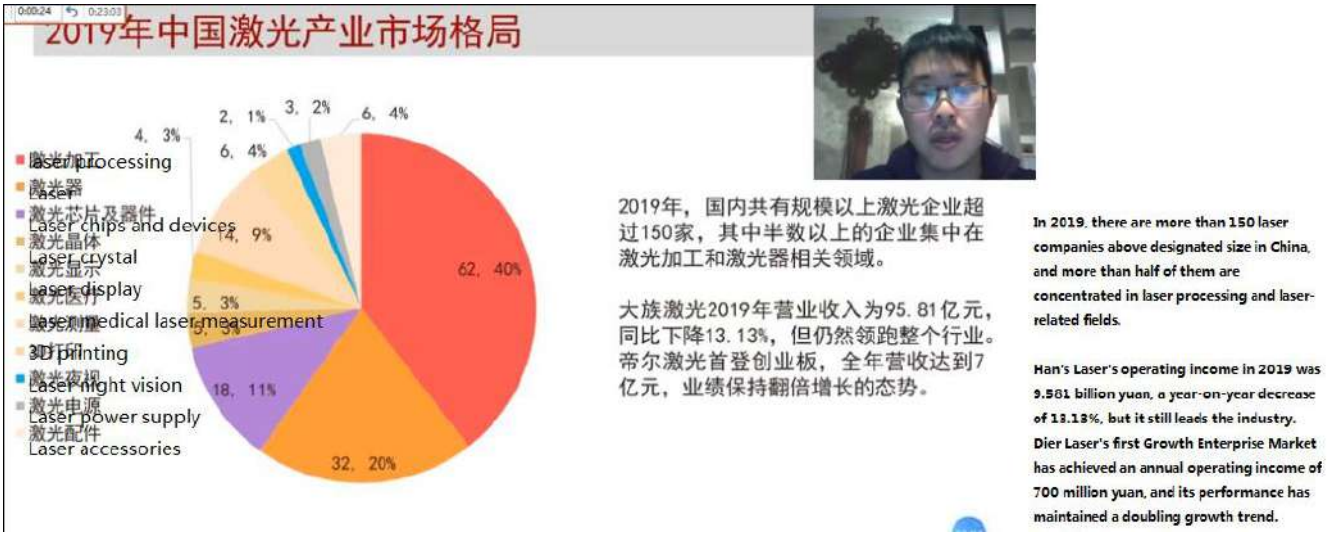
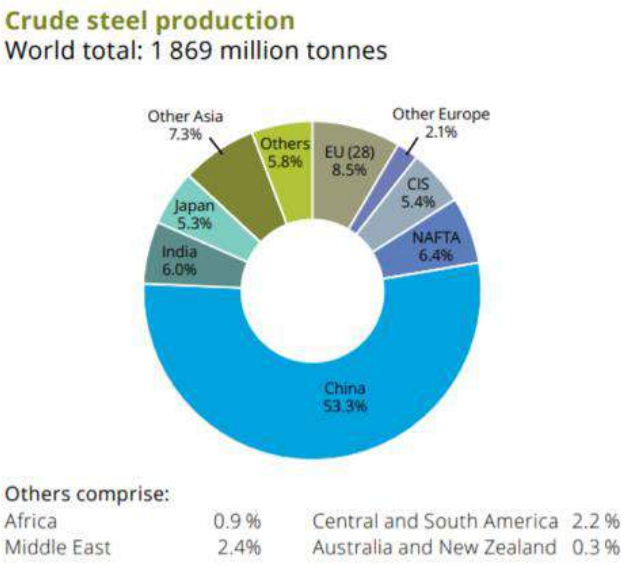


Figure 25: Laser companies in China

3.4 Focus on Steel[9]

China's steel industry has grown rapidly in recent decades, with China being now the world's largest producer and consumer of steel as showed in Figure 31.



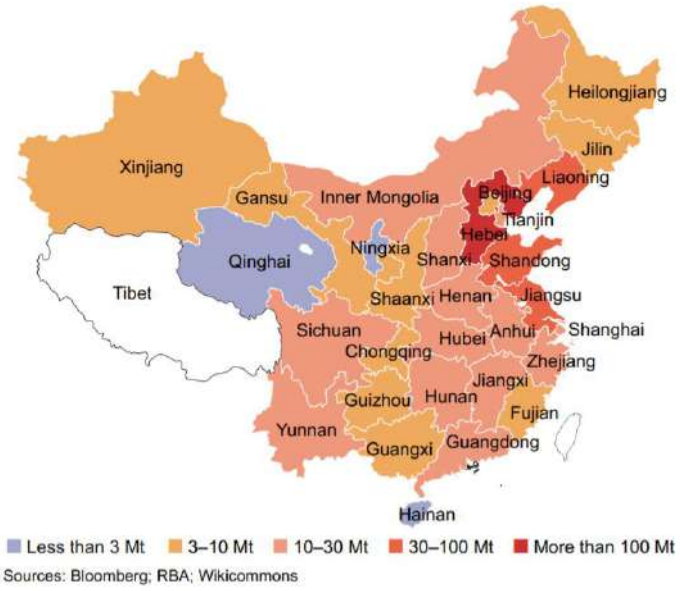
Source: 2020 World Steel in Figures, Worldsteel Association

Figure 26: Crude steel production 2019

Over the past 30 years, China's steel production has increased at a rapid pace as the economy has industrialized and urbanized. The expansion of steel production, particularly over the past decade, has been a significant driver of China's demand for raw materials, especially iron ore and coking coal. Through the 1980s and 1990s, the productivity of the sector was enhanced by the opening up of China to foreign trade and investment, which gave Chinese steel producers increased access to advanced technologies. China now accounts for around 45% of global steel production, which is significantly higher than its share of 15% at the start of the decade.

[9] China's Steel Industry, bulletin | December QUARTER 2010, Reserve Bank of Australia, 26p

Figure 1
China – Crude Steel Production in 2009 by Province



Source: Bloomberg, RBA, Wikicommons

Figure 27: China – Crude Steel Production in 2009 by Province

The Chinese steel industry is highly decentralized (Figure 32), consisting of a relatively small number of large, advanced steelmakers and a large number of small and medium-sized firms that produce lower-value steel products. In 2008, there were more than 660 companies producing crude steel, with thousands of other firms producing finished steel and steel related products. The top 10 producers accounted for less than 50 per cent of crude steel output, with the next 75 companies accounting for an additional 30 %. Most of the larger Chinese steel producers are state-owned, while a significant proportion of the smaller producers are private companies. Geographically, the industry is widely dispersed. Targets for industry consolidation through mergers and acquisitions or closures of small- to medium-sized firms were outlined. In June 2010, the State Council updated these targets with a goal of cultivating three to five very large, internationally competitive iron and steel conglomerates.

Industry	Share of total steel consumption
Construction	54
Machinery	18
Automobile	6
Home appliance	2
Rail, shipping and fuel [a]	5
Other	15

(a) 'Rail, shipping and fuel' is defined as the sum of the 'container', 'railway', 'shipbuilding' and 'petroleum' categories
Source: Wu (2009)

Figure 28: Chinese Steel Consumption by Industry in 2008 (in %)

The construction industry is the largest direct consumer of Chinese steel products, accounting for more than one-half of steel consumption. However, at least a quarter of steel consumption can be considered broadly as 'manufacturing', including the machinery, automobile and home appliance industries (Figure 33).

Chinese steel producers are expected to drive global steel production over the coming years. China accounted for half of global steel production in 2017. Increasing trade tensions in the global market accompanying complaints of Chinese steel dumping will force the Chinese Government to reduce

domestic steel production and exports. However, China's 2021 projected global steel production share is still a sizable 48%, growing significantly from a share of 31% in 2005. Chinese steel companies (Figure 34) are already starting to embrace smart factory and Industry 4.0 concepts and will benefit further from a well-defined Industry 4.0 roadmap. For example, in a steel melt shop, data driven models combined with scheduling and manufacturing system integration could help to manage steel temperatures from the basic oxygen furnace vessel to casting, thereby reducing energy consumption and improving cast product quality.

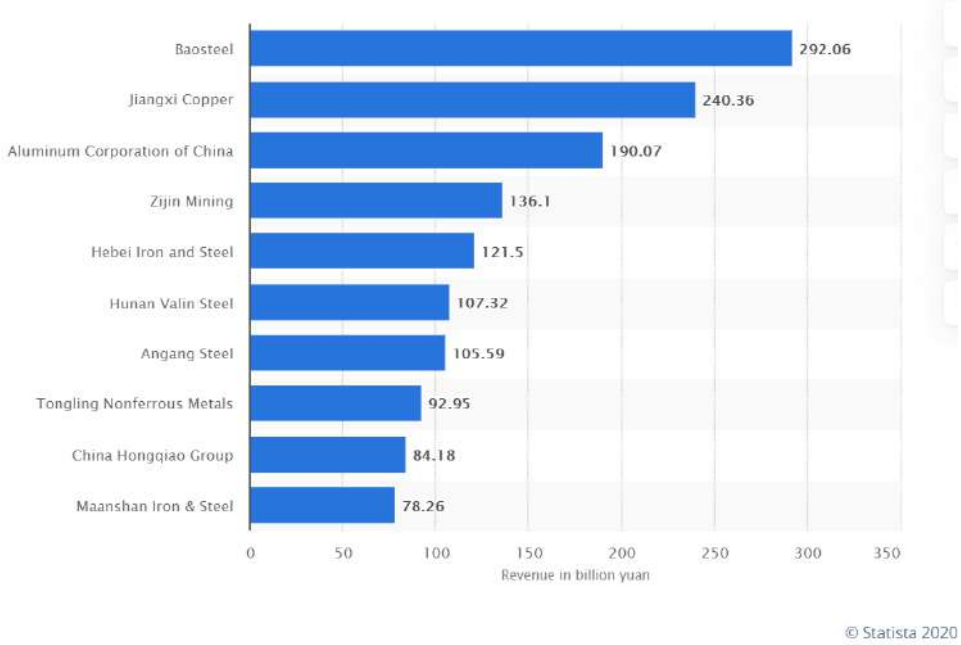


Figure 29: Leading Chinese metal companies

3.5 Focus on Advanced manufacturing

In 2015, China produced or assembled:

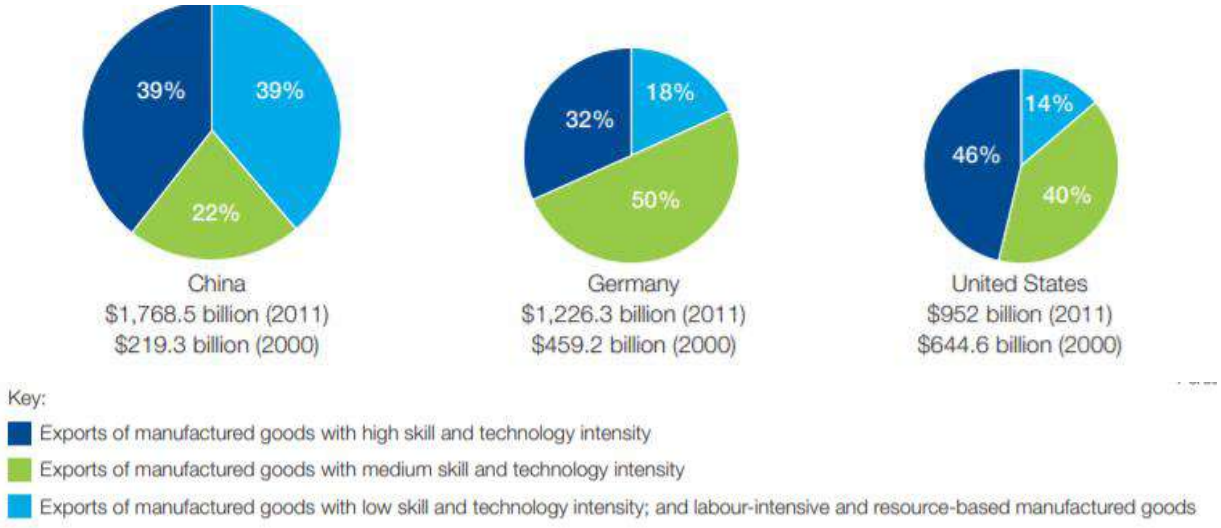
- 28% of the world's automobiles;
- 41% of the world's ships;
- 80%+ of the world's computers;
- 90%+ of the world's mobile phones;
- 60% of the world's colour TV sets;
- 50%+ of the world's refrigerators;
- 80% of the world's air-conditioners;
- 24% of the world's power; and
- Half of the world's steel.

Figure 1: China's manufacturing sector is expected to continue its upward trend
Manufacturing Value Added, 2012-22 (US$ trillion) and CAGR (%)

Source: BMI Research

Figure 30: China's manufacturing sector is expected to continue its upward trend

China is today the world's largest manufacturing economy which accounts for 40% of the national GDP and is expected to continue its growth (Figure 35).
However, the labor productivity of manufacturing is low and most of the products are easily consumable and low value added, locating on the low end of the international labor division compared to most advanced economies (Figure 36).
Driven initially by its ability to deliver low-cost labor and materials, China quickly advanced across a number of other competitive drivers – including infrastructure, favorable policies, a large consumer base, and established supplier network – over the past 10-15 years and evolved its manufacturing capabilities from low-cost goods to more advanced products.



Source: Global Competitiveness Index 2016, Deloitte

Figure 31: % of manufactured goods classify by level of technology in China, Germany and in the US

In this perspective, "Made in China 2025" policy seeks to engineer a shift for China from being a low-end manufacturer to becoming a high-end producer of goods. The goal is to tap into China's increasingly wealthy home consumer base as well as the value-added global sourcing segment. This has required transitioning the country's existing manufacturing infrastructure and labor market towards producing more specialized output – with targeted investments in research and development (R&D) and an emphasis on technological innovation. To centralize this vision, the government's Ministry of Industry and Information Technology released a Made in China (MIC) 2025 document in 2015 – pushing for leadership in robotics, information technology, and clean energy, among other sectors. Global factory model is no longer sufficient to create long term economic growth. Chinese firms need to absorb, adopt and develop advanced manufacturing technologies.

The Chinese Government has developed CM2025 in response to the domestic and international challenges that its manufacturing industry faces. While it may initially appear to be heavily inspired by Germany's Industry 4.0, CM2025 is actually more than that. Industry 4.0 is about technological advancement (Figure 37); CM2025 is about restructuring the entire industry (Figure 38) and making it more competitive using advancement in production technology as just one of the instruments. In other words, Industry 4.0 is only one part of the Chinese strategy.

Source: McKinsey & Company

Figure 32: Key technologies in Industry 4.0

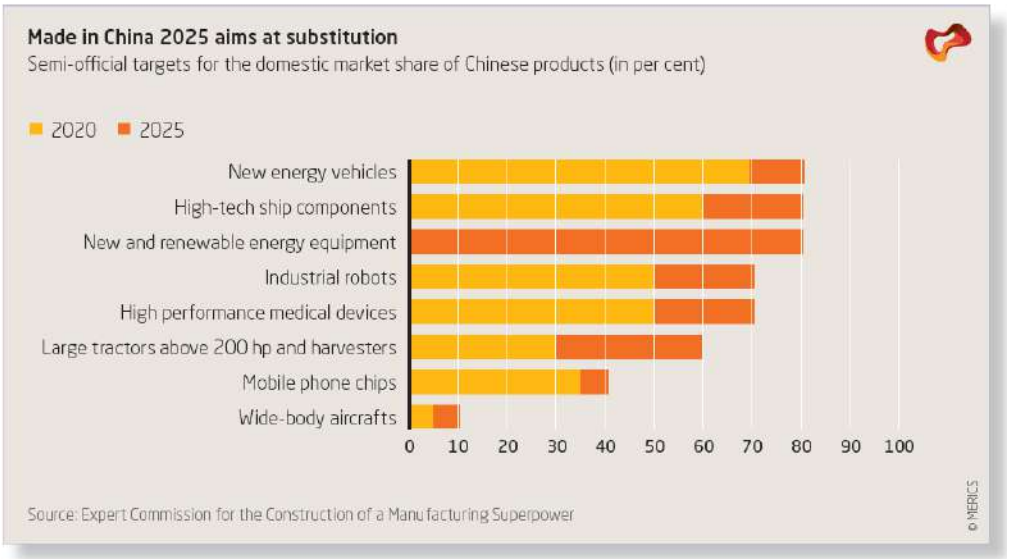


Figure 33: Chinese target in terms of domestic market share production in key technologies

MIC 2025 addresses the following over riding objectives: a big push in firm level industrial innovation capacity focus on R&D and patents, quality improvement and accelerated productivity growth, an expansion of informatization and digitization of industry, and green development focusing on a reduction of energy consumption, water usage and pollution.

Among the 10 priority sectors (Figure 39) China pushes into advanced manufacturing: new advanced information technology, automated machine tools and robotics and, aerospace and aeronautical equipment and new materials. Today China is the world's second largest investor in R&D with a forecasted spending of 396$ billion for 2016 and is ranked among the top five global R&D leaders in leading high-tech industries.

Figure 34: Made in China 2025: Target Sectors

Source: Graphic Asia Briefing Ltd

In the short and medium term, CM2025 does present attractive opportunities for some European businesses to play an important role. Numerous European companies have already established partnerships with Chinese companies in this respect, to provide critical components, technology and management skills for areas covered by CM2025. The President Xi Jinping encourage investment in advanced manufacturing by foreign-invested enterprises (FIEs) and to ensure that these companies receive equal treatment under strategic policies and measures related to CM2025[10].

Central provinces have seen the fastest manufacturing growth (Figure 40). China produces more than 90% of the world's smartphones, most of them in the "smartphone capital" of Shenzhen – even through wages have been rising fast. Around one quarter of the world's fiber optic cable is made by a cluster of factories in Wuhan. More major clusters are forming in central provinces. Chongqing, for example, is a growing center of automotive production that includes assembly plants for Hyunday, Changan Ford, Changan Suzuki and Lifan. Chongquing's swelling electronics manufacturing cluster includes a major Foxconn facility; Sichuan now produces 21% of Chinese-made computers[11].

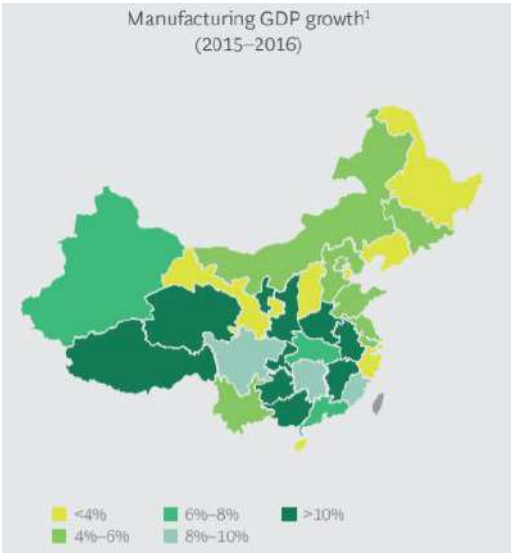
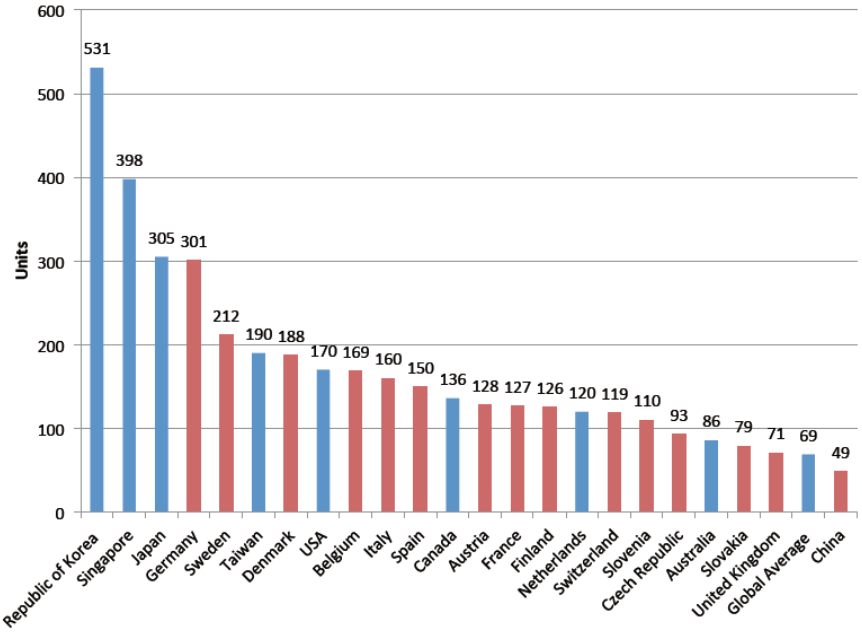


Figure 35: Manufacturing GDP growth (2015-2016)

[10] PWC, Global manufacturing & industrialization summit, "The future of manufacturing – China", 2019.
[11] China next leap in manufacturing, BCG, 2018, https://image-src.bcg.com/Images/BCG-Chinas-Next-Leap-in-Manufacturing-Dec-2018_tcm9-209521.pdf

At the same time, many Chinese manufacturers are accelerating their deployment of automation and robotics. The automotive sector is a good example. Back in 2011, US auto factories deployed 63 000 industrial robots, three times as many as Chinese facilities[12]. Over the following five years, Chinese auto plants reached parity by installing robots at three times the pace of those in the US. But there is still room for acceleration as the country remains far from others countries in number of industrial robots per workers as showed in Figure 41. The investment in Industry 4.0 manufacturing technologies with smart robots and advanced planning systems is an opportunity to improve flexibility and productivity.

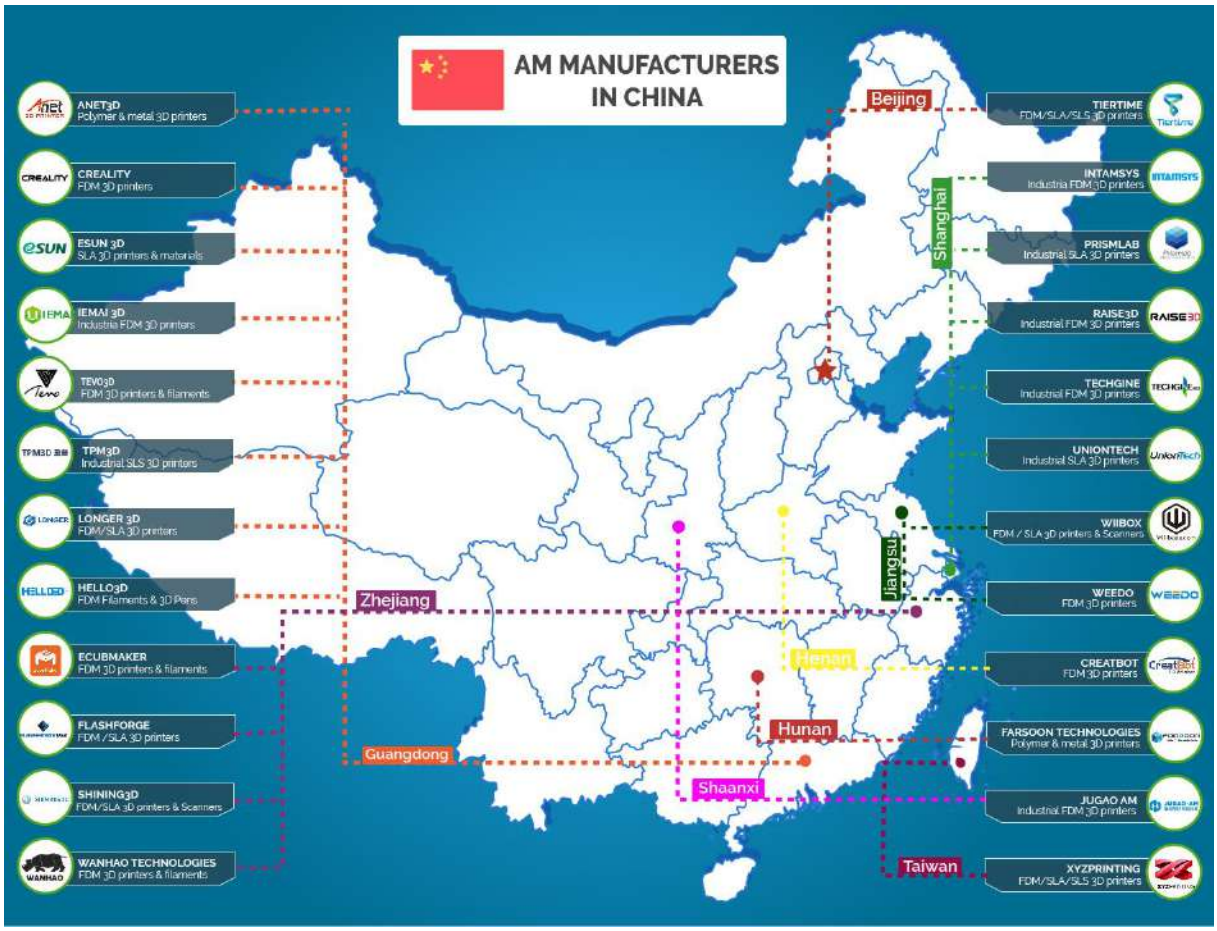


Source: World Robotics 2016, International Federation of Robots

Figure 36: Installation of Industrial Robots per 10,000 workers by Country

As an example, the Shanghai Lingang Industrial Area is planned as one of the major smart manufacturing parks under Made in China 2025 and is developing policies and incentives to attract advanced manufacturing companies to locate there and to support technological upgrading projects. It is a vast area, including an Equipment Industry Park, Logistics Park, the China (Shanghai) Pilot Free Trade Zone, Lingang Fengxian Industrial Park, Comprehensive Zone and Major Industrial Zone, with good transport connections by air, sea, river, rail and road.

[12] *World Robotics 2016, International Federation of Robots*



Source: https://www.3dnatives.com/en/am-manufacturers-china-241020194/#!

Figure 37: Advanced manufacturers in China

3.6 Focus on Aerospace[13]

China's international air transportation has experienced tremendous growth and major reforms over the past two decades. China is already the world's second-largest national air travel market. China's commercial aviation market is dominated by the "big three"—Air China, China Eastern, and China Southern (Figure 43). According to Boeing, China currently accounts for 15% of world's commercial

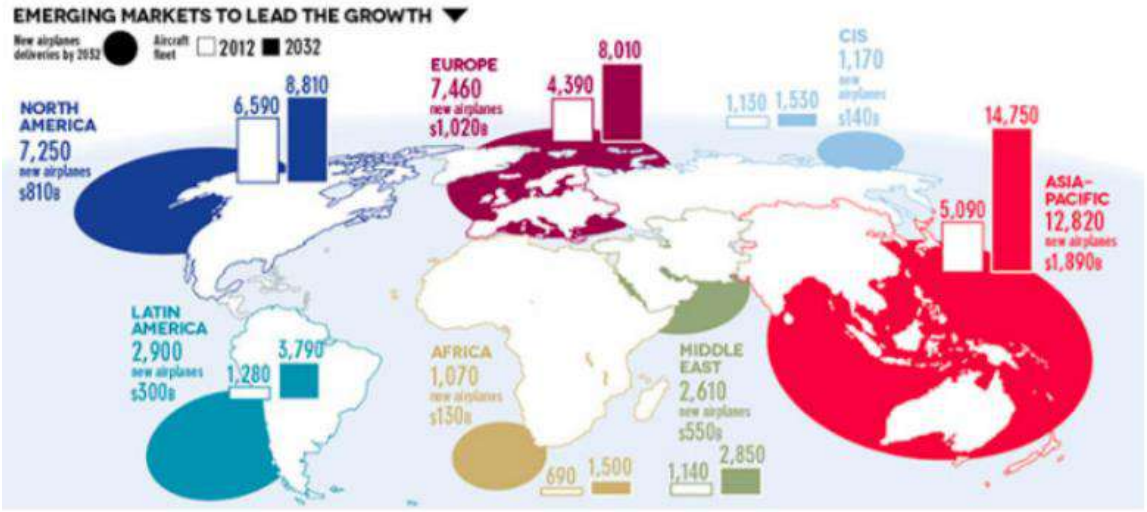
[13] International Air Transport Association, annual review, https://www.iata.org/en/publications/annual-review/

airplane fleet; by 2037 it will be nearly 20%. By 2024, China will replace the US as the world's largest aviation market, according to the International Air Transport Association (IATA).

Source: CAAC, 2019

Figure 38: Share of Passengers per Airline in 2019

China, the fastest-growing aviation market globally (Figure 44), could require 8,090 aircrafts over the next 20 years, worth about US$1.3 trillion, with nearly 75% being single-aisle aircraft. The robust aircraft demand is also likely to create a US$1.6 trillion opportunity for aftermarket services for its aircraft fleet over the 2019–2028 period.



Source: The Impact of the Commercial Aircraft Corporation of China (COMAC) in the Aircraft Manufacturer Industry

Figure 39: Regional Aircraft demand by 2032[14]

Forecasts predict that more than 30% of the new orders will be placed in Asia during the next two decades. This percentage is below the total number of orders combining Europe and North America, which is almost 50%. However, this area has a fleet growth rate (5.6%, 6.2% counting China) much higher than Europe and North America, which are 2.3% and 1.6% respectively.

[14] The Impact of the Commercial Aircraft Corporation of China (COMAC) in the Aircraft Manufacturer Industry, Juan Manuel Valle Moreno, Universiteit Utrecht

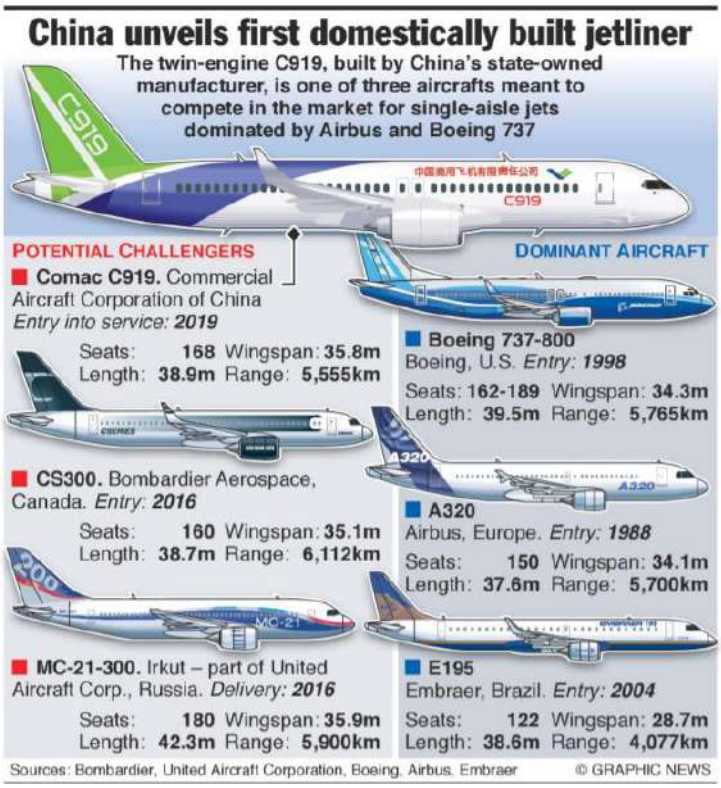
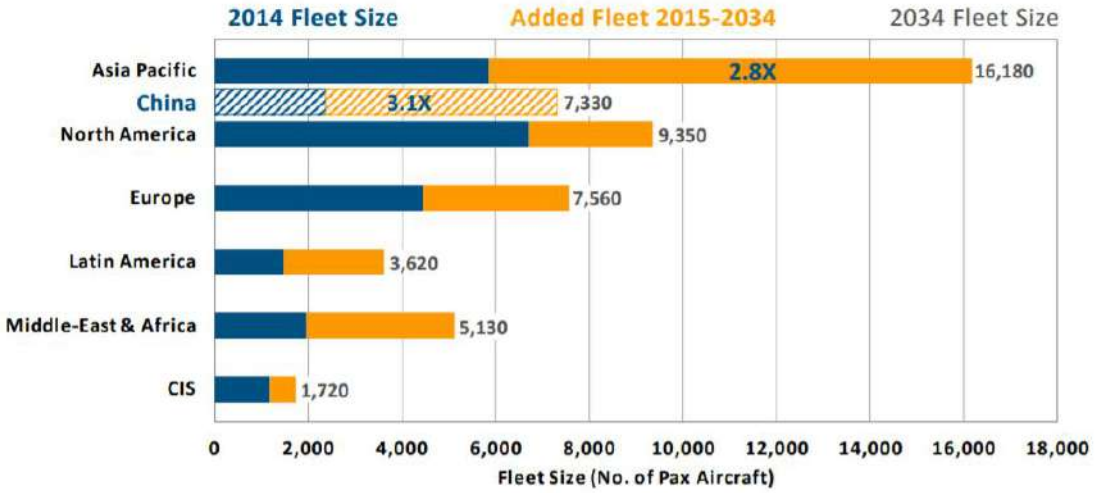


Figure 40: Aircraft competition

Although Airbus and Boeing are still the two majors' key players, emergent airplane manufacturing industries want to get involved in this profitable market and they intend to add new entrants to the regional jet and narrow-body or single-aisle segments such as: The Brazilian Embraer, the Canadian Bombardier and the Japanese Mitsubishi Aircraft Corporation (MAC) along with the government-funded United Aircraft Corporation of Russia (UAC) and the Commercial Aircraft Corporation of China (COMAC) are using their domestic markets to develop the required capabilities and technical skills to become global players (Figure 45).
Certainly, the commercial aviation industry is booming with predictions foreseeing a continuous growth rate for the next two decades, particularly in Asia area (Figure 46). This is clearly a great opportunity for aeroplane maker companies but also a challenge. It is important to note that aerospace equipment is part of the main goal identified by the "Made in China 2025" policy, and will therefore, attract investment and attention in the coming years.

China took a big step forward in the aircraft manufacturing business in 2008 with the formation of COMAC (the Commercial Aircraft Corporation of China). COMAC is a state-owned company, incorporated and producing aircraft in Shanghai. It brought together several smaller manufacturing and aeronautical companies across China, with a mission to manufacture large civilian jet aircraft. Such development is part of China's long-term development goals, incorporated in its "Five Year" and its "Made in China 2025" strategic plans.



Source: Parker

Figure 41: Fleet size by region

COMAC the Commercial Aircraft Corporation of China wants to enter the single-aisle segment, whose expected demand is 70% of the whole aviation industry over the next twenty years (Figure 47). China is interested in building a successful commercial airplane to demonstrate that it can equal the United States and the European Union and develop a national economy with high-tech industries.

COMAC's primary objective now is to build a larger passenger aircraft in order to become an independent innovative country and improve its competitiveness.
Essentially all aircraft manufactured in China, as well as major components such as engines and propellers, are produced by the Aviation Industry Corporation of China (AVIC) and Commercial Aircraft Corporation of China, Ltd. (COMAC) and their subsidiaries.

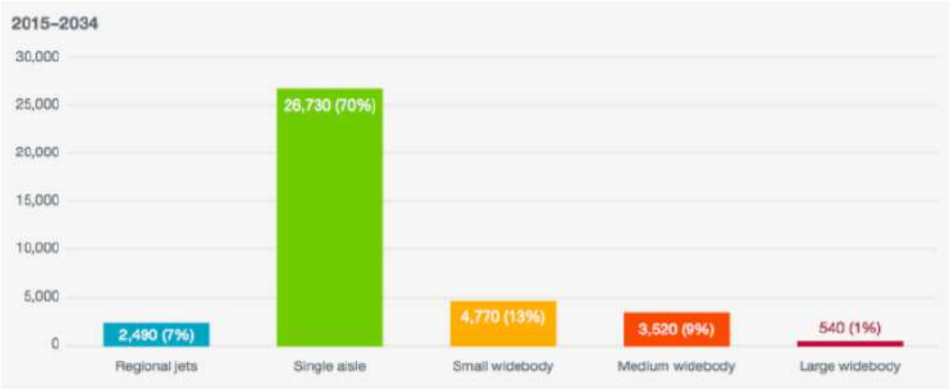


Figure 42: Forecast aircraft demand by segment

In December 2018, the government released an action plan which aims to make the civil aviation industry one of the best in the world by 2050. Initially, the focus will be on infrastructure and airspace capacity. From 2021 to 2035, the major areas of focus will be air transportation, aviation hubs, air service system, aviation systems, and air traffic management system.

China has launched the development of a homegrown contender, the COMAC (Commercial Aircraft Corporation of China) C919, a single-aisle, twin-engined aircraft with a seating capacity for between 150 and 180 passengers (depending on class configuration), suitable for servicing domestic and regional routes. This is designed to take on Boeing and Airbus, with specifications similar to the Boeing 737 and the Airbus A320.

Figure 43: C919

Figure 44: COMAC C919 suppliers

As of October 2020, six test aircrafts have been built with the contribution of Western partners (Figure 48), and the first airline delivery is expected in 2021. The launch customer will be China Eastern Airlines. Development and deliveries have already been delayed. There have been several technical problems as part of test flights. And the engines also caused delays. The US government considering blocking a deal with General Electric, but this was resolved in April 2020, and the C919 will use GE LEAP-1C engines.
COMAC has already accumulated an impressive number of orders, reporting that airlines and aircraft-leasing firms have placed orders for 1,065 C919s, with most of the demand coming from Chinese carriers.

Joint ventures with foreign enterprises came relatively late to the Chinese aviation industry. The first joint venture in this sector was established in 1996, when Pratt & Whitney partnered with the Chengdu Engine Group Company to establish a production facility in Chengdu to produce components for aircraft engines and industrial gas turbines. Since that time, however, foreign investment in the Chinese aviation sector has expanded rapidly, and today most major Western commercial aircraft manufacturers and aviation subsystems suppliers have established joint ventures in China (Figure 49). Joint ventures are frequently regarded as an effective vehicle for Western companies attempting to gain access to the Chinese market. Certainly, Chinese aviation industry leaders have made no secret of

their desire to trade market access for technology, and joint ventures are their vehicle of choice for gaining access to advanced Western technologies.

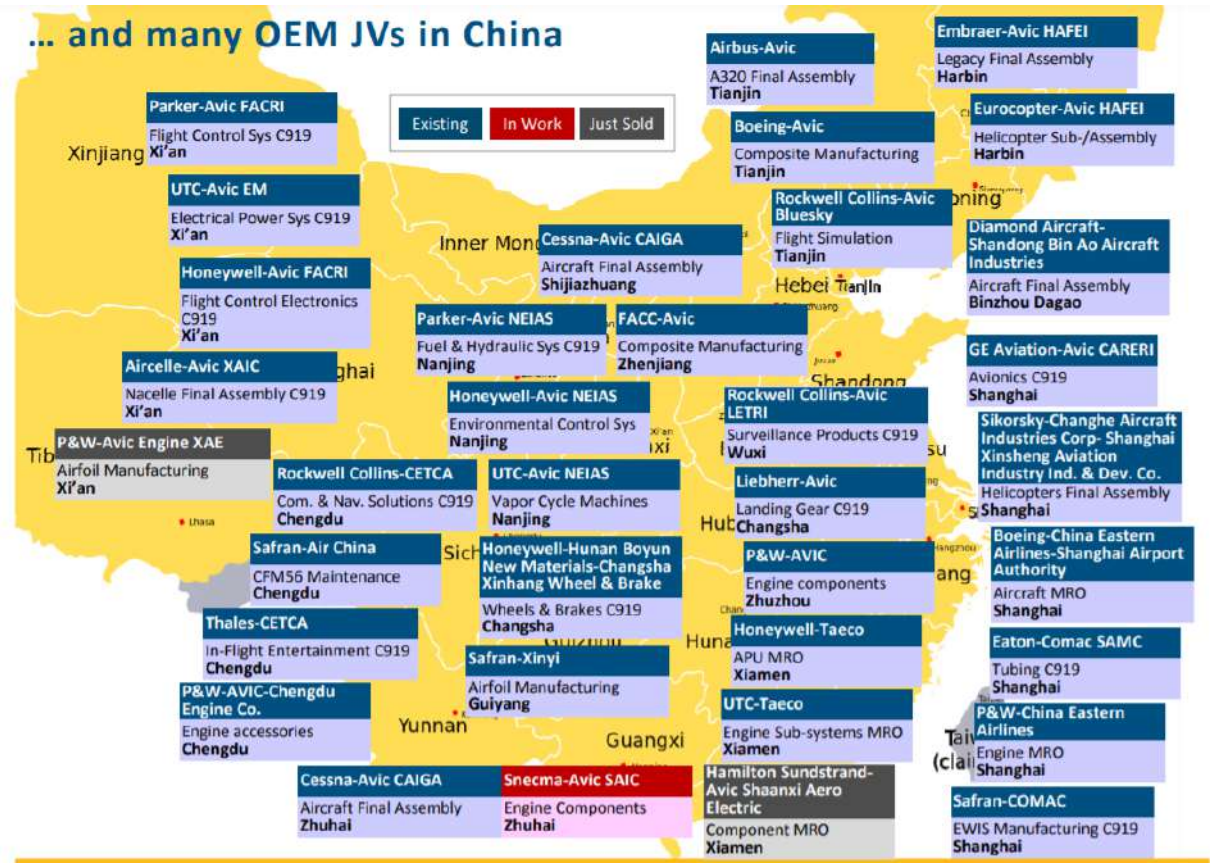


Figure 45: Examples of OEM JVs in China

China's main civil aviation clusters are located on its eastern coast, in the provinces/cities of Tianjin, Jiangsu, Shanghai and Guangdong, while the defense-oriented cluster is mainly developing in Shaanxi, in central China (Figure 50). Leading worldwide companies such as Boeing, Airbus, GE and Safran have entered the Chinese market for decades and are ramping up production and sourcing locally (Figure 51). However, China's local aviation supply chain is still undergoing development and facing serious challenges to fulfil the increasing demands from the top down.
The biggest players are AVIC and AECC and their subsidiaries.

In terms of ongoing programs, we can identify five different civil aircraft designs:

AG600 – The worlds' largest amphibious aircraft, designed to undertake fire-fighting and sea rescue roles. Completely engineered and produced in China, powered by four locally produced turboprop engines and able to accommodate 50 passengers.

MA60 – 80-seat turboprop aircraft. The first airframe has moved into structural test, with the second aircraft due to be rolled out later this year. The aircraft structure is locally produced with all systems supplied by overseas companies via local joint ventures (JVs).

ARJ21 – 80-90-seat regional jet, with 25 aircraft now in domestic operation. The ARJ-21 follows a similar local structure/overseas systems model.

C919 – 158-190-seat civil aircraft. Not yet certificated, six prototype aircraft are now flying from 3 different flight test centres. Local structure/overseas systems model is being used.

CR929 – China also has a joint venture with UAC in Russia to develop a larger family of wide-body aircraft, accommodating 250-280-310 passengers. Russia will produce the wings, COMAC will produce the fuselage and undertake final assembly. Due to its composite airframe, COMAC/UAC have invited overseas companies with past composite airframe experience to participate on the CR929, via local JVs.

Figure 46: China's Aerospace Industry

Other aircraft - AVIC is also working on the development of a range of Chinese-built helicopters through joint ventures with helicopter OEMs. The helicopters are mostly based on older OEM designs, to protect their latest intellectual property. However, new military helicopters designs are being developed in cooperation with Russia.

eVTOL and unmanned aircraft - One new technology area where China is leading the field is in the development of eVTOL urban air mobility vehicles where Chinese manufacturer EHang has already delivered 34 vehicles to different cities around the world and recently gained approval for commercial operations in China. Meanwhile, full size twin turboprop aircraft from the Antonov era are being converted to remotely-piloted vehicles (RPVs) for China Post overnight and off-shore deliveries. There are also a large number of ongoing commercial drone delivery projects.

Engines - One area where China has not progressed as quickly as it hoped has been in aero-engines. It was thought 25 years ago that China would now be self-sufficient in engines but now some experts think it may take another 25 years. China is currently using western engines to power ARJ21 and the C919 but the Aero Engine Corporation of China (AECC) is well advanced in the development of commercial engine alternatives to the CFM LEAP engine for single aisle aircraft and the Rolls Royce or GE engine to be used on the CR929. A family of turboshaft engines is also being developed with Safran as a JV.

Figure 47: International companies' presence in China

In 2019, China continued its vigorous airport construction plan across the country, with another 126 airport construction projects underway according to the report. This reflects China's ambition of fully interconnecting even the smaller cities in China by air, as mentioned in China's 13th Five-Year Plan (Figure 52).

Fig. 6 – Locating the Airports and Main Traffic Hubs

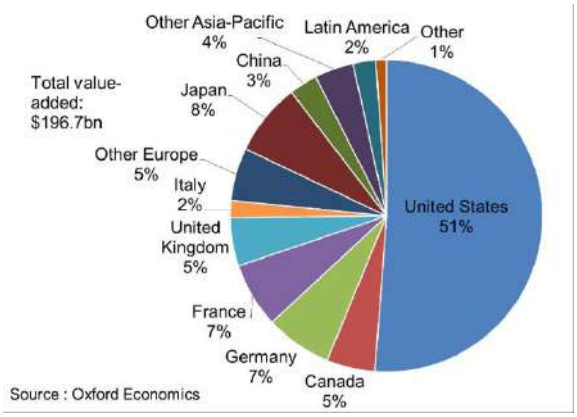
Source: CAAC (2019)

Figure 48: Chinese Airports and Corresponding Traffic

Aeronautics and space sectors are mainly dominated by the State and composed by public conglomerates (AVIC, COMAC, AECC for aeronautics and CASC and CASIC for space). Institutional bodies are omnipresent through NDRC, National Development and Reform Commission, MIIT, Ministry

of Industry and Information Technology, SASTIND, State Administration for Science, Technology and Industry for National Defence and MOST, Ministry of Science and Technology.

It has to be noted that private companies are emerging in the space sector (OneSpace, LinkSpace, LandSpace…) and in the aeronautics in the drone's sector (ZHZ, Future Aerospace, Haite, Xizi, Nanshan…). In terms of production, the US is still by far the major producer of aerospace items worldwide accounting for 51% of the production in 2016 while China was accounting for 3% (Figure 53).



Source: Oxford Economics

Figure 49: Global Aerospace production (2016)

3.7 Exhibitions and Events in China

- Semicon China Shanghai, www.semiconchina.org
- Laser World of Photonics China and Shanghai www.world-of-photonics-china.com
- Hong Kong Electronics Fair https://event.hktdc.com/fair/hkelectronicsfairse-en/HKTDC-Hong-Kong-Electronics-Fair-Spring-Edition/
- Photonics China Expo à Pékin www.cipeasia.com
- China International Optoelectronic Exposition Shenzhen, www.cioe.cn/en/index.html
- China International Aviation & Aerospace Exhibition, Zhuhai : https://www.airshow.com.cn/Category_1216/Index.aspx
- China Satellite Conference and Exhibition: http://www.china-satellite.org/?lang=en
- Beijing International Aviation & MRO Exhibition : http://www.beijingaviation.com/
- China Helicopter Exposition http://www.helicopter-china-expo.com/
- International design expo http://en.id-expo.com.cn/
- CIAMITE: Material Technology Equipment, Analytical Testing and Scientific Equipment and Laboratory Equipment Exhibition http://www.ciamite.com/en/
- EDICON: China, Electronic Design Innovation Conference, https://www.ediconchina.com/
- IME: China International Conference & Exhibition on Microwave and Antenna (IME/China) http://www.imwexpo.com/siteengine.php?do=en/index1
- "Terahertz Science and Technology Academic Conference" International Symposium on Ultrafast Phenomena and Terahertz Waves http://isuptw.com/
- Analytica 2020 World's Leading Trade Fair for laboratory technology, analysis, biotechnology and analytica conference https://www.analytica.de/en/
- BCEIA: International Summit on Instrumental Analysis http://www.bceia.cn/en/default.aspx

- OVC Wuhan: Optics Valley of China International Optoelectronic exposition and forum http://eng.ovcexpo.com.cn/

3.8 Covid-19 impact

During the COVID-19 pandemic China has implemented strict sanitary and non-sanitary measures to regain control of the outbreak. Even though clusters of COVID-19 cases have reappeared sporadically in various parts of the country, and are likely to continue doing so, the proven tracing, testing and isolation system prevents them from posing a major risk to economic activities. Hundreds of millions of people have been tested by the nearly 4 000 testing institutions countrywide. The coronavirus pandemic appears to have been brought under control in most of the country, but there is an unknown number of asymptomatic carriers of the virus and citizens returning from abroad also bring it back, so quarantines and hygienic measures have continued. The sharp drop-in economic activity was followed by a rapid rebound as of early autumn (Figure 54), almost all activities had restarted and exceeded pre-pandemic levels in seasonally adjusted terms. Exports in September 2020 rose 9.9%, while imports grew 13.2%, official data show.

Source: National Bureau of Statistics

Figure 50: China's GDP Data of Q1 2019- Q3 2020

Chinese companies are making up a greater share of the world's exports, manufacturing consumer electronics, personal protection equipment and other goods in high demand during the pandemic. China's economic recovery has also been dependent for months on huge investments in highways, high-speed train lines and other infrastructure. And in recent weeks, the country has seen the beginning of a recovery in domestic consumption. But activity is resuming now even in places like Wuhan, the central Chinese city where the new coronavirus first emerged.

One risk to China's recovery is its heavy dependence on exports. still represent over 17% of China's economy, more than double the proportion that they make up in the American economy. This is a strength but also a weakness because in the frame of the covid-19 crisis, the European economy difficulties will impact China. When the world economy is doing well, China is reinforced.

Still, China's GDP will reach in 2021 the level forecasted by western experts end of 2019 before the covid-19 crisis. The only difference is that instead of a GDP 5% annual growth, 2020 will be about 2%, but followed by an exceptional increase of forecasted 8% according to the World Bank and The International Monetary Fund. There is no other country among G20 members with such performance. China is definitively the world economic driver. There are two major consequences to this situation. Firstly, in the next years, China will move from developing country to developed country. Secondly, because the American economy is expected to contract by more than 4% in 2020, the gap between the US and China is reducing faster than forecasted. Chinese GDP will catch up the American in 2028 or 2029, earlier than forecasted before.

It must be noted that 2021 CPC, Communist Party of China, will celebrate its centenary on July 1, 2021. In this context, the Chinese president will push to reach all the objectives set politically: continuous growth, controlled financial debt, less energy intensive economy and a clear reduction of inequalities.

Conclusion

The study highlights the importance of the Chinese market, leader in several fields detailed such as photonics and steel production and quickly catching up the other more advanced economies regarding aerospace and advanced manufacturing. In the past decades, China shifted its economy from being agriculture-dependent to tech-driven. Despite being one of the fastest world's economy, the country faces economic challenges that could dampen future growth (such as a high unemployment rate). The next five-year plan (2021-2025) states China main objectives for the future. In fact, the country will highly increase investments in domestic technology and innovation into emerging technologies such as 5G, AI, cloud storage, and Quantum computing to upgrade Chinese industries. The country plans to be the leader in critical and emerging technologies.

4. Country Report: Japan

4.1 General overview

Key data:

- GDP 2019: 5,081,769 million USD (*vs 21 million for the US)*
- GDP per capita: 40,246 (*vs 65 000 for the US*)
- Annual growth in 2019: 0,7%
- Third world largest economy in the world
- Ranks 11 in the list of countries by population (126,292,623 people, 1,62% of the total world population)
- 378,000 Km2, 347 inhabitant/km²
- a 6 852 islands archipelago
- The median age is 48.4 years

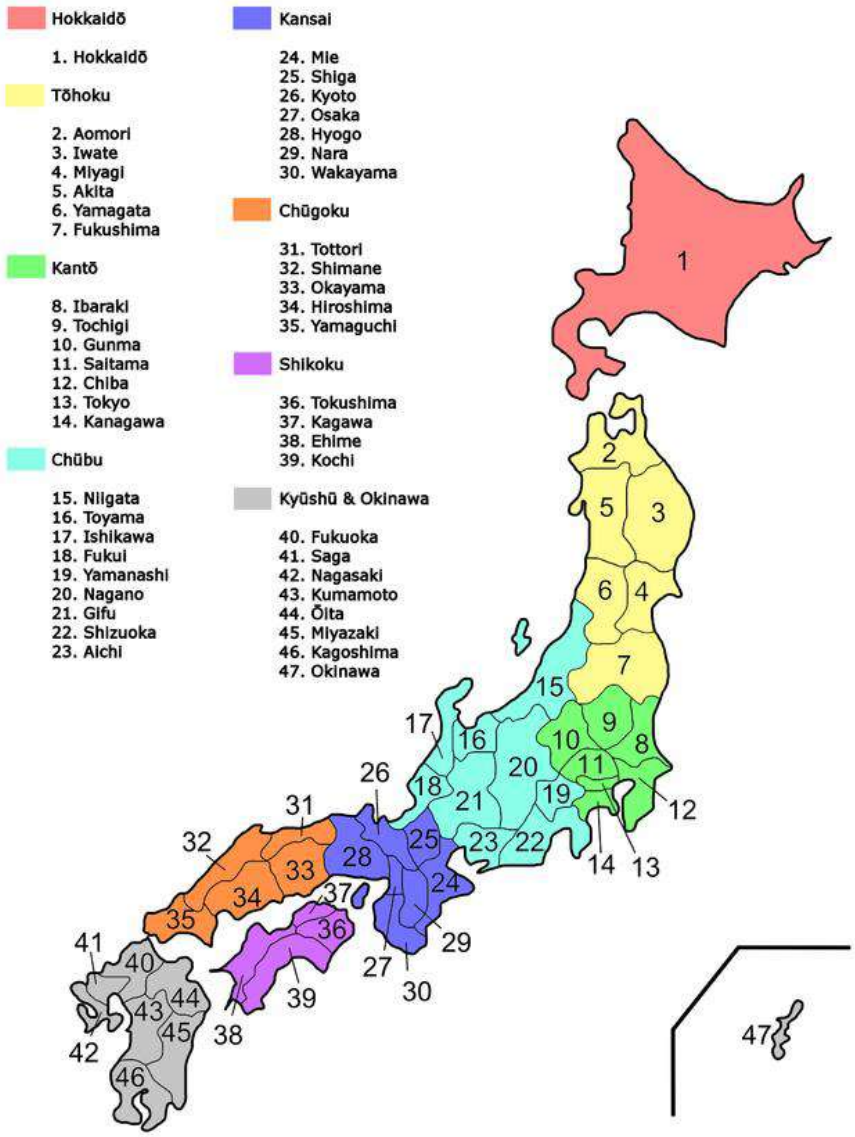


Figure 51: Japan areas

According to the World Economic Forum Report, Japan is the third-largest economy in the world, and contributes almost 6% to the global GDP. 70% of the country GDP is concentrated in the regions of Kanto (1.932Mds USD), Chubu (739Mds USD) and Kansai (761Mds USD), headed by the metropoles of Tokyo, Nagoya and Osaka.

The financial crisis of 2008-09 hit hard the Japanese economy; it was the only major advanced economy that experienced negative economic growth in 2008 and continued to contract sharply in 2009. The impact of the sub-prime crisis that originated in the U.S. on the Japanese economy was majorly due to the severe impact on Japan's exports. Japan's Prime Minister Shinzo Abe adopted, at the same time, in 2017, the "Abenomics 2.0" program which aims to accelerate efforts towards comprehensive reforms in three vital areas: 1) boosting productivity, 2) driving innovation and trade, and 3) energizing corporate activities.

In Japan, economic growth is projected to be 0.6% in 2020 and 0.7% in 2021. Although exports have remained flat since mid-2018, wage income has increased at a rate of 1.3% annually in real terms since mid-2018 and has been supporting domestic business investment and household consumption.

The biggest challenge to face for the country is the rapid aging process[15]. Japan registers the higher proportion in the world with 20% of population being over 65 years old. The latter directly impacts the economic growth by reducing labor force, which is a major factor in production. With the coming labor shortage, the government intends to encourage women to work more, but also to resort to immigration (mainly Asian). Indeed, foreign residents represent 2,73 million people in 2018, an increase of 6,6% in one year.

The first largest industry of Japan is the services sector which is the top contributor to the Japanese GDP – it accounts for around three-quarters of the country's total economic output such as retailing, banking, insurance, transportation, real estate, and telecommunications are all highly-developed industries in Japan. For example, Japan Airlines is recognised as one of the largest airlines around the globe.

Japan's manufacturing sector is very diversified with a broad variety of highly-advanced industries. In fact, manufacturing industries contribute nearly 30% to the Japanese GDP. Industrial activities are concentrated in several regions of the country, with the Keihin industrial region, the Hanshin industrial region, and the Chukyo-Tokai industrial region being the major industrial centers. Japan boasts high technological development and has come to the forefront in many fields, including automobile manufacturing, electronics, optical fibers, biochemistry, semiconductors, optoelectronics, facsimile, copy machines, optical media, amid others. Presently, the country is focusing on the manufacture of high-tech and precision items, for instance, optical instruments, robotics, and hybrid vehicles.

Automotive manufacturing is one of the most successful sectors in Japan, commanding a great share of the world's automotive business. Japan takes the third spot on the list of the world's largest automobiles producing countries. At present, Japan produces motor vehicles, tires, engines, and other auto components and parts. The prominent automotive industry players in Japan include Toyota, Isuzu, Mitsubishi, Honda, Suzuki, Nissan, Mazda, Subaru. Some world's leading motorcycles manufacturers like Yamaha, Honda, Kawasaki, and Suzuki are also based in Japan.

Japan's electronics industry is the biggest consumer electronics industry around the world, though the share held by the Japanese companies has declined in the wake of the growing competition from the major rivals (namely South Korea, China, and Taiwan). Japanese companies have introduced a great

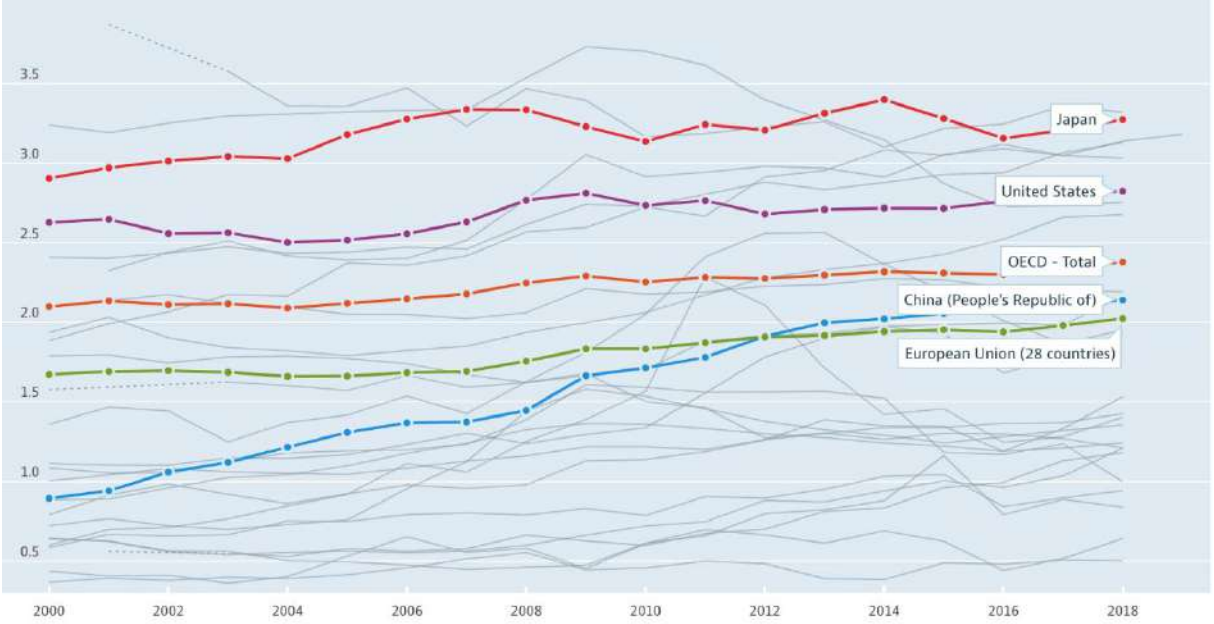
[15] See https://www.oecd.org/economy/japan-economic-snapshot/

number of important innovations and have ranked a mid-top country in terms of patent filings. The country's electronics industry players pioneered the transistor radio, first mass-produced laptops, LCD screens, solar cells, VHS recorders, to name a few. Some of the widely renowned electronics companies based in Japan include Canon, Fujifilm, Sony, Nikon, Panasonic, Nintendo, Pioneer, Hitachi, Casio, Akai, JVC Kenwood, Toshiba, Sharp Corp., to name a few.

Japan is highly dependent upon the import of natural resources. For example, it is the world's largest net buyer of food products in the world[16]. The United States is the leading supplier of its agricultural imports, as well as agricultural capital equipment and related technologies according to US export statistics. Total U.S. food, agricultural, and fishery exports to Japan were worth more than $13 billion (10bn€) in 2018[17]. Japan is also the world's largest importer of liquefied natural gas (LNG) and the third-largest coal importer.

4.2 Research and Development in Japan

According to OECD report, as seen in the below Figure 56 and Figure 57, the country is one the biggest R&D investors. Japan spent 3.4% of its GDP in 2018 on R&D investments while OECD countries spend 2.3% on average.



This indicator is measured in USD constant prices using 2010 base year and Purchasing Power Parities (PPPs) and as percentage of GDP.

Source: OECD https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

Figure 52: Gross domestic spending on R&D Total, % of GDP 2000 – 2019

[16] See https://www.export.gov/article?series=a0pt0000000PAu7AAG&type=Country_Commercial__kav
[17] See https://ustr.gov/countries-regions/japan-korea-apec/japan

Source: UNESCO

Figure 53: R&D spending in Japan

The top ten leading Japanese institutions for high-quality science start from the University of Tokyo – the biggest university in Japan. Kyoto, Osaka and Tohoku Universities are in the second, third and fourth place respectively. RIKEN, Japan's leading research institute, is fifth, then follows Tokyo Institute of Technology (sixth), Nagoya University (seventh), Kyushu University (eight) and Hokkaido University (ninth). The National Institute for Materials Science is tenth.

RIKEN is Japan's largest research institution renowned for high-quality research in a diverse range of scientific disciplines. Founded in 1917 as a private research foundation in Tokyo, RIKEN has grown rapidly to a network of world-class research centers and institutes across Japan. One of the main centers related to photonics is RIKEN Center for Advanced Photonics74 (RAP). RAP focus areas are attosecond lasers, near-field optics, metamaterials and terahertz light.

Universities and Research Centers in Japan:

Entity	Field
AIST: National Institute of Advanced Industrial Science and Technology	Research Institute for Advanced Electronics and Photonics / Platform Photonics Research Center
Institute of Industrial Science (IIS), University of Tokyo	Nanoscience Center for Photonics, Electronics, and Materials Engineering
Institute of Laser Engineering, Osaka University	one of the most important research institutes in Japan specialized in high-power laser equipment needs, for semiconductor lasers, fiber lasers, and laser sources luminous X-ray to terahertz.
Institute for Laser Technology	various fields of application for lasers (nanotechnologies, energy, high intensity lasers, life science, manufacturing)
Institute for Solid State Physics (ISSP)	research center at national scale with a very large number of research groups, especially the one on lasers and synchrotrons.
Kansai Photon Science Institute (KPSI)	KPSI focuses mainly on high intensity lasers, photonics and synchrotron radiation

National Institute of Information and Communications Technology (NICT)	electromagnetic wireless communications, cybersecurity, open innovation and new technologies
Photon Science Center, University of Tokyo	advanced research in the fields of optics and photonics, they organized an annual event for several years "Hikari Forum"
Photonics Center, Osaka University	specialized in nanophotonic with the program « Advanced Nanophotonics in the Emerging Fields of Nano-imaging, Spectroscopy, Nonlinear Optics, Plasmonic/Metamaterials and Devices »
RIKEN	One of the largest research institutions, specialized in photonics
Tokyo Metropolitan Industrial Technology Research Institute	several divisions (electrical/electronic, optics, mechanics, biotechnology, information, environment, IoT)
University of Electro-Communications	development of applicable technologies: uper-frequency-stabilized lasers, high-quality and ultra-low-loss mirrors, adaptive and/or active optics, ceramic lasers, fiber lasers, ect

4.3 Focus on Photonics

Japan has traditionally been one of the strongest players in the global photonics industry. Despite losing market share in recent years, Japan still accounts for approximately 21% of the global photonics production according to Photonics 21 report[18]. As a result of the global shift of production to more cost-competitive countries, Japanese players are being confronted with growing competition from emerging Asian countries, such as China and South Korea. Consequently, Japan is trying to look for new application industries. The domestic research landscape exhibits close cooperation between government and companies for commercialization of research results, as a response to increasing level of foreign competition.

Photonics companies in Japan:

Company	Sector/Products
Anritsu Corporation	test and measurement instruments, optical equipment, sensors and X-ray devices
Hamamatsu Photonics K.K	optics, lasers and scientific instruments
Hoya Corporation	health fields (lenses contacts and medical), also in electronics for photomasks.
Iwasaki Eletric Co., Ltd	fields related to light (lighting and optical applications), products can be used in various fields such as (infrastructure, commercial, special environments)
Kyocera SOC Corporation	specialized in ceramics and electronics: productions of high-precision optical equipment, components and lasers.
Laserx Co., Ltd	conception and fabrication of laser equipment's (laser processing, welding and cutting machines)
Nikon Corporation	specialist in optics, for the fields of image, lithography, optical equipment related to health.

[18] See https://www.flipsnack.com/photonics21/key-data-market-research-study-photonics-2020/full-view.html

NTTElectrononics	development and fabrication of products related to security of optical networks, systems and equipment related to photonics and semiconductors.
Mitsubishi Eletric Corporation	major supplier in many industries (automotive, aeronautics, industrial equipment): optical devices, high-performance devices frequency, radar systems, antennas, laser machines, mechatronics, mechatronic systems, frequency communications
Nikkiso Co., Ltd	Both in the industry, with pumps, valves, equipment of precision, or in the medical field for medical devices, the company also manufactures equipment that is used for air purification, air purification, water purification
Phluxi, Inc	Important know-how in the field of terahertz technologies, production and sale of laser equipment located between UV and THz, as well as all types of products related to lasers and THz (generators, oscillators) sources, passive components)
Pulstec Industrual Co., Ltd	X-ray based scanners, easily and quickly transportable and light, 3D scanners that can be used for robotics, or measurement systems, in addition to offering sensors optics.
QD Laser, Inc	specialized in lasers applied to the field of semiconductors (precision tooling, optical communications and sensors) as well as image projection on the retina.
ROHM Co., Ltd	One of the leading suppliers of electronic micro components: opto-equipment, at namely optical sensors, laser diodes and LEDs.
Sigmakoki Co., Ltd	produces in particular the various optical equipment used in the laser field: mirrors, filters, lasers and equipment measuring
Shimadzu Corporation	advanced fields (instruments of measurement for medical and industrial equipment, and aeronautics): spectrometry, radiography, X-rays, imaging
Trimatiz Limited	high-speed control equipment in the optical field: design and manufacture of optical equipment and electronic products
Yamakura Photonics Co. Ltdd	specialized in the field of glass (materials and components), glass/ceramic substrates for electronics and opto-electronic components

The Japanese companies were pioneers in many segments of photonics, especially information technology and displays (See below Figure 58 the classification of photonics related technologies by OITDA). Now, nearly half of the photonics production of companies headquartered in Japan is happening overseas, mainly in China and that makes up almost half of the photonics production there. More than ten years ago, Japan was the major producer of photonics with the global share of 34%, not including the overseas production. While in 2011 that share shrunk to 21% and in 2015 the share was only about 15%. If to include overseas production, Japan was still a major producer with 40% share in 2011 and 30% in 2015.The total domestic Japanese photonics market in 2015 is valued at 8.6 trillion JPY (64 billion EUR with the EUR/JPY exchange rate 134 in 2015 and 111 in 2011) according to the data by the Japanese Optoelectronics Industry and Technology Development Association (OITDA).

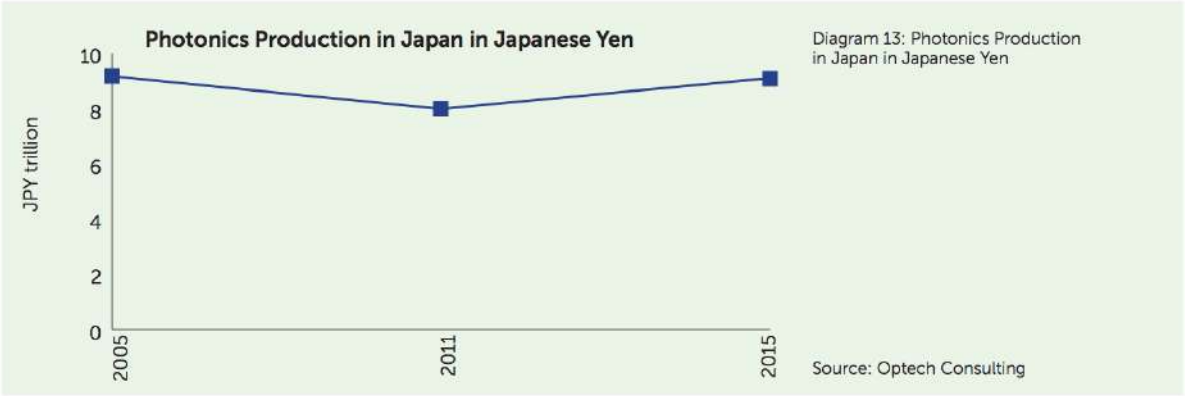
1. Optical Communication:	Optical transmission equipment/systems, optical fiber fusion splicer, light emitting devices, photo detectors, optical passive components, optical fiber, optical connectors, etc.
2. Optical Storage:	Optical disc equipment (read-only, recordable), optical disc media, laser diodes, etc.
3. Input/Output (I/O):	Optical printers, multifunction printers, digital cameras, digital video cameras, camera mobile phones, image sensors, etc.
4. Display and Solid-state Lighting:	Flat-panel display devices and equipment, projectors, solid-state lighting devices and equipment, LED (for lighting and displays), etc.
5. Photovoltaic Energy:	Photovoltaic power generation systems, photovoltaic cells and modules
6. Laser/Optical Processing:	Laser/Optical processing equipment, Lamp/LD lithography, additive manufacturing (3D printers), laser oscillators
7. Sensing and Measuring:	Optical measuring instruments, optical sensing equipment
8. Others:	Hybrid optical devices, etc.

Source: OITDA

Figure 54: Classification of optoelectronics industry by OITDA

According to the Economist Intelligence Unit, in Japan about 99% of businesses are small and medium-sized enterprises (SME). Out of them, even though only 11% are doing manufacturing, it is a big and important group next to the number of huge and world-famous Japanese manufacturing corporations. One thing to note is that many big companies have diverse portfolios of products and photonics related are usually just a part of it. For example, according to OITDA, some of the core photonics industry companies are Hitachi, NEC, Toshiba, Mitsubishi, Fujitsu, Panasonic and all of them are big corporations manufacturing a wide range of products.

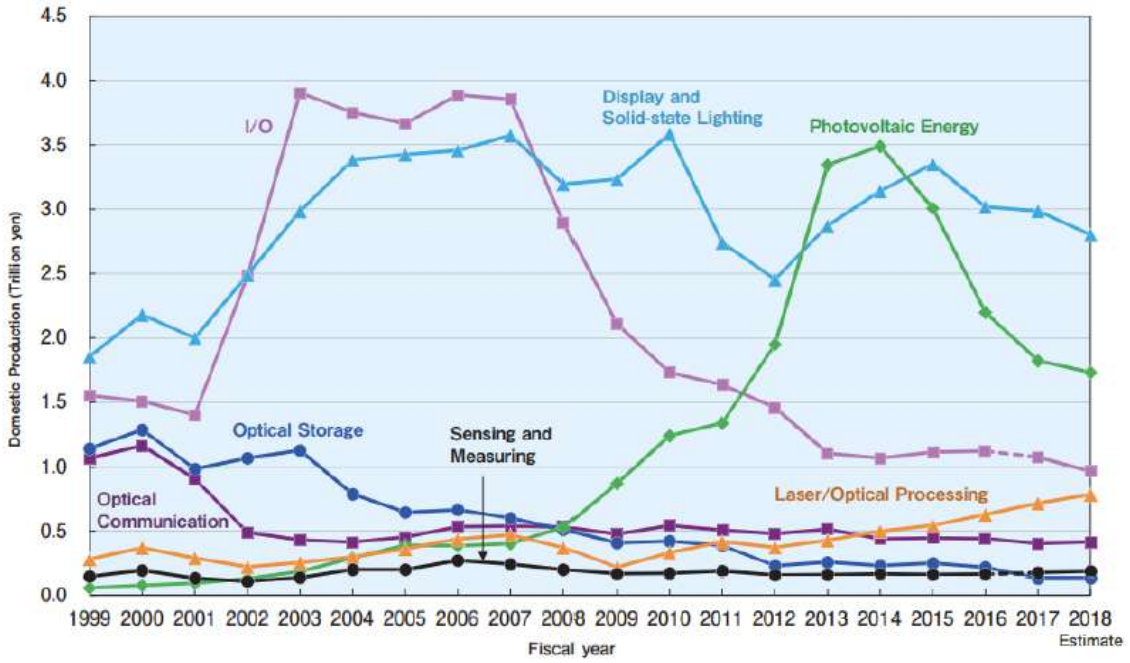
<u>Photonics production:</u>



Source: Optech Consulting

Figure 55: Photonics productions in Japan (in Yen, 1 euro=126 yen, exchange rate of January 2021)

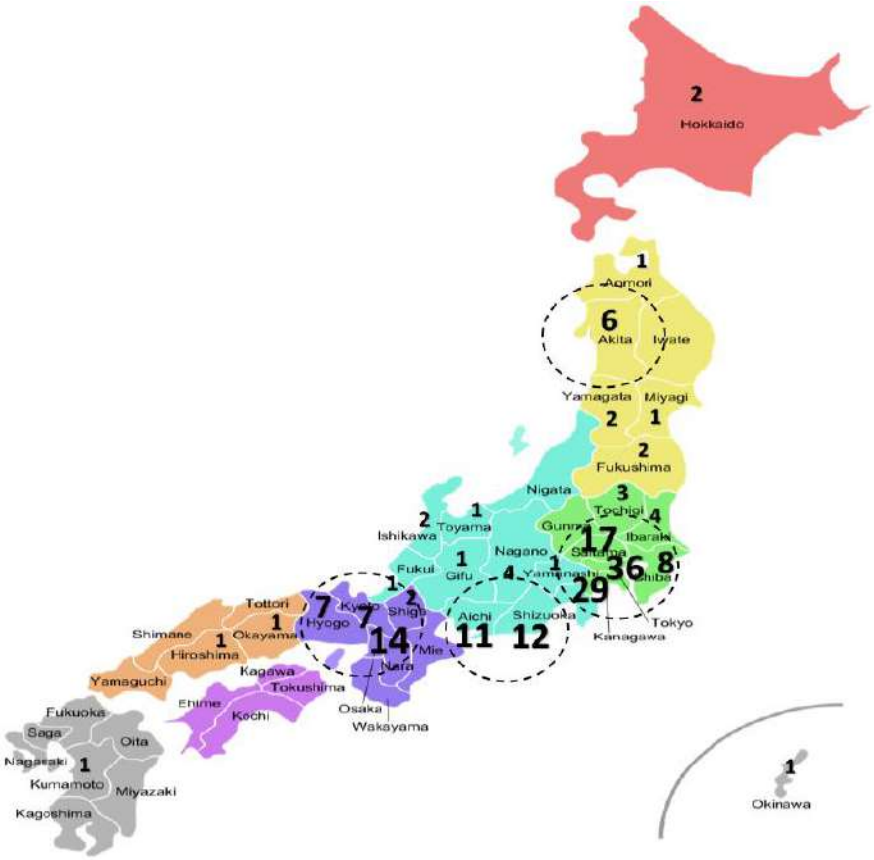
In 2020 according to Figure 59, Japanese photonics production accounted for nearly 10 trillion JPY (79bn€). Optical communications, laser/optical processing, and sensing and measuring, which are mainly related to the domestic market, are easily influenced by domestic economic conditions and capital investments, are reflecting the trends in the economic conditions, and grew substantially in 2013.



Sources partie 1.2 : Japan Electronics and Information Technology Industries Association, Cabinet Office, JEITA , OITDA

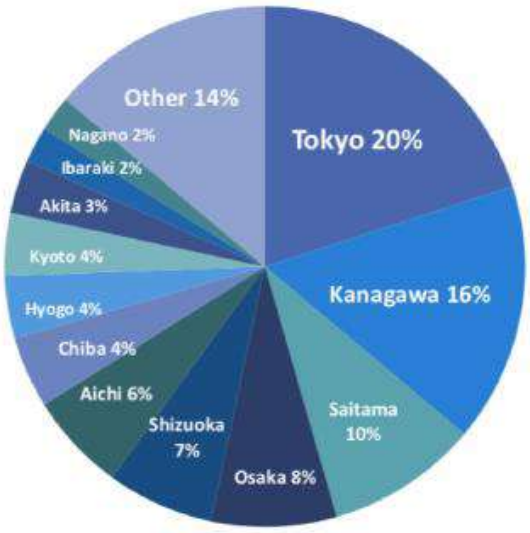
Figure 56: Productions by each field

Today, the segments of information technology and displays still contribute the largest parts to the production volume in Japan (Figure 60). Five medium size segments contribute between 5 billion Euros and 10 billion euros per year: production technology, measurement & displays, medical technology & life science, components & systems, lighting. Market shares of the Japanese domestic production in the global market range between 10% and 30% for the above-mentioned segments as well as for communication. Only two segments hold a smaller market share: photovoltaics and defense & security.



Picture 5 – Map of Japan with the number of companies related to photonics in each prefecture (over 180 companies in the map).

Source: PHOTONICS FOR LIFE SCIENCE AND INDUSTRIAL MANUFACTURING – BUSINESS AND COOPERATION OPPORTUNITIES IN JAPAN, EU-Japan Centre for Industrial Cooperation (2018)



Source: EU-Japan Centre

Figure 57: Map of Japan with the number of companies related to photonics in each prefecture

The companies related to photonics are concentrated in, Tokyo, Kanagawa, Saitama, Osaka, and Shizuoka. Companies headquarters are usually located in Tokyo, with satellites offices in Osaka and Nagoya.

Among the companies identified by the EU-Japan Centre for Industrial Cooperation (see reference at the end of the document) in 2018, the majority comes from the following sectors: Laser processing equipment, Optics and Laser products.

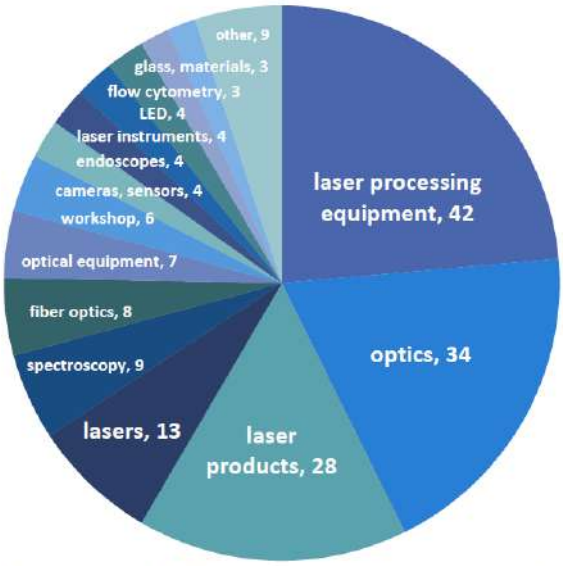


Chart 7 – The number of Japanese photonics related companies in each sector.

Source: EU-Japan Centre

Figure 58: % of photonics companies per area

Source: PHOTONICS FOR LIFE SCIENCE AND INDUSTRIAL MANUFACTURING – BUSINESS AND COOPERATION OPPORTUNITIES IN JAPAN, EU-Japan Centre for Industrial Cooperation (2018)

Figure 59: The number of Japanese photonics related companies in each sector

Photonics companies per segment:

The first category is laser processing equipment and that correlates well with the fact that Japan is among the leaders in the world of machining equipment producers. Majority of the companies are located in the Kanagawa (11) and Aichi (6) area. And about half of the companies are smaller ones, with less than 1000 employees. Most of them are producing laser cutting/drilling and welding equipment.

Table 8 – Some of the laser processing equipment manufacturers.

Source: EU-Japan Centre

Figure 60: Japanese laser processing equipment manufacturers

In second position, there are optics production companies. There are many small companies manufacturing various optical components, some of them very specialized – for example technical corporation making only prisms. There are a few big companies like Nikon and Kyocera that are also manufacturers of optical components, but that is very small part of their business. Majority of the optics companies are around Tokyo (9), in Saitama (5) and Kanagawa (3). Historically, Tokyo was an area where producers like Pentax and Nikon had factories building optical systems for defence applications that grew hugely during the world wars and small optics workshops grew around them. There are companies manufacturing precision glass, filters, coatings, aspheres, precision optical assemblies, electro-optics, fibre optics and many more products.

Optics producing companies
Nikon, KYOCERA, OptoSigma®, MLens NATSUME OPTICAL CORP.

Table 9 – Some of the optics producing companies.

Source: EU-Japan Centre

Figure 61: Japanese optics producing companies

Then, in third position in terms of photonics related Japanese companies, there is the laser segment. There are not many laser manufacturing companies in Japan anymore. Before, many big companies used to make some kind of lasers, but now only a few are remaining. Companies like Mitsubishi, NTT, Fujikura, Omron and Gigaphoton are still manufacturing lasers. Mitsubishi and Fanuc are manufacturers of CO_2 lasers. Fanuc is also a leading industrial robot manufacturer in the world. Spectronix is a picosecond and nanosecond laser producing company from Osaka. Most laser manufacturers are concentrated in Kanagawa (5) and Saitama (3) areas.

Laser products segment includes manufacturers of the laser diode and other components or manufacturers of systems and equipment that is not used for laser processing. Most of the companies are in Saitama (5), Tokyo (3), Osaka (3), Kyoto (3) and Kanagawa (3). Some of the companies in this group are well known producers like Toshiba, Shimadzu or Sumitomo – big and with a wide range of products related to lasers and photonics.

Table 11 – Some of the laser manufacturing companies.

Source: EU-Japan Centre

Figure 62: Japanese laser manufacturing companies

Table 10 – Some of the laser products companies.

Source: EU-Japan Centre

Figure 63: Japanese laser products companies

Photonics related companies
HAMAMATSU NIKKISO Microtrac Total Solutions in Particle Characterization nano photon NIDEK NEC GLASS FOR FUTURE Nippon Electric Glass KIMMON KOHA

Table 13 – Some of the photonics related companies.

Source: EU-Japan Centre

Figure 64: Japanese photonics related companies

In Europe, one of the best-known photonics company from Japan is Hamamatsu Photonics. They are producing optical sensors, optical components, cameras, light & radiation sources, lasers various detectors, spectroscopy solutions and other systems and components for light applications, and also manufacturing support systems, semiconductor manufacturing support systems, photometry systems, life science & medical systems. Hamamatsu Photonics has several R&D centers in Japan and is closely collaborating with universities. With Shizuoka University they even have established a new university dedicated to photonics called - The Graduate School for the Creation of New Photonics Industries.

In terms of distributors, there are two different kinds in Japan: one is big corporations with hundreds of products and the other is specialized distributors dealing with just certain kinds of products. When dealing with big corporate distributors, it is important to remember that usually, the majority of revenue for them does not come from photonics' products and because of hundreds of products and standardized processes, there can be a lack of active sales.

Figure 65: Some japanese distributors

Table 18 – Some of the distributors in Japan.

Source: EU-Japan Centre

Top 15 oldest distributor		Top 15 newest distributors	
Marubun	1844	Nanoxeed	2017
Fujitok	1945	Scansol	2015
Sanyo trading	1947	Akitech Leo	2013
Kyoei Sangyo Co., Ltd.	1947	Astron	2013
Ryokosha Corporation	1947	Hikari	2012
OSAKA KOHKI CO., LTD.	1950	Aisay	2010
Hakuto	1953	Optotec	2009
TOYO Corporation	1953	Kokyo	2009
New metals and chemicals corporation	1957	Enable K.K.	2009
Japan Laser	1968	Prolinx	2009
Kantum	1977	LxRay Co., Ltd.	2008
FIT Leadintex, Inc.	1978	Sevensix	2007
KLV	1979	Optopia	2005
Hi-Technology	1980	Edgesemicon	2004
Kyokko	1980	Japan Device	2004

Table 19 – Oldest and newest photonics distributors in Japan.

Source: EU-Japan Centre

Figure 66: Japanese distributors list

Table 20 – Photonics and industrial manufacturing related associations in Japan.

Source: EU-Japan Centre

Figure 67: List of Japanese photonics related association

Associations varied from simple organizations uniting just a few companies to the ones that have facilities and laboratories to help with the developments for the members. Most of the associations are also actively involved in the standard's development and can certainly influence the industry. The big societies organize big events with opportunities for companies to promote their products. And usually companies are more actively involved in the activities of societies than associations.
One more interesting association, not mentioned above, is the laser and optics related equipment distributors' association – Japan Importers Association of Lasers and ElectroOptics (JIAL).

Among the associations, OITDA has been promoting the formulation of a research and development strategy and commercialization strategy through cooperation among industry, academia and government regarding the optoelectronics technologies. At the same time, OITDA has engaged in the following priority issues: survey and research on the optoelectronics technology and industry,

promotion of technology development, promotion of standardization, creation of new business, and development of human resources. In 2020, they have developed the Optical technology roadmap of next generation network beyond the 5G mobile communication system, called “Beyond 5G“. They are working on developing the roadmaps of optical access technology and optical device technology for implementing such network.
Indeed, Japan is looking to be the leader for 5G technology and is putting a lot of effort to achieve this goal through R&D programs and various applications tests. It has become a governmental priority to be able to showcase their capabilities in this field during the next Olympic Games replanned in 2021.

Photonics related technologies are essential for achieving the connected industries advocated by the Government of Japan. The key technologies are to collect, transmit and utilize the huge amount of data efficiently. Optoelectronics technology includes many important key technologies such as sensors for data collection, high-speed and large-capacity optical communication systems for data transmission and high-speed & low-power optoelectronic integrated circuits for information processing.

Photonics societies
LASER SOCIETY OF JAPAN THIN FILM SOCIETY 特定非営利活動法人 日本フォトニクス協議会 JAPAN PHOTONICS COUNCIL OPTICAL SOCIETY OF JAPAN
Laser processing societies
Japan Laser Processing Society JSLT LASER TECHNOLOGY SOCIETY
Life science and medical societies
JSLSM Japan Society for Laser Surgery and Medicine 日本レーザー歯学会 Japanese Society for Laser Dentistry

Table 22 – Photonics societies in Japan.

Source: EU-Japan Centre

Figure 68: Photonics societies in Japan

- Regulations

For products sending waves such as wifi or Bluetooth, a specific certification called GITEKI is compulsory to market it.

4.4 Focus on Steel

In Japan, the monthly steel consumption indicator decreased by 3.2% in the first nine months of 2019. Steel demand from the construction, industrial machinery, and automobile sectors have been stagnant, while demand from the shipbuilding sector has been gradually increasing along with recovery of shipbuilding activities (JISF, 2019).

Steel demand growth in Japan is slowing. The construction sector in Japan should experience almost stagnant growth as a result of the decline in residential construction. Furthermore, car production is being affected by weak demand in export markets, such as Korea. As a result of these factors, Japanese steel demand is forecast to decrease by 0.6% in 2020 (WorldSteel, 2019).

Major steel-producing countries 2018 and 2019

million tonnes, crude steel production

Country	2019		2018	
	Rank	Tonnage	Rank	Tonnage
China	1	996.3	1	920.0
India	2	111.2	2	109.3
Japan	3	99.3	3	104.3
United States	4	87.8	4	86.6
Russia	5	71.9	6	72.1
South Korea	6	71.4	5	72.5
Germany	7	39.7	7	42.4
Turkey	8	33.7	8	37.3
Brazil	9	32.2	9	35.4
Iran	10	25.6	10	24.5
Italy	11	23.2	11	24.5
Taiwan, China	12	22.0	12	23.2
Ukraine	13	20.8	13	21.1
Vietnam	14	20.1	15	15.5
Mexico	15	18.5	14	20.2

Source: 2020 World Steel in Figures, World Steel Association

Figure 69: Major Steel-producing countries 2018 and 2019

Despite a small decrease in production of 5 million tonnes between 2018 and 2019, Japan maintained the 3rd place in the world, behind China and India (Figure 73). The steel industry around the world is grappling with the effects of COVID-19. The decline in global steel demand in the first half of 2020 is predictable but perhaps more painful as it came after slower than expected growth in 2019 due to the continuing manufacturing recession in the developed countries. The steel industry remains at the core of a sustainable modern society.

The Japanese steel industry is going ahead with the “Commitment to a Low Carbon Society”, a voluntary initiative that started in 2013 with four central components: eco-process, eco-products, eco-solution and the development of innovative technologies. First goal is to improve the steel industry’s energy efficiency and the second is to contribute to fight against global warming.

One research topic is to develop academic and corporate sector research activities technologies for aging steel mill equipment and extending the life of this equipment. Research also covers measures for tsunamis, soil liquefaction and other disaster-related issues. In addition, there are activities involving new ideas for steel structure technologies and construction methods that the steel industry has created.

Japanese Steel related associations:

- Japan Iron and Steel Federation: https://www.jisf.or.jp/en/index.html
- Japan Automobile Manufacturers Association
- Shipbuilders Association of Japan
- Japan Electrical Manufacturers Association

4.5 Focus on Advanced manufacturing

Today, despite an overall stagnation on the economy for nearly two decades, Japan's industries are still among the most highly advanced and innovative in the world (Figure 74). Japanese manufacturing products, particularly in electronics and automobiles, are the world leaders in both production and technological advancements in their respective fields. In 2012, Industry was responsible for 27.5% of Japan's GDP. Major industries in Japan include motor vehicles, electronic equipment, machine tools, steel and nonferrous metals, ships, chemicals, textiles, and processed foods.

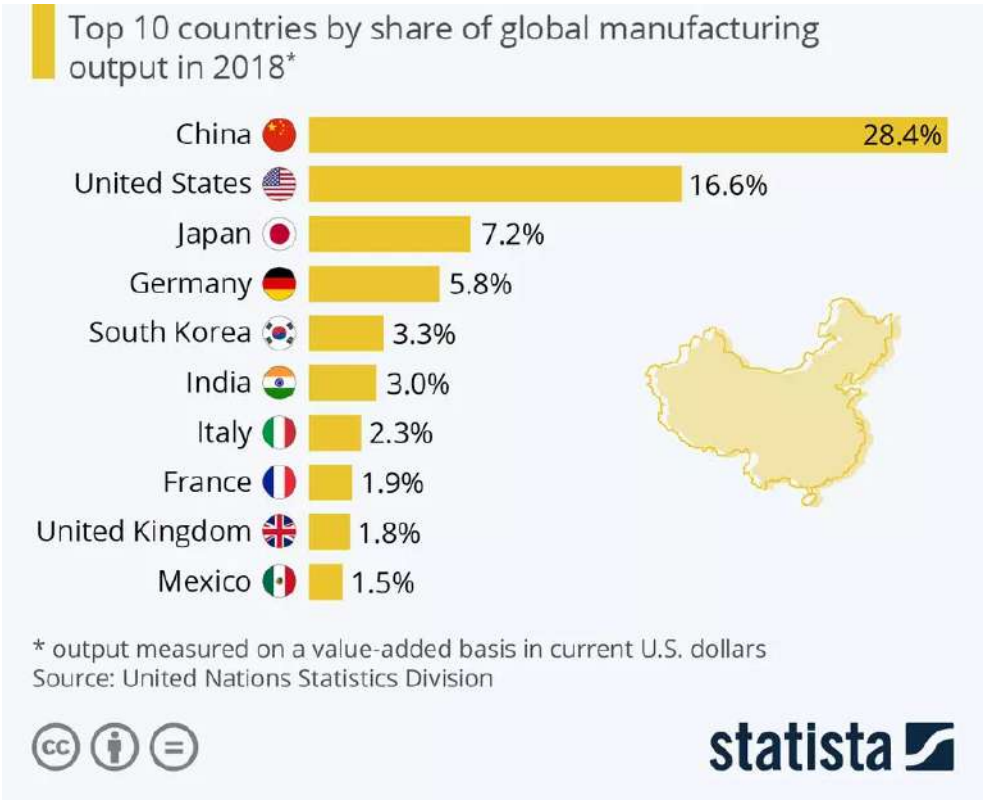


Figure 70: First 10 manufacturing countries

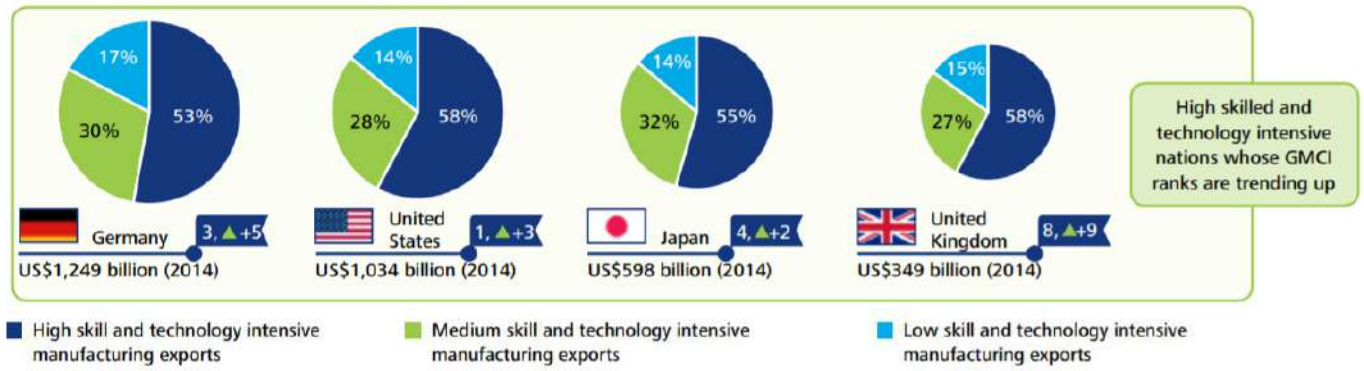
Source: World Economic Forum

Japan's automobile industry produces the second largest number of vehicles in the world behind China. Japan is home to six of the top twenty largest vehicle manufacturers in the world – Toyota (1st), Renault-Nissan (4th), Honda (8th), Suzuki (10th), Mazda (14th), Mitsubishi (16th). The automobile industry also managed to register a massive 10.5% growth in 2009, in spite of the global financial crisis. Japan is also the world's largest electronics manufacturer with prominent companies such as Sony, Casio, Mitsubishi Electric, Panasonic, Canon, Fujitsu, Nikon, Yamaha etc. Japanese electronic products are renowned for their innovation and quality. However, the turmoil from the 2011 tsunami/earthquake disaster greatly affected its industries, dropping Japan from the 8th highest industrial production growth rate in the world in 2010 to the 8th worst in 2011.

Despite the historical significance of Japanese manufacturing, services are the dominant component of the economy – contributing to 71.4% of the GDP in 2012. Major services in Japan include banking,

insurance, retailing, transportation and telecommunications. The Tokyo Stock Exchange is the third largest stock exchange in the world by market capitalisation – with a total market capitalization of US$3.3 trillion as of December 2011.

In many manufacturing industries – particularly in the electronics and automotive sectors – the term "Japanese" is synonymous with high quality and technologically advanced products, and in a wide variety of sectors, Japanese companies are world leaders in both production and technological advancements in their respective fields. According to the global competitiveness index established in 2016 by Deloitte, Japan has almost the equivalent number of high skill and technology manufacturing exports than the US (Figure 75).



Source: Global Competitiveness Index 2016, Deloitte

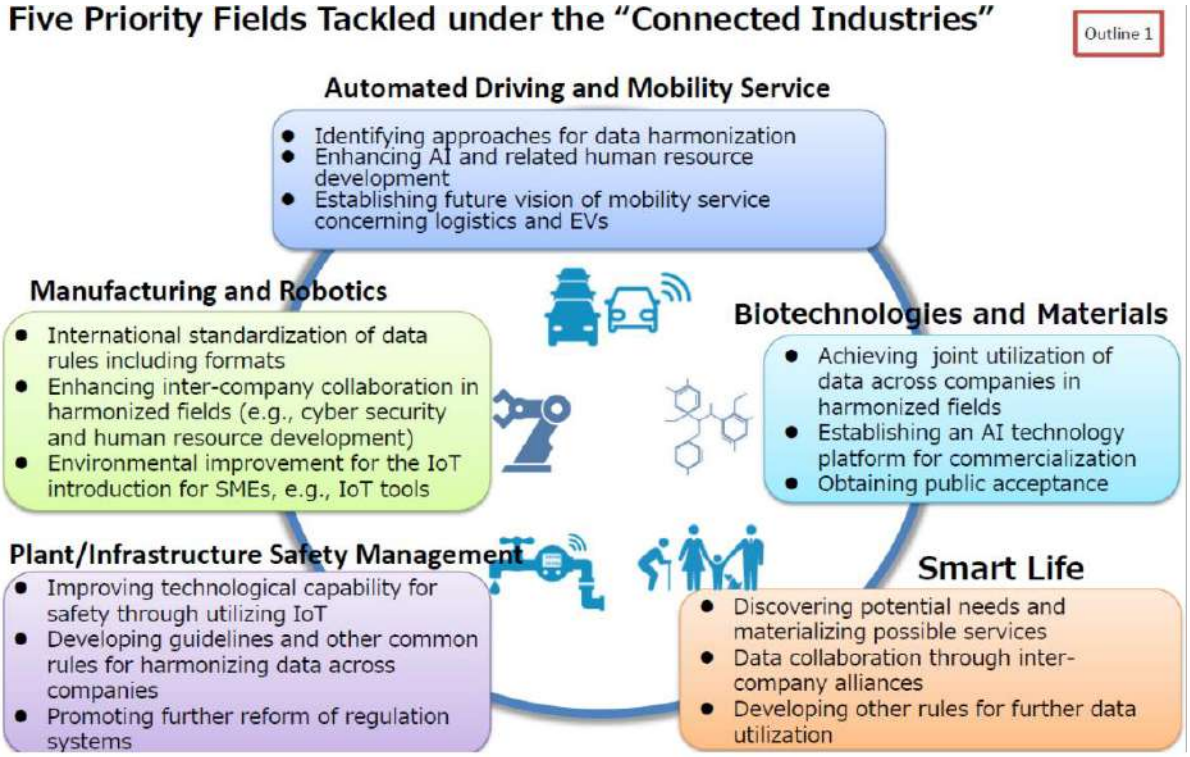
Figure 71: Manufacturing exports of nations based on technology intensity

Despite Japan being one of the largest economies in the world and recognized internationally for its advanced research and development capabilities, the country is facing several challenges. For instance, Japan's ageing, shrinking population could adversely impact overall production of the Japanese workforce – which is critical to world-class competitive manufacturing. Other challenges include high taxes, high post-Fukushima energy costs, limited access to natural resources, and currency appreciation of the Japanese yen.

In 2010, the government approved an economic growth strategy formally called the "Rebirth Strategy for Japan", which lays out economic goals for 2020. This strategy takes advantage of Japan's strengths in manufacturing and technology, targeting the development of US$ 1.3 trillion of new industries and 4.7 million jobs by 2020. The government designated four key priority areas: innovative energy and environmental products, technologies and practices; the medical sector, including development of leading pharmaceuticals and medical equipment; agriculture; and small and medium-sized enterprises[19]. Advanced manufacturing remains one of Japan's core sectors, and its performance is closely tied to the health of the broader economy. These industries account for 7% of Japan's employment, 6.7% of its GDP, and 60% of R&D spending; they also produce more than two-thirds of Japan's exports.

Japan's Prime Minister Shinzo Abe vision of the "Society 5.0" aims to integrate the innovations of the fourth industrial revolution (Big Data, AI, robotics, IoT) into everyday life. In this perspective, the government has launched the "Connected Industries" initiative detailed in below Figure 76.

[19] See https://reports.weforum.org/manufacturing-growth/japan/



Source: METI
https://www.meti.go.jp/policy/mono_info_service/connected_industries/pdf/initiative2017.pdf

Figure 72: Priorities identified under the "Connected Industries"

Industries per area:[20]

Japan's capital city, Tokyo (population 13.8 million), forms the core of an urban area that, along with the suburban prefectures of Kanagawa, Saitama, and Chiba, boasts a total population of over 36 million, roughly equivalent to the New York and Los Angeles metropolitan areas combined. It is Japan's center of government, business, higher education, information, media, fashion, and culture. The region – often referred to as the "Kanto" region – accounts for about one-third of Japan's total GDP. Most major Japanese companies, trade associations, and foreign companies have their headquarters or major branches in Tokyo.

The major advantages of establishing a presence in Tokyo are the city's concentration of major companies and high-income consumers, proximity to the powerful central government regulatory agencies, and location at the hub of Japan's highly centralized transportation networks, including airports.

Japan's Kansai region lies in the west-central part of the main island of Honshu and is made up of the following seven prefectures: Mie, Nara, Wakayama, Kyoto, Osaka, Hyōgo and Shiga. With a land area of roughly 13,000 square miles, a population exceeding 20 million and an economy of nearly $1 trillion, Kansai is an economic powerhouse and an essential segment of the Japanese market. The region is anchored by Osaka, a vast metropolitan area second only to Tokyo in scale and includes the major port city of Kobe as well as two historically significant political and cultural treasures in Nara and Kyoto.

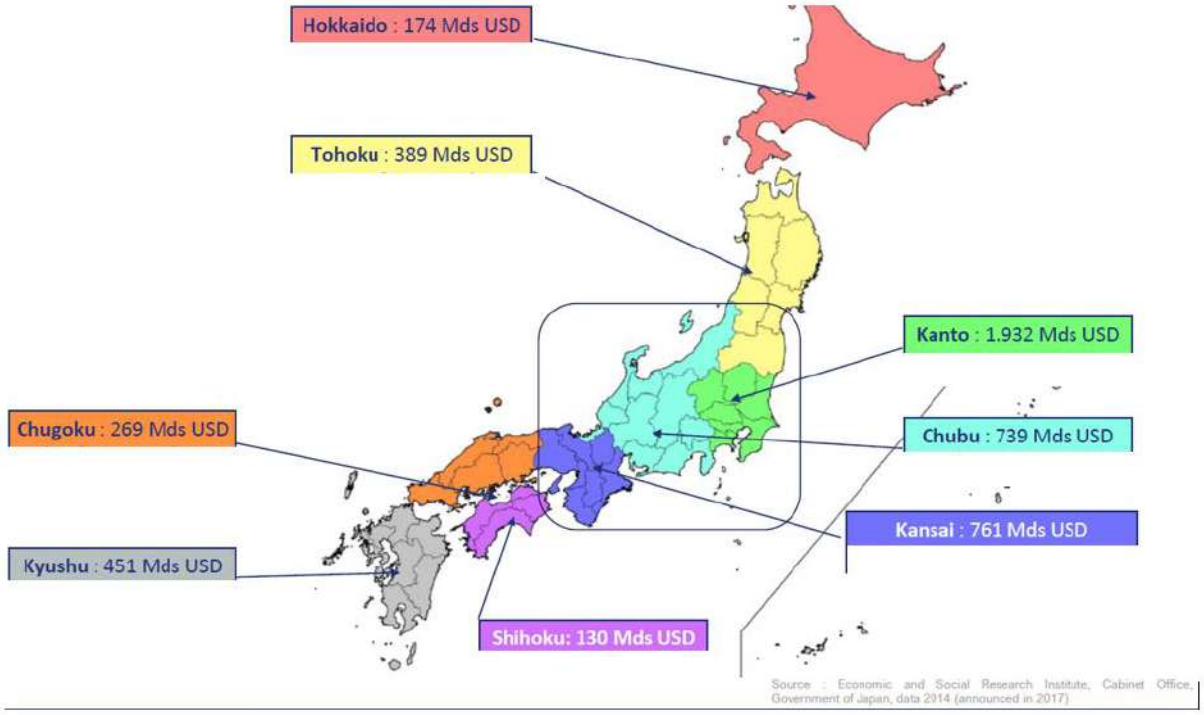
Kansai's economic base is diverse, including electronics, food, pharmaceuticals, biotech, chemicals, textiles, and other vibrant industries. In GRP terms, Kansai by itself would rank as the world's 16th

[20] See full description on this US website: https://www.selectusa.gov/article?id=Japan-Market-Entry-Strategy

largest economy (between Mexico and Indonesia) and the fifth largest in Asia (behind, China, Japan, India and Korea). The region leads Japan in the production of lithium-ion batteries, medicinal drugs and solar cells.

Kansai is home to some of the world's best-known corporations, such as Daihatsu (automotive), Daikin (air conditioning units), Asics (footwear), Kawasaki Heavy Industries (transportation manufacturing), Kyocera (ceramics), Montbell (outdoor gear), Omron (electronic components), Panasonic (electronics, home appliances), and Suntory (whiskey and beverages), Capcom (video games), Mizuno (sporting goods), Shimano's (bicycle parts and fishing equipment), and Takeda (pharmaceuticals).

Figure 73: Area per GDP



Chubu borders both the Kanto and Tohoku regions and is home to much of Japan's advanced manufacturing, especially around Nagoya, the largest city in the region and home to automotive giant Toyota. Chubu accounts for 15% of Japan's GDP and produces about 25% of its manufactured products. It hosts the headquarters or main factories of world-class manufacturers in autos and motorcycles (Toyota, Honda, Mitsubishi, Suzuki, Yamaha), auto parts (Denso, Aisin), aerospace (Mitsubishi Heavy Industries, Kawasaki Heavy Industries, Subaru), resin materials (Toray), machine tools (Mazak, Okuma, DMG Mori Seiki), power tools (Makita), ceramics (Noritake, NGK Insulators, NGK Spark Plug, Ibiden) and office automation (Brother).

Central Japan's keystone auto industry is accelerating the development and production of "green cars" (low fuel consumption and emission vehicles). Toyota introduced a newly developed fuel cell vehicle (FCV) in 2014 — the "Mirai" ('future') — which the world's biggest automaker is touting as the ultimate green car because FCVs produce no CO2 emissions. Toyota produced about 3,000 Mirais car model in 2017, up from 700 in 2015. The government of Aichi Prefecture, where Toyota is headquartered, is aggressively supporting the development of next-generation automotive technologies. It subsidizes about one-fourth of the construction cost of new hydrogen stations, of which 21 are currently in

operation around the prefecture and has been forward-leaning in allowing developers to test self-driving vehicles on public roads.

More than half of Japan's 1.4 trillion yen (11.11bn€) aerospace sector is based in Central Japan, where factories operated by Mitsubishi Heavy Industries, Kawasaki Heavy Industries, and Subaru collectively produce 35% of the Boeing 787 Dreamliner.
In December 2011, the Japanese government designated the region as a Special Economic Zone for promoting the aerospace industry. The program includes a free trade zone, investment incentives, and the creation of a national center for research into composite materials. The program brings together 73 municipalities from five prefectures and more than 200 companies and associations, including small enterprises as well as major corporations.
The defense industry is also strong in Central Japan. Mitsubishi Heavy Industries is partnering with American firms such as Lockheed Martin and Raytheon to develop and produce fighter planes and missiles. The Japanese manufacturer started assembling F-35s under license at its Komaki South Plant in December 2015, the first of which was delivered to the Japan Self Defense Force in January 2018. In October 2012, the region hosted Asia's largest aerospace trade show, "Japan Aerospace 2012" which featured a total of 665 aerospace-related firms and organizations from over 32 countries.

The Kyushu/Yamaguchi region of southwestern Japan consists of seven prefectures on Kyushu Island (Fukuoka, Oita, Saga, Nagasaki, Kumamoto, Miyazaki, Kagoshima) and Yamaguchi Prefecture on the southern tip of Honshu, with a combined population of about 14.5 million. The region's roughly $450 billion economy constitutes Japan's fourth largest economic center, representing about 10% of national GDP, which makes it one of the thirty largest economies in the world (larger than either Austria or Thailand). This region is traditionally known as Japan's gateway to Asia and enjoys extensive historical, cultural, and trade ties with continental Asia, particularly South Korea, China, Southeast Asia, and Taiwan.

Kyushu is often called "Silicon Island," "Car Island," "Food Island," "Hot Springs Island," and "Solar Island." The region accounts for 29% of Japan's total production of semiconductors and IC chips by value. Northern Kyushu also boasts over 14.7% of Japan's automobile output, up from 5% in 2000, with Toyota, Nissan, and Daihatsu operating state-of-the-art final assembly facilities, and Honda's advanced motorcycle plant. Kyushu's agricultural sector produces 20% of Japan's agricultural output and ranks first in Japan in livestock output (about $6.9 billion in 2016).

The region accounts for about 20% of solar module production, and also includes important industries such as steel manufacturing and ship-building. Japan's two space-launch facilities are located in Kagoshima Prefecture. International tourism to Kyushu has been a driver of growth in recent years, with foreign arrivals doubling since 2014. While manufacturing and agriculture are prevalent in Fukuoka Prefecture's surrounding areas, the city's economy is service-based. Kitakyushu City became the region's second special economic zone in 2016, emphasizing robotics and innovation for elder and nursing care.

Northern Japan consists of Hokkaido and six prefectures of northern Honshu (collectively known as "Tohoku"): Aomori, Akita, Miyagi, Iwate, Fukushima, and Yamagata. Together they comprise roughly one-third of Japan's landmass and one-ninth of its population. These prefectures comprise Japan's agricultural heartland, with large-scale and diverse farming, including dairy and livestock, in Hokkaido, and highly-prized rice growing in Akita and Miyagi Prefectures in Tohoku. Hokkaido's tertiary industries (i.e. wholesale, retail, and service industries) account for 78.1% of the region's economy, which is higher than the national average, due to Hokkaido's thriving tourism industry.

Tohoku, on the other hand, has manufacturing plants in sectors such as auto assembly, auto parts, electronic components, devices and circuits, and ICT (Information & Communication Technology) equipment.

Okinawa – Japan's only subtropical region and its southernmost prefecture – comprises 160 islands (40 inhabited) stretching over 623 miles from mainland Japan to Taiwan, but its 1.4 million people and $37 billion economy are concentrated on the largest island, also called Okinawa. Tourism is Okinawa's major economic activity.

While consumption in Japan is expected to stay flat, consumption throughout all of Asia (including Japan) has doubled in the past ten years, and it is expected to grow by more than 170% in the decade ahead.

Source: McKinsey Global Institute

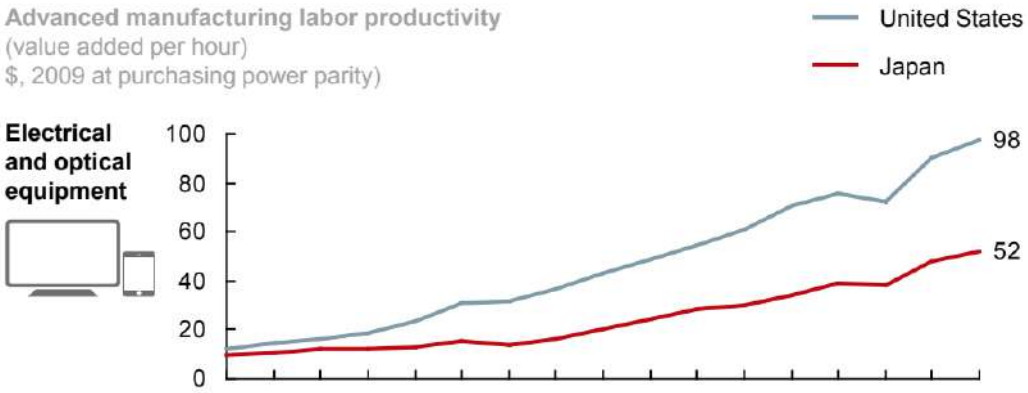


Figure 74: Advanced manufacturing labor productivity

Today, 40% of additive manufacturing machines for professional use are installed in North America, 28% in Europe and 27% in Asia/Pacific. The United States continues to dominate the market, followed by Japan, China and Germany. Japan is also catching up the US in terms of advanced manufacturing labor productivity as showed in Figure 78.

The use of industrial 3D printing in Japan is expected to rise, especially for the use of large-scale production such as automotive, aerospace and machine tools. A unique reason for Japan's interest in this sector is the shrinking of Japan's population. A projected net decrease of 2 million people is expected in the next 10 years. Additive manufacturing in mass production may play an important role in addressing this issue. Japan's Additive Manufacturing and 3D Printing market is expected to grow over the next 5 years anticipating increased industrial use. Japan's total Additive manufacturing/3D Printing equipment sales, including printing supplies and services, was 30.8 billion yen (about $291.1million) in 2017. IDC Japan, an IT research firm projected that this market will experience consistent growth for 5 years, with average growth rates at 9.1% until 2022[21].

Japan's Smart Robot Market

"Smart robots" are defined as robots which have been enhanced with IoT and AI technologies. Robots can be broadly divided into either industrial robots (handling welding, painting, assembly, transport, etc., at manufacturing sites), and service robots (used for mobility (transportation), medical/nursing/welfare/healthcare, security, cleaning, infrastructure, and so on).
In addition to the growing number of cutting-edge initiatives in Japan, when it comes to demand for industrial robots, the Japanese market ranks 1st globally by number of robots in operation. Production-wise, around 50% of global robot shipments are manufactured in Japan. Demand for service robots in Japan is expected to grow significantly at a CAGR of 13.9% over the 20-year period leading up to 2035. Japan also has a strong global presence as a production market, ranking 4th in the world by number of service robot manufacturers (Figure 79).

[21] See https://www.trade.gov/market-intelligence/japan-additive-manufacturing-and-3d-printing

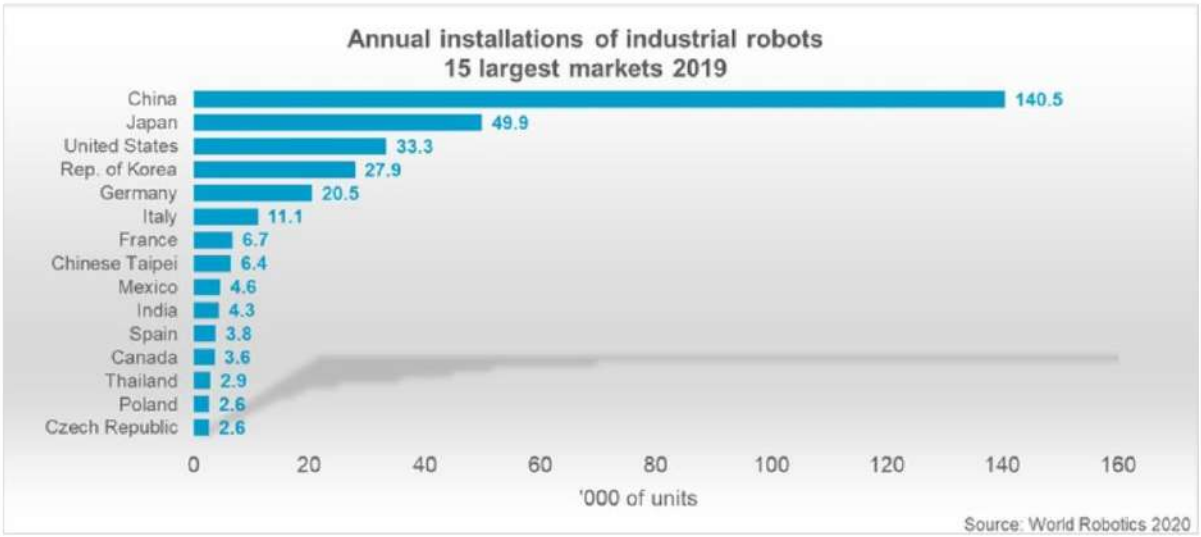


Figure 75: Annual installations of industrial robots TOP 15 countries

Globally, COVID-19 also offers a chance for modernization and digitalization of production on the way to recovery. In the long run, the benefits of increasing robot installations remain the same: rapid production and delivery of customized products at competitive prices are the main incentives. Automation enables manufacturers to keep production in developed economies - or reshore it - without sacrificing cost efficiency. The range of industrial robots continues to expand – from traditional caged robots capable of handling all payloads quickly and precisely to new collaborative robots that work safely alongside humans, fully integrated into workbenches.

The new World Robotics 2020 Industrial Robots report shows a record of 2.7 million industrial robots operating in factories around the world – an increase of 12%. Sales of new robots remain on a high level with 373,000 units shipped globally in 2019. This is 12% less compared to 2018, but still the 3rd highest sales volume ever recorded. “The stock of industrial robots operating in factories around the world today marks the highest level in history,” says Milton Guerry, President of the International Federation of Robotics. “Driven by the success story of smart production and automation this is a worldwide increase of about 85% within five years (2014-2019). The recent slowdown in sales by 12% reflects the difficult times the two main customer industries, automotive and electrical/electronics, have experienced.”

Asia remains the strongest market for industrial robots - operational stock for the region´s largest adopter China rose by 21% and reached about 783,000 units in 2019. Japan ranks second with about 355,000 units – plus 12 %. A runner-up is India with a new record of about 26,300 units – plus 15%. Within five years, India has doubled the number of industrial robots operating in the country´s factories. The share of newly installed robots in Asia was about two thirds of global supply. Sales of almost 140,500 new robots in China is below the record years of 2018 and 2017 but still more than double the numbers sold five years ago (2014: 57,000 units). Installations of top Asian markets slowed down – in China (minus 9%) and Japan (minus 10%).

Numerous foreign companies developing their business in Japan have become major players in the market. Effective options for foreign companies entering the Japanese market include forming a development and manufacturing partnership with research institutions or domestic companies in the same industry or forming a sales partnership with domestic agents to utilize their distribution channels.

Japanese robots' companies

Companies	Products
Fanuc	Wire-cut electric discharge machine
	Injection molding machine
Yaskawa Eletric	Grinding and assembly robot
Hitachi Zosen, NTT Data	Welding/Machining equipment
WHILL	Wheelchair
Intuitive surgical	Surgical robot
Panasonic	Autonomous mobile robot for hospitals
Cyberdyne	Medical robot suit
ALSOK	Security robot
IRobot	Cleaning robot
Ixs Research	Equipment inspection drone
Terra Drone KDDI	Equipment inspection drone
Topy Industries	Rescue robot
Fujitsu	Conversation robot for elderly
SoftBank Robotics	Reception/Guide robot

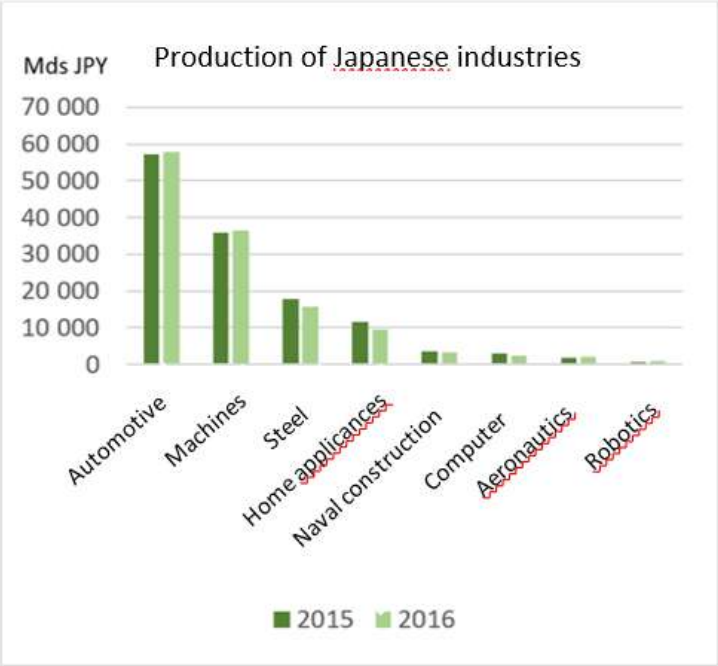
Types of Partnerships		Examples
Technical Partnership	• Licensing agreements and joint development contracts between multiple companies, and centering on intellectual property rights (technical patents, know-how, etc.).	• US-based AI startup, Skymind, formed a partnership with SoftBank to jointly develop a prototype for a robot which can identify and locate moving objects within a room – a necessary function for robots across a variety of fields, including factory work.
Production Partnership	• Enhancing production capabilities by contracting out a part of production or the manufacturing process.	• On June 27, 2016, US company AKA announced that it had signed a memorandum of understanding with Vaio for manufacture and maintenance of the former's AI robot, Musio. • On May 30, 2017, AKA announced that they will join forces with Kashiwazaki US TEC and will manufacture Musio in Japan.
Sales Partnership	• Partnership which utilizes sales channels, a partner's brand, or other sales resources.	• In October 2017, Tokyo-based Creek and River partnered with Taiwanese AI and robotics startup, Intumit, to allow Creek and River distribution rights in Japan for Intumit's AI platform, Smart Robot.

Source: JETRO, Market Report Smart Robots

Figure 76: Market Entry Opportunities

4.6 Focus on Aerospace

Japan's defense industry is tiny compared to that of other developed nations— its defense production accounts for just 0.5% of total Japanese industrial production (Figure 81).

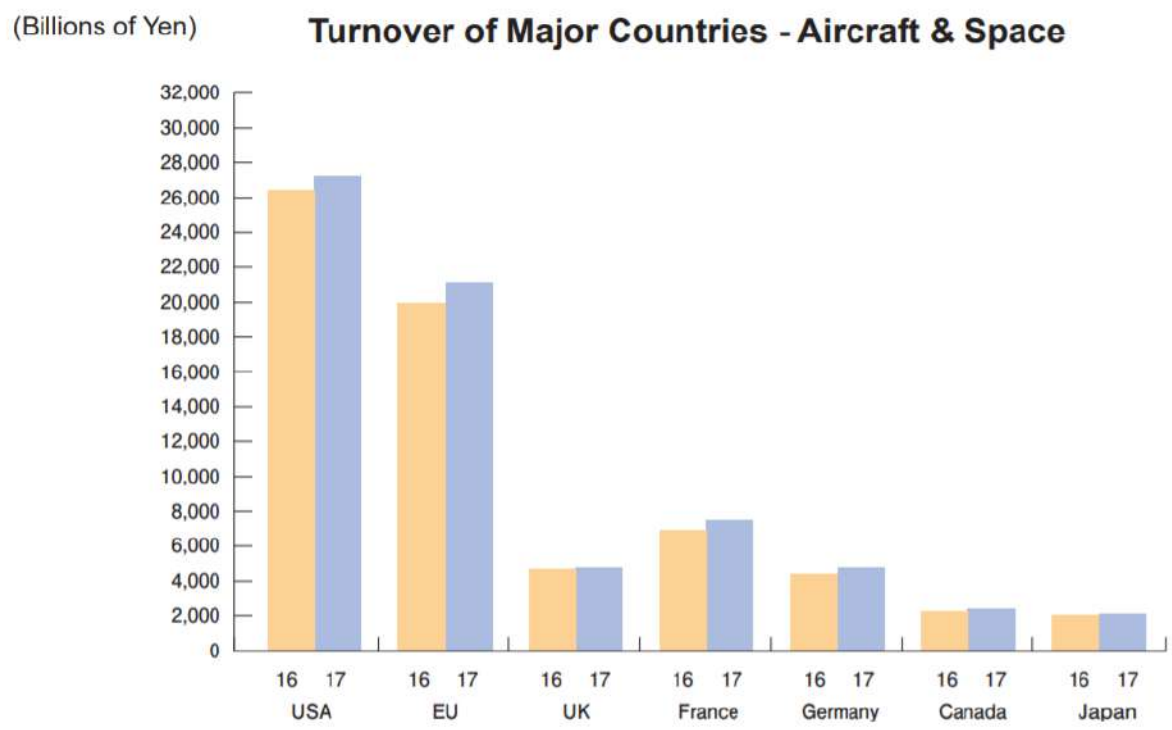


Source : SER Tokyo

Figure 77: Japanese industries production

Indeed, the top-ranked Japanese defense manufacturer, Mitsubishi Heavy Industries (MHI), is only 22th in the global standings, with the second largest manufacturer, Kawasaki Heavy Industries (KHI), a distant 38th (2017 data). Japanese defense industry, apart from its size and market, is that in spite of its quasi-isolationism it has managed to become a world leader in the design and manufacture of components essential for defense systems worldwide. Japan's success formula is simple: to counter its legislative constraints and late-start, it has relied on the force-multiplier effect of technology transfers as the primary means of accessing and managing defense technology and in creating conditions conducive to technology transfer such as civil-military clusters, by focusing on the development of dual-use technologies, and by participating in the global supply chain of its only security ally, the United States.

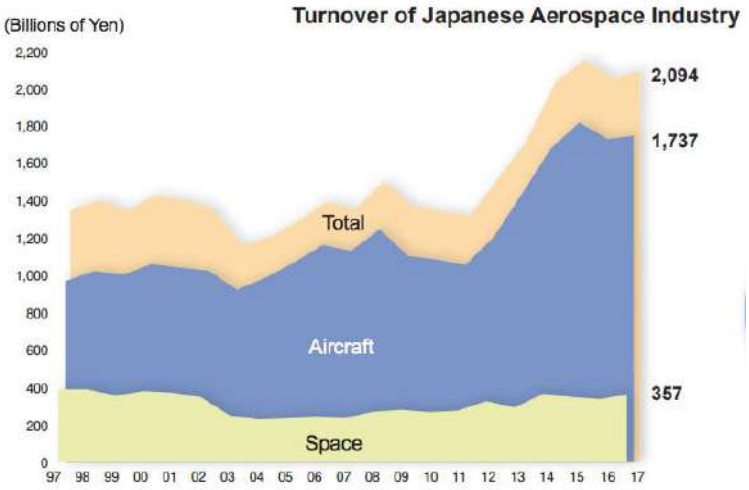
Japan centralizes its aerospace production for aircraft components designed for overseas commercial and defense aircrafts. Compared with other region of the world, Japan's aerospace turnover is relatively low but is the largest market in Asia. The value of production of the Japanese aerospace is primarily in providing aircraft components for commercial aircraft produced for overseas customers and defense aircraft. In recent years, the value of defense aircraft production has grown steadily, in line with the Japanese Defense Budget.



Source: Japanese Aerospace Industry2015, The Society of Japanese Aerospace Companies (Sjac)

Figure 78: Turnover of major countries - Aircraft & Space

In 2015 the Japanese Aerospace industry increased by 3% from the previous year to reach a turnover of 2,094 billion Yen (15,8M€) according to Figure 82. Aircraft accounted for the two third of the turnover while space was only representing one third as detailed in the below graph, Figure 83.



Source: Japanese Aerospace Industry 2019-2020, The Society of Japanese Aerospace Companies (Sjac)

Figure 79: Turnover of Japanese Aerospace Industry (in Billions of Yen)

Japan is expected to be a key market for the aerospace and defense sector. According to the Deloitte's Global Aerospace and defense industry outlook, Japan's passenger traffic is expected to grow at about

3.0 percent over the next 20 years. Moreover, Japan's two major airlines are expanding their network to Southeast Asia to capture the solid demand from the region, which is expected to contribute to passenger traffic growth in the near term.

Figure 80: Aerospace Japanese companies

- **Aircraft Production**

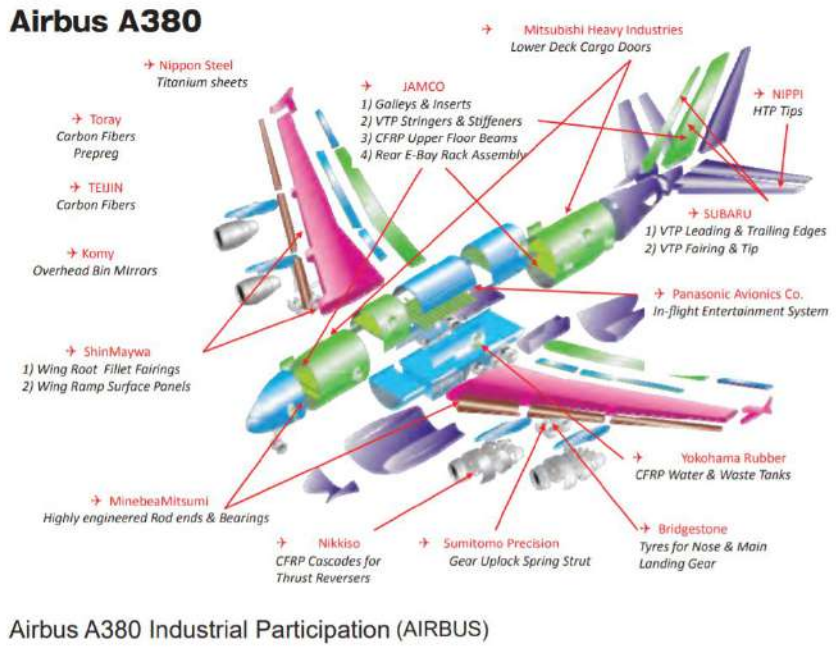
Japan plays a role in the global production of aircrafts. Despite being part of multinational development of aircrafts (see Figure 85 below), Japanese companies were officially contracted to produce 21% of the main components of Boeing777X. Mitsubishi Heavy Industries is a key supplier to commercial aircraft makers Boeing and Airbus who dominate the industry (Figure 86).

Participation in International Projects

Project	Area of participation	Scope of participation
Boeing 767	Forward fuselage, aft fuselage, main landing gear door, etc.	15% program partner
Boeing 777. 777X	Center section, center fuselage, aft fuselage, etc.	21% program partner
Boeing 787	Wings, center wings, front fuselage, etc.	35% program partner
Bombardier Challenger 350	Wings, main landing gear	RSP
Bombardier G 5000 / 6000	Wings, center wings, center fuselage	RSP
Bombardier CRJ 700 / 900	Nose and main landing gear system	RSP
Embraer 170 / 190	Wings and center wings	RSP
Gulfstream	Flaps and landing gear operation devices, etc.	Supplier
Airbus A380	Cargo doors, vertical stabilizer structure material, carbon fiber, water tanks, etc.	Supplier

Figure 81: Participation in International Projects

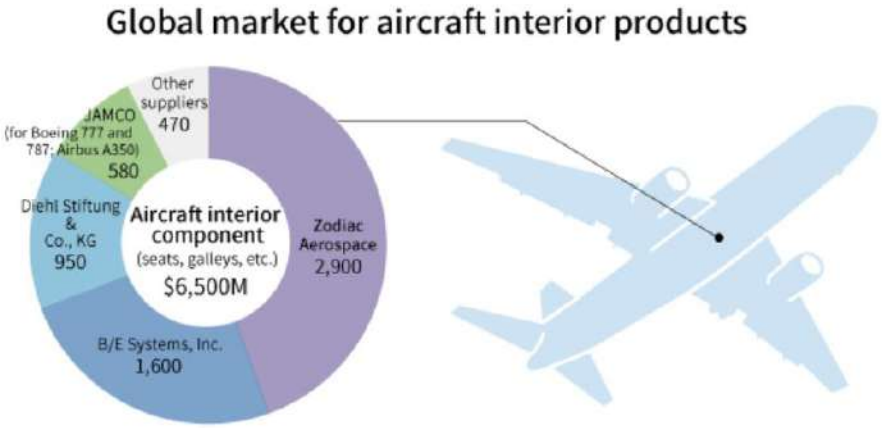
Source: Japanese Aerospace Industry 2019-2020, The Society of Japanese Aerospace Companies (Sjac)



Airbus A380 Industrial Participation (AIRBUS)

Figure 82: A380 participation of Japanese companies

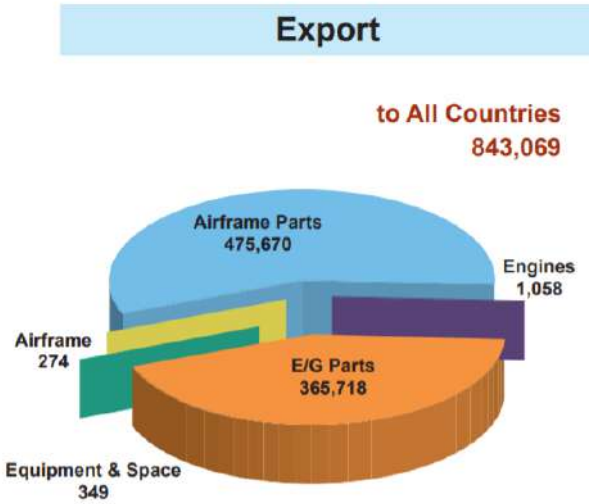
The Foreign Trade Aircraft is driven by Boeing's production. Indeed, exports have been increasing year by year since 2010 to provide aerospace parts for Boeing77, 787 aircrafts and CF34. The majority of exports are airframe parts and E/G parts. The majority of aircraft interiors are produced in Europe or North America. As seen in the below graph Figure 87, JAMCO is the fourth major aircraft interiors that registers 580 million USD.



Source: Study by the Society of Japanese Aerospace Companies (data as of 2013)

Figure 83: Aircraft interiors suppliers

Today, Japanese aircraft manufacturers have their own capability to develop, produce and maintain a wide range of defense aircraft, such as fighter, transporter, patrol plane, trainer and search & rescue vessel, which has thus contributed to the national defense. They mainly export E/G parts and Aiframe parts according to the Japanese aerospace society as showed in Figure 88. These technical capabilities not only contribute significantly to the design and manufacture of civil aircraft as the ripple effect, but also have widely spread to other industries, and form the basis of Japan's industrial technology.



Source: SJAC report

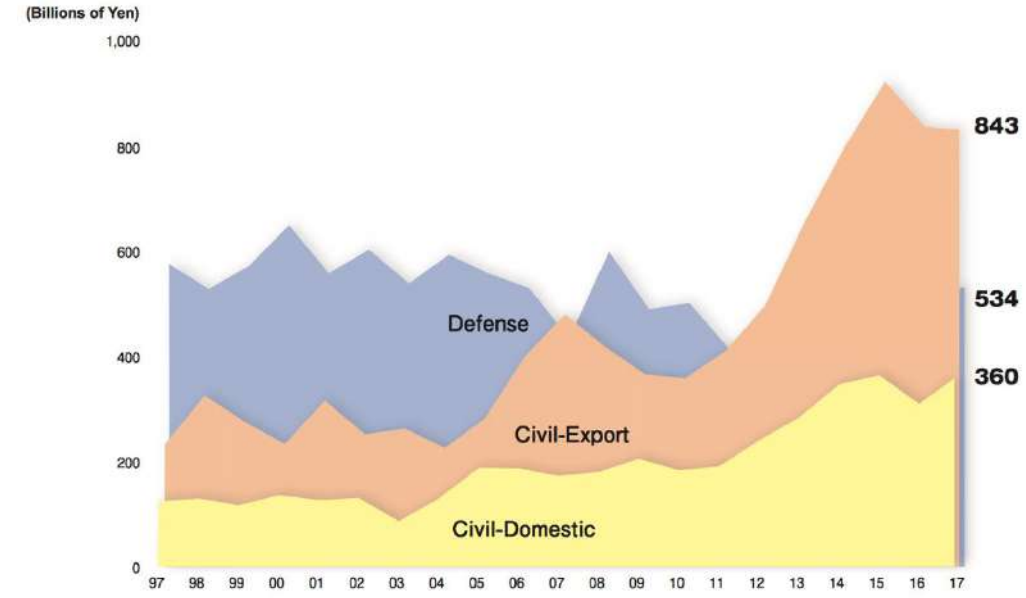
Figure 84: Export from Japanese aerospace industry in 2017

- **Air Transport is a growing sector**

Air Transport contributes for a major part in Japan's economy. The most important benefits come from the spending of foreign tourists. Asia-Pacific is the largest source of arrivals (93%), followed by North America (3.8%) and Europe (3.5%). The domestic Air Transport records around 70 million passengers per year in Japan. The three main airports in terms of passengers are Tokyo Haneda reaching 85 million passengers per year, Tokyo Narita with 38 million and Osaka Kansai with 27 million. The government has the ambition to reinforce their capacities in the frame of the Olympic Games and the objective to develop the tourism. Air travel is dominated by Japan Airlines (JAL) and All Nipon Airways (ANA), which are the two biggest players of the industry.

For a certain period after the end of the war, Japan was forbidden from any activities related to the development and production of aircraft, and its aerospace industry fell behind those of the US and Europe. Starting with the licensed production of defense aircraft, national development and production systems have grown. The development and manufacture of defense aircraft was the base of the Japanese aerospace industry, and in recent years the F-2 fighter (a joint Japan-US project), the OH-1 observation helicopter, the T-7 trainer US-2 amphibious search & rescue flying boat have been successfully developed and produced in this country.
In the Civil aircraft market, the key Japan manufacturers are Mitsubishi Heavy Industries, Kawasaki Heavy Industries, and Fuji Heavy Industries, supplying about 35 percent of the content for the Boeing 787.

Looking at aircraft production by the type of demand, the defense sector demand totaled 534 billion yen (4.22bn€, 31% of aircraft production). Export of civil aircraft came to 843 billion yen, (6.69bn€) (49% of aircraft production) in 2017. In the past years, the country has not been successful in the defense market as civil export production represent most of the demand, followed by civil domestic production.



Source: Japanese Aerospace Industry 2019-2020, The Society of Japanese Aerospace Companies (Sjac)

Figure 85: Aircraft production by demand

The Japan Aerospace and Defense Market is expected to grow by 4% annually until 2025. The Japanese Aerospace sector benefits globally from strong reputation, particularly in the R&D field. In the recent years, the country reinforced its defense budget by 1.3 billion USD (a growth of 2.75% in 2020 compared to 2017). In 2014, the Prime Minister Abe Shinzo lifted the arms embargo policy established in the 1960s. This initiative will now allow arm exports (only if they contribute to international and peace cooperation or security interests).

Long associated with the production of US aircrafts, Japan can now turn the page by building a homegrown fighter. On November 2020, the Defense Ministry signed an agreement with Mitsubishi Heavy as the main contractor to produce 90 of the next generation jets, aimed to replace the Self-Defense Forces' F-2s. The Japanese government encouraged the SpaceJet programme (Figure 90) in a bid to establish itself as a global commercial plane maker. But plans for Japan's first homegrown passenger plane in more than five decades have been frozen as the airline industry suffers from a deep drop in demand. Mitsubishi Heavy Industries, the company behind the new SpaceJet, is cutting its budget for the project and freeze development of its SpaceJet regional jet to bolster other parts of its business. Test flights in the US were suspended this year due to the virus pandemic. The company posted a 62.5% fall in its second quarter operating profit. The decision to cut back on funding was prompted by the downturn in the airline industry brought on by coronavirus travel curbs. Delivery of the plane had already been pushed back five times from its originally planned 2013 introduction. Deliveries of the aircraft will now be pushed back until after the fiscal year ending March 2022.

Mitsubishi SpaceJet (Mitsubishi Aircraft Corporation)

Figure 86: Japanese SpaceJet Aircraft

Japan is also looking to develop future technologies of air transport such as the flying car in the frame of an air mobility program launched in 2018 and with an objective of marketing in 2023. The government considers this new mean of mobility as a possibility to reach isolated areas or regions affected by natural disasters. Another ongoing research program is dedicated to developing a hybrid electric aircraft to reduce carbon footprint and global warming in general (Figure 91).

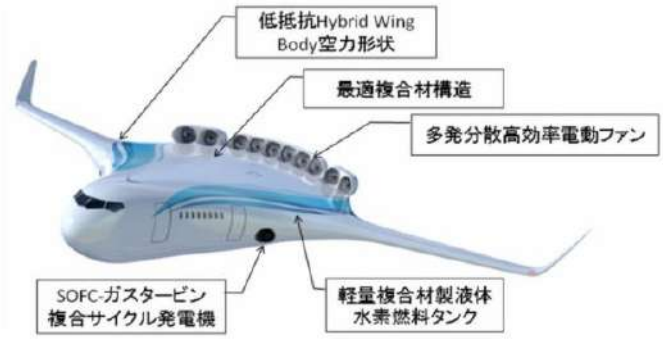


Figure 87: Prototype of hybrid electric aircraft

4.7 Exhibitions and Events in Japan:

- Photonix: 3 different exhibitions specializing in laser processing, optics and optical measuring/analytical technology.https://www.photonix-expo.jp/en-gb.html
- Semicon: an international trade show for the electronics manufacturing supply chain, covering everything from the front-end to back-end processes of semiconductors to SMART applications such as automobiles and IoT devices. https://www.semiconjapan.org/en
- All About Photonics (Opto Japan) https://www.optojapan.jp/
- Asia-Pacific Laser Symposium https://www.apls-2020.org/
- CEATEC https://www.ceatec.com/en/
- Nepcon: 7 shows specialized in essential areas for electronics manufacturing and R&D, the show has increased its value as an exhibition representing Asia's leading one-stop venue for all those involved in electronics industry https://www.nepconjapan.jp/en-gb.html
- Optics and Photonics International Exhibition (OPIE): the exhibition consists of Laser Expo, Lens Expo, IR+UV Expo, Industrial Camera Expo, Medical & Imaging Expo, Space & Astronomical Expo and Positioning Expo. Concurrently Optics and Photonics International Congress with 14

sub-conferences will happen and this combination usually attracts many of photonics companies from Japan and overseas. https://opicon.jp/

- Japan International Aerospace Exhibition: largest Japanese exhibition in the aeronautics sector, Japan Aerospace is a reference exhibition for Asia organised by the Society of Japanese Aerospace Companies (SJAC). Large numbers of world's major aerospace companies, aviation clusters, authorities and research institutions participate in this exhibition. http://www.japanaerospace.jp/en/
  Next in 2024
- Manufacturing World Japan: Launched more than 30 years ago, Manufacturing World Japan has grown as World's leading exhibition for manufacturing industry. https://www.japan-mfg.jp/en-gb.html
- TCT Japan: Japan's 3D Printing and Additive Manufacturing events. TCT Japan will draw ever growing numbers of industry professionals together in Tokyo to address the challenges of additive manufacturing, 3D printing, design and engineering, driving greater adoption across all industry sectors resulting in a positive impact on the Japanese manufacturing industry. https://www.tctjapan.jp/outline_en.html
- Fiber Optics Expo: the biggest, by the official number of visitors – 67 thousand, from the photonics exhibitions. Fiber optics is a big industry in Japan, for example, of Japan's 38,7 million fixed broadband subscriptions, 75% were fiber. This is one of the highest percentages in the world. And there are many big companies involved with fiber optics like NTT, NEC, Fujitsu and Sumitomo, most of them are among the exhibitors.
- International Symposium on Industrial Electronics https://www.isie2021.org/
- International Symposium on Laser Precision Microfabrication http://www.jlps.gr.jp/lpm/lpm2021/
- MEMS SENSING & NETWORK SYSTEM https://www.optojapan.jp/mems/en/
- Manufacturing World Japan https://www.japan-mfg.jp/en-gb.html
  Big show addressing various fiels as engineering, VR, mechanical components, medical devices, smart factories, IoT, aerospace and sensors. Very interesting to reach industrial companies. Every year
- Optics 2021 https://opticsconferences.com/
  International symposium focus on optics organised by an American structure, USG United Scientif Group, every two years.

4.8 Covid-19 Impact in Japan

According to OECD report[22], in the management of Covid-19 pandemic, Japan, did better than most countries in flattening the curve of the COVID-19 epidemic and containing the first wave of the virus, according to the OECD's first analysis of the impact of COVID-19 on health systems of countries across the Asia-Pacific as well as governments' responses to control the virus. The country developed effective testing, tracing and isolation systems, as well as trust and compliance with social distancing and other key guidelines. Despite three consecutive declined quarters, the country experienced a growth of 5.3% of its GDP in quarter 3 (Figure 92).

[22] See https://www.oecd.org/japan/asia-pacific-countries-have-managed-covid-19-crisis-relatively-well-but-major-challenges-remain-in-low-middle-income-countries.htm

Quarterly GDP at market prices 2020			
Date	Quarterly GDP	Quat. GDP Growth (%)	Quat. GDP Annual Growth (%)
2020Q3	915,636M.$	5.3%	-5.7%
2020Q2	968,801M.$	-8.3%	-10.3%
2020Q1	1,029,217M.$	-0.5%	-2.1%

Source : https://countryeconomy.com/gdp/japan

Figure 88: Japan Quaterly GDP

Due to the rapid recovery of large trading partners, Japan's exports have also started to recover, while imports have so far remained sluggish (Figure 93). Exports to China have been exceptionally strong, thanks in part to China's ability to keep infection rates low and to rebound to pre-pandemic levels of output.

The Japan government put in place several initiatives to maintain its economy while controlling the pandemic. First, it is simultaneously encouraging more services consumption yet preparing for a drop in such spending. The Bank of Japan offers low-cost loans to stimulate spending. The country also maintained its subsidy programs for dining out and domestic travel despite the surge in COVID-19 cases. In addition, travel restrictions have been loosened for visitors coming from countries with low infection rates (Australia, Singapore, South Korea). Indeed, the "Go to" Japan campaign aims to boost domestic travel by offering up to 50% discount on transportation and tourism activities.

Figure 89: Total exports and import of goods in Japan

Source: OECD ECONOMIC OUTLOOK, VOLUME 2020 ISSUE 2: PRELIMINARY VERSION © OECD 2020

Japan's relatively low infection rates and ample government support should foster a relatively strong recovery. However, already-cautious consumers may pull back on their spending as infection rates move higher. As part of the consequences of the Covid-19 crisis, Japanese have reinforced their policy to relocate in their production activity from China into the country. Since the early 2000s as Chinese labour costs rose, there has been talk of a "China Plus One" strategy - a policy of managing risk by locating plants and facilities in China and one other Asian nation. The near total shutdown of China's factories in February as the world's No. 2 economy sought to stamp out the coronavirus has, however,

rammed Japan's China dependence home. The government's 220-billion-yen (1.74bn€) allocation is the first time it has offered subsidies for bringing back manufacturing. It is also offering 23.5 billion yen to Japanese firms to strengthen and diversify supply chains in Southeast Asia. But for many others, China remains the cheaper option.

Compared to other countries, teleworking is of particular interest in Japan. According to a survey conducted by PwC targeting Chief Financial Officers in 23 countries and regions around the world, 88% of CFOs of Japanese companies responded that they would work to "make remote work a permanent option for roles that allow it" and 68% would "improve remote work experience" as tasks to be undertaken after on-site work is resumed. Compared to the global response rate, the above two response rates were high in Japan.

The COVID-19 shock in early 2020 triggered a major recession and real GDP is projected to shrink by around 5¼% this yea[23]r. The economy is gradually strengthening although growth remains sluggish. Ongoing difficulties in bringing COVID-19 infections under control hold back domestic demand. As restrictions are lifted in the near term, consumption is expected to recover, supported by government subsidies and incentives.
In addition, recovering external demand, as the sanitary situation of trading partners improves, will sustain export growth. While the whole amount of capital investment from domestic companies is decreasing, investment in the digital field, in which demand is further rising with COVID-19, is expected to increase. Overall, GDP is projected to expand by 2¼% in 2021 and 1½% in 2022, assuming further economic stimulus. However, without any action beyond the measures currently in place, the recovery may slow. A resilient and sustainable economic expansion will require further policy support and structural reforms. The digital transformation of businesses, consumers, and administrative organizations, and the search for and adoption of new models are not merely temporary shifts in response to the virus. Instead, they may lead to a medium- to long-term economic, social progress.

Conclusion

As seen in the study, Japan appears to be a very strategic export market in the scope of PIMAP+ activities. The country offers great perspectives for SME's willing to expand and develop business opportunities. The highly skilled and committed workforce is one of its biggest strengths. However, the country is facing several challenges that risk undermining the further development of this world power. Indeed, the aging population may prevent the economic and social development of the country in the next decade. However, despite rising tensions with China, Japan appears to be handling better than other major economies due to the ample fiscal and monetary stimulus raised by the government during the pandemic.

[23] See https://www2.deloitte.com/us/en/insights/economy/asia-pacific/japan-economic-outlook.html

5. Conclusion

China and Japan are two markets with high potential in terms of photonics technologies and application fields where photonics can have an added value such as in aerospace, metalworking and advanced manufacturing industries. European SMEs should consider them as a potential target when they are looking to expand their international business. Indeed, the data available from Eurostat Trade by Enterprise Characteristics (TEC) database suggests that 60% of all exporting firms (including SMEs) depend on exports to only one or two extra-EU markets. It could be argued that a less concentrated export strategy could reduce the exposure to volatility in markets and in addition enhance the SMEs potential to reach a wider number of international consumers[24].
However, it is necessary to consider the local competition, their appetite for technology partnerships and the cost of this strategy that need to be built on the long-term. Some parameters must be considered as the legal framework, the local taxes and the language barriers.

At the European level, SMEs can be supported by the Enterprise Europe Network[25] which provides a wide range of services: market intelligence and capacity building services, advises on local business conditions, EU tender opportunities and helps to apply for calls, supports to identify sources of finance, helps to protect and expand IPR, draft patents and IPR exploitation strategies. There is one national point of contact in each EU country and others located in all the main export markets worldwide.

Looking at Japan specifically, the EU has created the EU-Japan Center[26] which aims at promoting all forms of industrial, trade and investment cooperation between the EU and Japan and at improving EU and Japanese companies' competitiveness and cooperation by facilitating exchanges of experience and know-how between EU and Japanese businesses. They are business oriented and can offer support on the following issues: training for EU executives, business missions, tax and procurement helpdesk, logistical support to set up locally, along with policy analysis and services dedicated to innovation and R&D.

For China, the EU SME Centre launched its phase 3 this year dedicated to strengthening and supporting the development of trade and cooperation between the EU and China with the implementation of several services. They offer free webinars on business culture, compliances issues, and publications on specific markets opportunities. They also deliver trainings, provide information on local exhibitions, and offer a self-diagnosis tool.
In parallel, the IP SME Helpdesk[27] supports SMEs to both protect and enforce their Intellectual Property (IP) rights in or relating to China, Latin America, Southeast Asia through the provision of free information and services. These take the form of jargon-free, first-line, confidential advice on intellectual property and related issues, plus training, materials and online resources.

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7. List of figures