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Growing Tension around Taiwan and Higher Risks in Semiconductor Industry

—If semiconductor supply is suspended, global GDP could decline by USD 800 billion per year —

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〈Summary〉

◆ In addition to vulnerability due to the spread of COVID-19, Taiwan faces many problems such as power shortages and natural disasters as well as geopolitical risks with the escalation of the U.S.-China rivalry over the Taiwan Strait. If these risks materialize in Taiwan, a severe supply chain shock from the semiconductor industry could greatly depress the global economy.

◆ Taiwan's semiconductor industry has expanded its global share in recent years. In particular, it gained superiority in the production of cutting-edge logic semiconductors, which are important components for smartphones and computers. Taiwanese semiconductor companies mainly take orders from U.S. companies, but their production bases for products using semiconductors are concentrated in China and Southeast Asia, which has a great influence on value added and job creation in related industries in Asia.

◆ If risks such as natural disasters and military conflict materialize, Taiwan's semiconductor industry could be forced to suspend production. The impact on the global economy is estimated to be USD 67 billion in the case of a one-month suspension and 800 billion (1.0% of the global GDP) in the case of a one-year suspension. By industry, the impact on the electronic products industry, particularly smartphones and computers, is expected to be large, and added value in this industry alone is expected to decline by 533 billion per year. By country, the value added that would be lost in China and the United States would be large, and the ratio of losses in value added to GDP would be large in Vietnam and Malaysia. This estimate only takes the primary impact into consideration, but if such a situation were

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to occur, the semiconductor shortage would lead to a supply shortage of electronic products, which would likely cause a secondary impact to spread in industries other than manufacturing, such as communications and information services.

◆ While the risks in Taiwan are growing, developed countries are working to attract the semiconductor industry to their own areas and are planning to set aside a large amount of their government's budgets for it. However, it is not easy to significantly reduce the dependence on Taiwan's semiconductors because 1) the possibility of large-scale production base transfers to developed countries is low due to high costs, 2) it will take years to start plant operation even if a transfer is decided, and 3) the Taiwanese government is reluctant to relocate its production base. As the semiconductor industry in Taiwan is surrounded by various supply suspension risks, it remains necessary to brace for a crisis in the electronic products industry, mainly in China and Southeast Asia.

● **This is a English version of "台湾情勢緊迫化と高まる半導体リスク― 半導体供給停止の場合、アジアを中心に付加価値が年 88 兆円減 ―" in JRI Research Focus (The original version is available at https://www.jri.co.jp/MediaLibrary/file/report/researchfocus/pdf/12810.pdf)**

1. Introduction

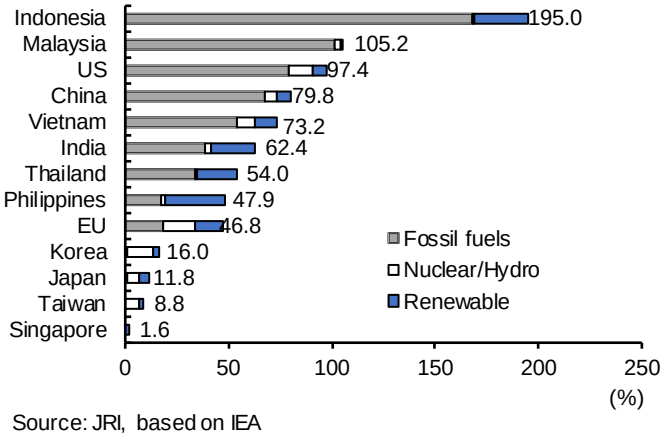
Taiwan is facing risks of power shortages and natural disasters as well as restrictions on economic activity due to COVID-19. Tensions over the Taiwan Strait have also grown rapidly, and geopolitical risks are extremely high in recent years. Because Taiwan's semiconductor industry has a large share of the world market, there are growing concerns over global supply chain shock from the semiconductor industry when the risks materialize. The share of Taiwanese semiconductor sales (including foundries[1]) has risen to 25% of the global market. Taiwan also has a large share in cutting-edge semiconductor production, and smartphones and computers which use these products as important parts are increasingly dependent on Taiwan's semiconductors.

In this paper, we examine 1) the risks involved in Taiwan and 2) the world's dependence on Taiwan's semiconductors. We then analyze 3) what industries, countries and regions might be affected if Taiwan's semiconductor industry were forced to suspend production.

2. Various risks surrounding Taiwan

In recent years, Taiwan has been surrounded by various risk factors. In May, a semiconductor plant was shut down in Taiwan as the number of COVID-19 cases surged. Taiwan lags behind others in its COVID-19 vaccination drive due to a delay in obtaining vaccines, and only 1.3% of Taiwan's 23.5 million people are fully vaccinated as of the end of July. Taiwan is not a member of the United Nations, and this exposes Taiwan's weakness in that it is uncertain whether or not it will be able to receive swift international assistance.

Figure 1. Energy Self-Efficiency Ratios in Major Economies



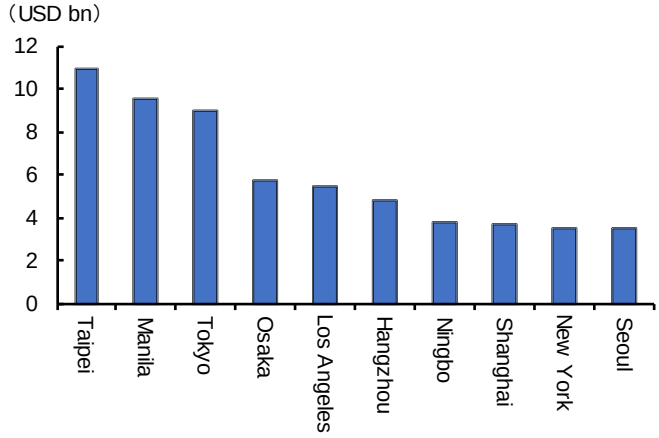
Source: JRI, based on IEA
Note: The energy self-sufficiency rate is the ratio betw een national primary energy output (coal, oil, natural gas, nuclear, hydraulic and renew able energies) and consumption of primary energy in a given year.

There is also concern about energy supply. Taiwan had rolling blackouts across the island in May due to a grid malfunction at the Singda Power Plant in Kaohsiung. Although there was no big impact on semiconductor production, it highlighted the insufficient electric power, following a power outage in August 2017 due to a fuel supply error at a thermal power plant. Most of its primary energy sources are derived from imported fossil fuels, and Taiwan's energy self-sufficiency rate is only 8.8% (Nuclear power: 6.5%, renewable energy: 1.8%, etc.) (Figure 1). In addition, the Tsai administration passed a bill to amend the Electricity Act in January 2017 in the wake of the accident at the Fukushima Daiichi Nuclear Power Plant, and now plans to phase out nuclear power generation by 2025.[2]

[1] In many cases, semiconductor sales do not include foundries that contract only for manufacturing from semiconductor manufacturers, but in this case, the ratio is calculated in such a way in order to measure the size of the Taiwanese semiconductor industry. As of 2019, 20% of the wafer fabrication capacity for semiconductor manufacturing worldwide was in Taiwan (see SIA/BCG [2021]).
[2] The government plans to increase the share of electricity generated from renewable energy sources to 20%, but the goal is not expected to be easy to achieve.

Natural disasters are also a cause for concern. Semiconductors require large amounts of water during the manufacturing process, but Taiwan experienced a drought in June that increased the risks related to semiconductor production. There is also a greater risk of flooding, as the annual average number of typhoons is larger than in Japan. Also, the impact of earthquakes cannot be ignored. A 7.6 magnitude earthquake struck central Taiwan on September 21, 1999, leaving as many as 2,415 people's lives lost and having a major impact on the semiconductor industry. At that time, in addition to a power outage, equipment such as quartz tubes were damaged, which caused a few weeks' delay in semiconductor supply.[3] According to the economic output at risk from natural threats of the Lloyd's City Risk Index,[4] Taipei City had the largest risk for natural disasters among major cities (Figure 2).

Figure 2. GDP@risk by Natural Catastrophe and Climate in The Lloyd's City Risk Index



Source: JRI, based on Lloyd's City Risk Index (2018)
Note: The Lloyd's City Risk Index measures the GDP@Risk of 279 cities across the world from 22 threats. Risk from natural catastrophe and climate includes 9 indicators such as tropical windstorm, earthquake, volcano, etc.

It should also be noted that geopolitical risks are increasing. This was triggered by remarks made by the former U.S. Commander of United States Indo-Pacific Command Philip Davidson at the Senate Armed Services Committee on March 9, 2021, where he stated that China could invade Taiwan within six years (Table 1). It is premature to think that an emergency would develop immediately as Mark Milley, a chairman of the Joint Chiefs

Table 1. Recent Developments Surrounding the Taiwan Strait

March 9, 2021	U.S. Navy Admiral Philip Davidson said China could invade Taiwan within the next six years.
April 19, 2021	A U.S.-Japan joint statement after a summit referred to the "importance of peace and stability in the Taiwan Strait."
May 18, 2021	The U.S. Navy's seventh fleet said its Arleigh Burke-class guided-missile destroyer USS Curtis Wilbur conducted a "routine" transit through the Taiwan Strait.
May 21, 2021	A U.S.-Korea joint statement after a summit included references to the Taiwan Strait and South China Sea.
May 27, 2021	Echoing the U.S.-Japan joint statement in April, Japan and the EU affirmed the "importance of peace and stability across the Taiwan Strait" in a statement.
June 13, 2021	The G-7 has referred to the Taiwan situation in a leaders' statement.
June 15, 2021	As many as 28 Chinese military aircraft, including fighter jets, entered Taiwan's air defense identification zone (ADIZ).
June 17, 2021	Chairman of the Joint Chiefs of Staff General Mark Milley said on Thursday there was a low probability that China would try to take over Taiwan militarily in the near-term.
July 1, 2021	China's President Xi Jinping said China maintains an "unshakeable commitment" to unification with Taiwan at an event marking the centenary of the CCP.

Source: JRI, based on various media reports

[3] See the Nikkei Cross Tech article on March 14, 2011. (https://xtech.nikkei.com/dm/article/FEATURE/20110314/190322/).
[4] Lloyd's City Risk Index, developed with the Cambridge Centre for Risk Studies, looks at economic exposure of 279 cities around the world to 22 specific threats, including natural catastrophes and man-made events.

of Staff, denied in June that China could attempt to take over Taiwan militarily within two years. However, at the Japan-U.S. summit and the G7 summit, the leaders of industrialized nations referred to the peace and stability of the Taiwan Strait, and have kept up pressure on China's hardline stance toward Taiwan. Meanwhile, China emphasized the importance of the Taiwan issue at a ceremony for the 100th anniversary of the founding of the Communist Party of China.

As such, Taiwan is faced with various risks, including power shortages, natural disasters, and relations with China. Above all, we must be clearly aware of the risks to Taiwan and Taiwan's key industry, semiconductors.

3. Taiwan's dependence on semiconductors in the global economy

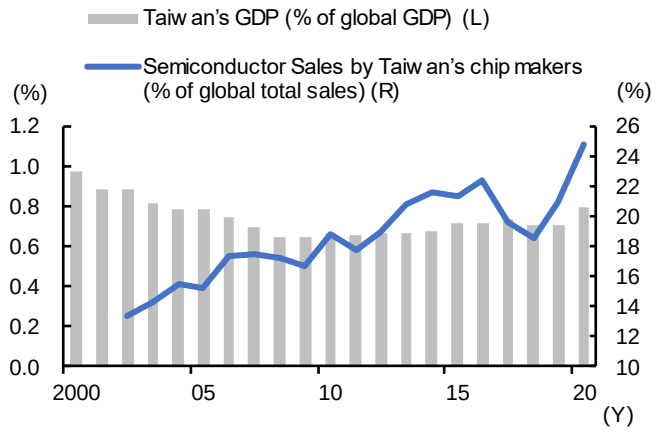
Taiwan's semiconductor industry has rapidly increased its share in the global market in recent years, producing key components for smartphones and computers. Although Taiwan's semiconductor companies do a lot of business with U.S.-based companies, many of their semiconductor manufacturing bases are in China and Southeast Asia, which has a significant impact on value added and job creation in the regions.

Q. What is the global share of Taiwan's semiconductors?

A. It has reached 25% with continued growth.

Taiwanese companies' share of global semiconductor sales (including foundries) continues to grow. From 2017 to 2018, the share of Korean companies rose thanks to strong demand for memory for servers, etc. In 2020, however, thanks to the special IT demand that accelerated due to the spread of COVID-19, sales at Taiwanese companies grew to about 25% of the global total (Figure 3). Although Taiwan's global GDP share has been stagnant since its peak in 2000, its presence in the semiconductor sector has been growing.

Figure 3. Taiwan's GDP and Semiconductor Sales (% of global GDP/sales)



Source: JRI, based on WSTS, TSIA, IMF and CEIC
Note: In many cases, semiconductor sales do not include foundries that contract only for manufacturing from semiconductor manufacturers, but in this case, the ratio is calculated in such a way in order to measure the size of the Taiwanese semiconductor industry.

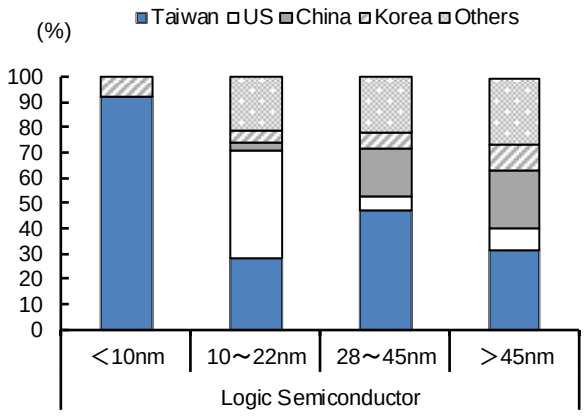
Q. For what kind of applications are Taiwan's semiconductors being used?

A. Mainly high-tech products such as smartphones and computers.

Semiconductors include integrated circuits (memory, logic, micro, analog), sensors, etc. Taiwan gained superiority in production of logic semiconductors which perform control, processing and arithmetic processing. Notably, 92% of the capacity for cutting-edge logic semiconductor manufacturing is located in Taiwan (Figure 4). This cutting-edge logic is mostly used for high-tech products such as smartphones and computers, while it is rarely used for home appliances and automobiles (Figure 5). Taiwan Semiconductor Manufacturing Co. (TSMC) and United Microelectronics Corporation (UMC) are large semiconductor foundries with over 50% of

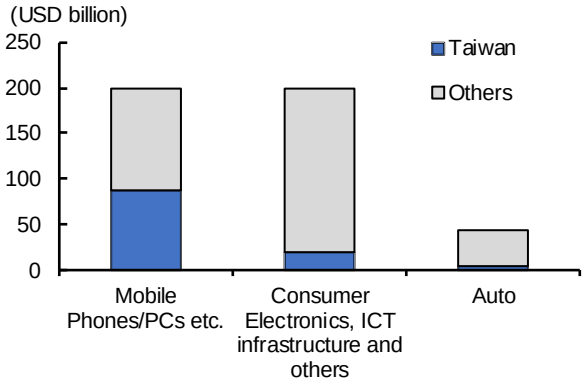
the share of the foundry market, and they account for 81% and 66% of their sales from smartphones and high-performance computers.

Figure 4. Global Wafer Fabrication Capacity for Logic Semiconductors (2019)



Source: SIA/BCG (2021)
Note: 5nm, which is used for smartphones etc., the most advanced logic, with smaller ones requiring more advanced technology.

Figure 5. Global Sales of Semiconductor and the Application Market (Estimates in 2020)



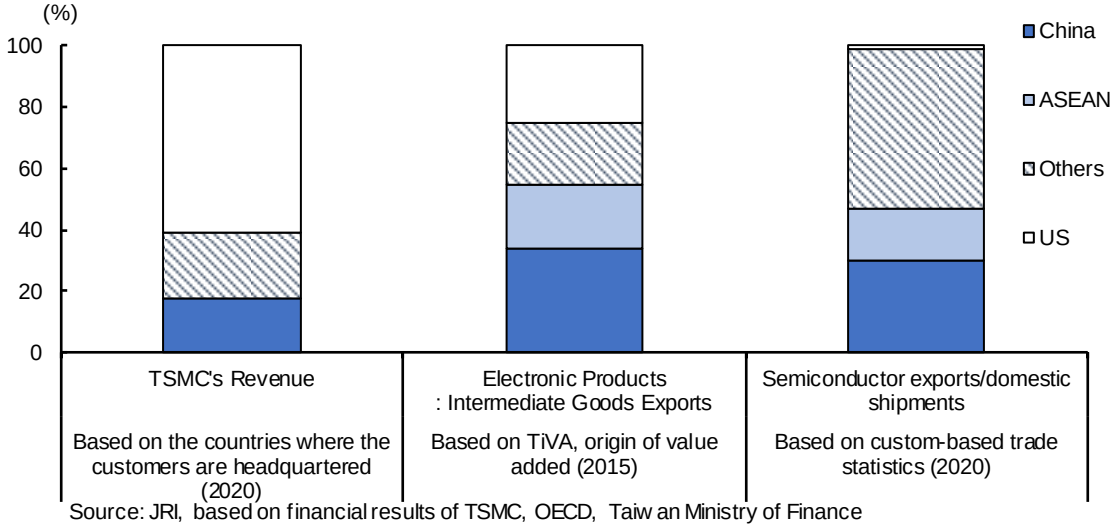
Source: JRI estimates
Note: Global sales of semiconductor are actual values in 2020. The value of each application is estimated by using the 2019 data of SIA, and the values for Taiwan are estimated from financial results of TSMC and UMC.

Q. Which countries and regions have demand for Taiwan's semiconductors?

A. Mainly China and Southeast Asian countries import them to assemble/manufacture products.

Looking at TSMC's customers, U.S. companies account for a large share of its revenue (e.g., smartphones for Apple Inc). However, the production base to assemble/manufacture products using semiconductors made in Taiwan is centered in China and Southeast Asia, so exports to the United States are small while exports to China and Southeast Asia are large (Figure 6).

Figure 6. Sales/Shipment of Taiwan's Semiconductors by Geographic Area; the Difference between the Client's Nationality (location of HQ) and Export Destination (place of assembly/manufacture)



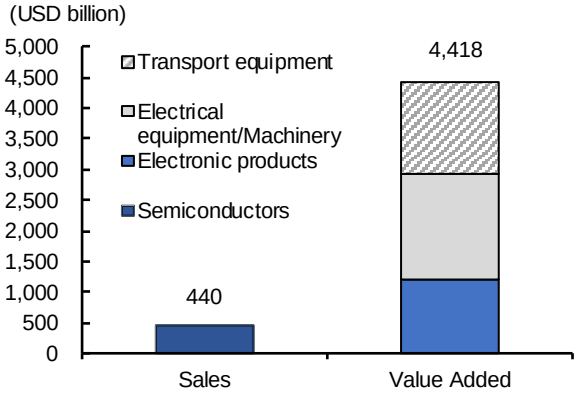
Source: JRI, based on financial results of TSMC, OECD, Taiwan Ministry of Finance

4. Estimated impact on major industries, countries and regions by suspension of semiconductor supply

Taiwan's semiconductor industry has been increasing its share in the world market in recent years, and if the risks mentioned above materialize, the global economy is expected to face a significant drop off. In the following, we estimate the impact on the global economy in the case of a suspension of production activity in Taiwan's semiconductor industry.

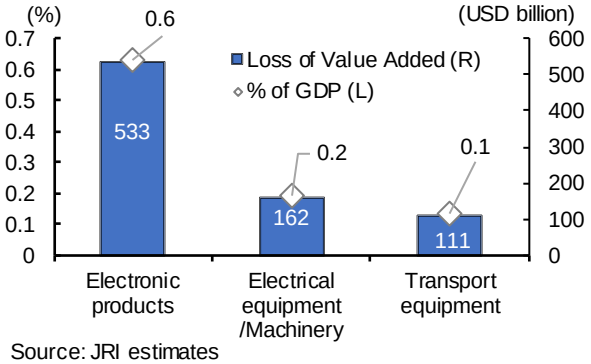
In 2020, global sales of semiconductors amounted to USD 440.3 billion, which is the source of value added of USD 4.4 trillion in manufacturing industries[5] such as "A. Electronics," "B. Electrical equipment and machinery" and "C. Transport equipment" (Figure 7). If the supply of semiconductors were to be halted, there would be a large impact on global value added in these industries. Assuming that semiconductors are used for all of the value added created in each industry,[6] we estimate the impact of the suspension of Taiwan's semiconductor supply in each industry based on the estimated values in Figure 5 (the data is reclassified in a form that extends to related industries in A to C). The results show that the loss in added value is USD 67.1 billion (0.08% of the global GDP) for a one-month suspension and approximately USD 800 billion (1.0% of the global GDP) for a one-year suspension. By industry, the impact on the electronic product industry including smartphones and computers could have significant damages, with the loss of value added of USD 44 billion in a month and of USD 533 billion[7] (0.6% of the global GDP) if it continues for one year (Figure 8).

Figure 7. Global Sales of Semiconductors and Industries that Use Semiconductors



Source: JRI, based on WSTS, OECD, World Bank
Note: Data for value added in the related industries are estimated based on OECD Inter-Country Input-Output (ICIO) Tables (2015) and Global GDP for 2020 and value added of manufacturing (% of GDP) .

Figure 8. Estimated Impacts on Global GDP in the Case of a One-year Suspension of Semiconductor Supply from Taiwan



Source: JRI estimates
Note: Assuming that semiconductors are used for all products to create added value in each industry, we estimated the impact of the suspension of semiconductor supply from Taiwan on related industries including 1. Electronics (mobile phones/PCs etc.), 2. Electrical equipment and machinery (consumer electronics, ICT infrastructure and others), and 3. Transport equipment (auto).

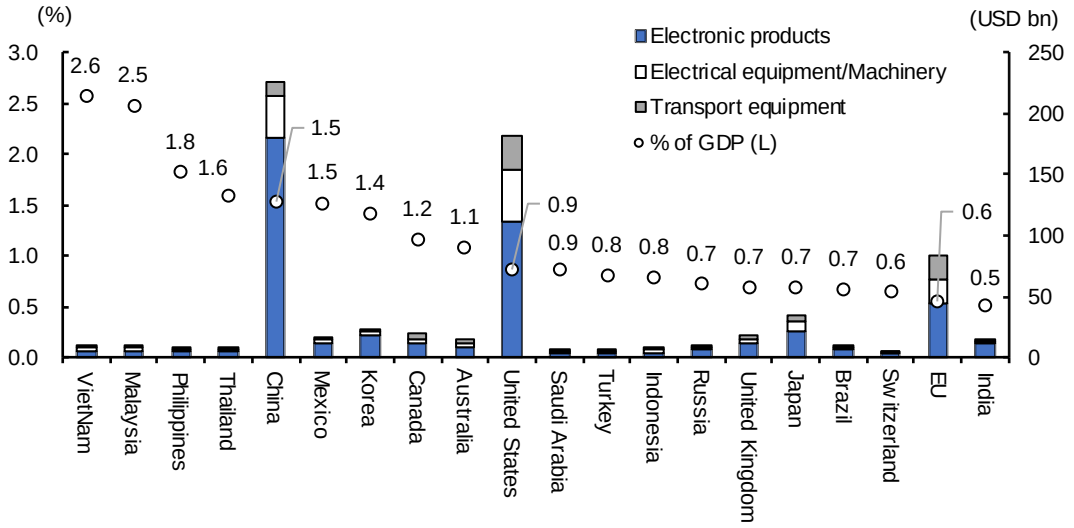
[5] The industries which use semiconductors and are considered related industries in this paper are:
A: smartphones and computers (ISIC 26. computer, electronic and optical products),
B. home appliances, ICT infrastructure, etc. (ISIC 27. electrical equipment, general machinery: 28. machinery and equipment),
C. automotive (ISIC 29. motor vehicles, trailers and semi-trailers, 30. other transport equipment).

[6] The estimates are based on a strong assumption that the added value in each industry will be reduced to zero if semiconductor production is reduced to zero.

[7] SIA/BCG [2021] shows the "extreme hypothetical scenario" of semiconductor production in Taiwan being shut down completely for one year, causing a USD 490 billion hit to annual revenue for electronic device makers worldwide. Since SIA/BCG does not provide details of the estimates, such as the definition of the industries affected, we cannot judge if the estimates can be compared with those in this paper. Another difference is that, while this paper estimates the impact on an value added basis, SIA/BCG estimates the impact on a revenue basis.

We also estimate the impact by country, based on the import share from Taiwan in terms of the value added in electronic intermediate goods shown in Figure 6.[8] The loss of value added is greater in China and the United States in terms of value, but greater in Vietnam and Malaysia as a percentage of GDP (Figure 9). In Japan, the loss of added value after a one-month suspension is estimated at about USD 2.9 billion (35 billion for one year, 0.7% of GDP).

Figure 9. Estimated Impacts on GDP by Country/Region
in the Case of a One-year Suspension of Semiconductor Supply from Taiwan



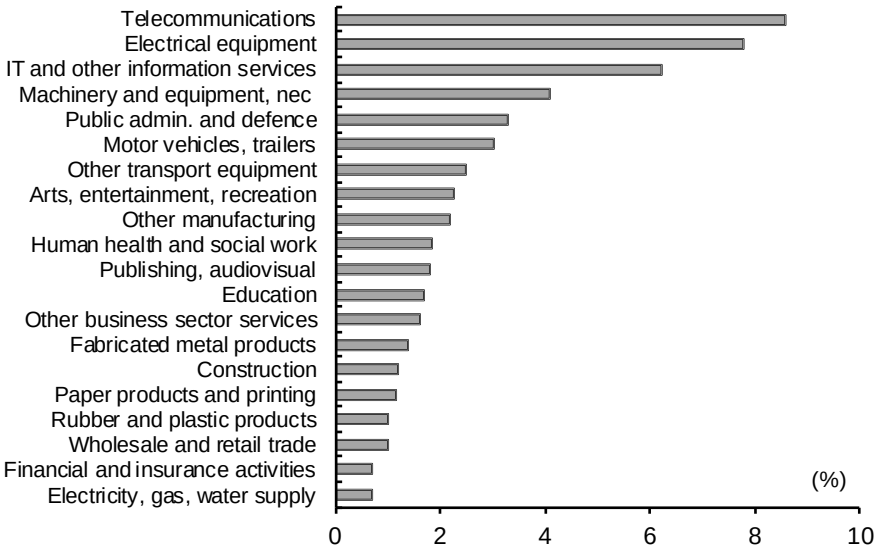
Source: JRI estimates
Note: Impacts for each country and region are estimated by the export share of electronic products (intermediate goods, origin of value added) from Taiwan.

We note that the estimation results do not take into account alternate production by non-Taiwanese companies. Also, the estimated impact on the auto industry is small as semiconductors produced by Taiwanese companies are, relatively, not widely used in automobiles. However, in the auto industry, even if the ratio of the intermediate input is small, often production will stop due to inability to procure special parts. If special parts were to be manufactured in Taiwan, the suspension of production would cause serious damage to automobile supply chains (see Appendix).

In addition, the calculations here cover only direct impacts. In practice, secondary effects may occur. Many industries, including the service industry, use several electronic products as intermediate input (Figure 10). If electronic products cannot be produced due to a shortage of semiconductors, it is highly likely that other non-manufacturing industries will suffer serious damage, such as the telecommunications and information service industries.

[8] Exports based on customs may be overvalued as re-exports/roundabout exports are included (e.g., exports to Hong Kong). Re-exports/roundabout exports would have no impact on the production activities of the export destination, such as actual processing and assembly to create value added. Therefore, the share of value added exports estimated by the OECD is used in this paper to capture the actual impact of production activities.

Figure 10. Input of Electronic Products
(% of Global Total Input) by Industry



Source: JRI, based on OECD Inter-Country Input-Output Table (2015)

5. Conclusion

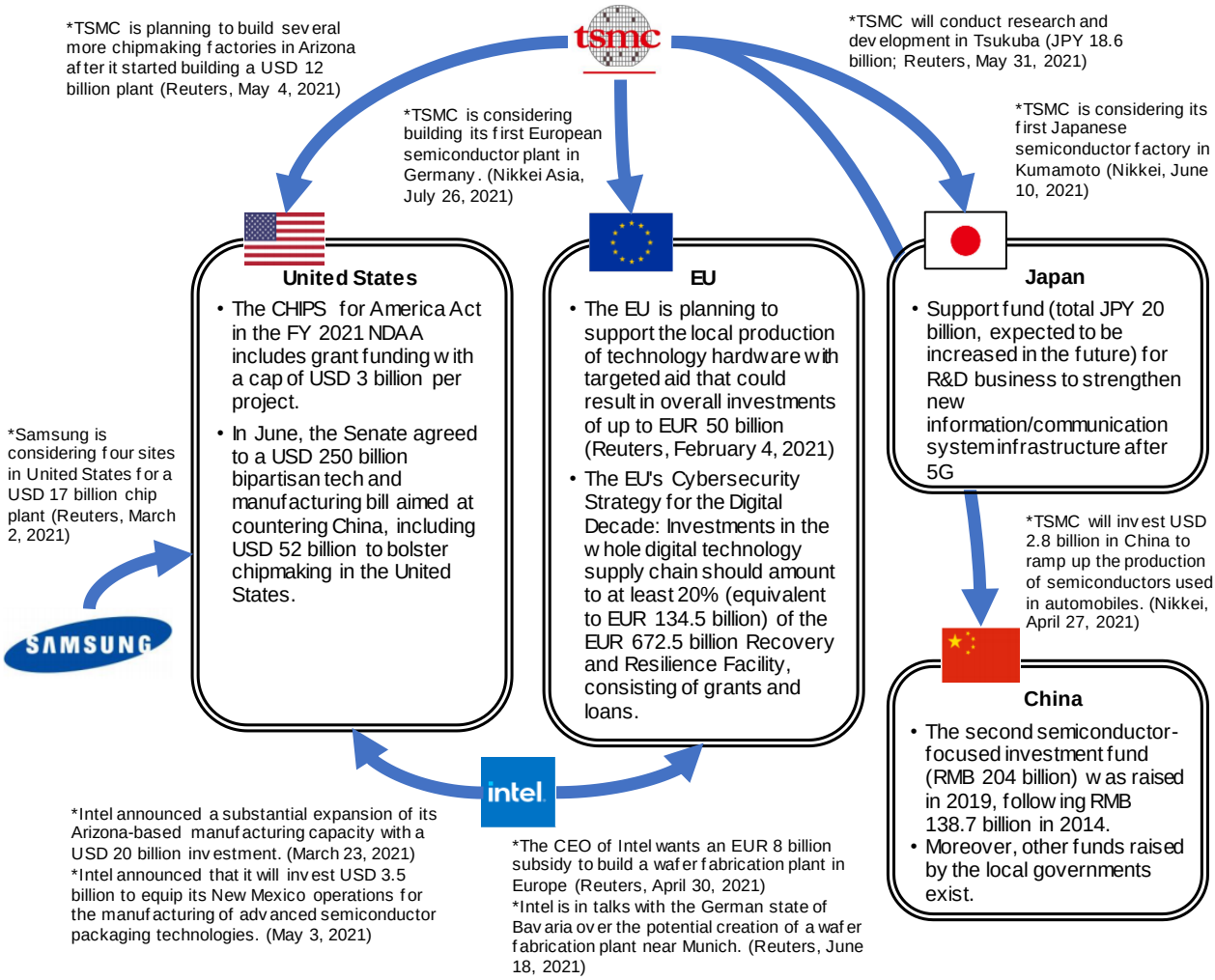
If Taiwan's various risks materialize, the global electronics industry, notably in Asia, is expected to face serious damage.

The U.S. and European authorities are working to attract the semiconductor industry to their own countries and regions, and plan to provide large-scale state-funded support. The U.S. senate passed the Innovation and Competition Act, which includes US $52 billion in investment in the semiconductor industry, and support for up to €50 billion in investment is planned in Europe (Figure 11). Taking advantage of the situation, major semiconductor companies including TSMC have started to consider building plants in the United States and Europe. In May 2020, TSMC announced plans to build an advanced chip fabrication plant in Arizona at the request of the then U.S. President Donald Trump's administration (approximately USD 12 billion in investment between 2021 and 29, with construction starting in 2021). In May 2021, it was reported that the company was considering investing in several more chipmaking factories in Arizona. In July 2021, the media reported that TSMC might plan a new plant in Germany. In Japan, the LDP's working group on semiconductor strategy has called for support measures worth trillions of yen, close to those in the United States and Europe. The Japanese government has already succeeded in inviting TSMC's research and development center to Tsukuba City,[9] and is now considering inviting a semiconductor plant in Kumamoto Prefecture.

However, it should be noted that 1) the possibility of large-scale production base transfers to developed countries is low due to high costs, 2) it will take years to start plant operation even if a transfer is decided, and 3) the Taiwanese government is reluctant to relocate its production base.

[9] Japanese manufacturers and research institutes that have strengths in manufacturing equipment and materials for semiconductors will participate in a development project with TSMC. The Japanese government will provide JPY 19 billion in subsidies, more than half of the project's cost of JPY 37 billion.

Figure 11. Major Countries' Policies to Attract the Semiconductor Industry and Recent Actions of Major Chip Makers



Source: JRI based on various media reports

First of all, regarding 1), TSMC founder Morris Chang (張忠謀) has pointed out that, in relation to investment in the United States, short-term federal and state subsidies would do little to reverse the competitive disadvantage of the United States in the long term. Therefore, production in developed countries is likely to be costly, and the shift in semiconductor production bases is expected to be small. Also, developed countries may just be hoping that they can secure a given level of advanced technology in consideration of security issues. In Asia, where the impact is large, incentives to attract the semiconductor industry are expected to be greater, but so far there have been no notable moves. Due to the difficult political situation, it is unlikely to be easy for China to attract more production bases from Taiwan. In Southeast Asia, it is also not easy to attract them as there are not enough human resources and infrastructure.

Secondly, as for the time until the start of operation, TSMC's plant in Arizona that the company made their decision on in May last year is scheduled to start production in the January–March of 2024. It will take over three years from the decision to the start of operations, which means that it will take time to reduce the risk even if successful.

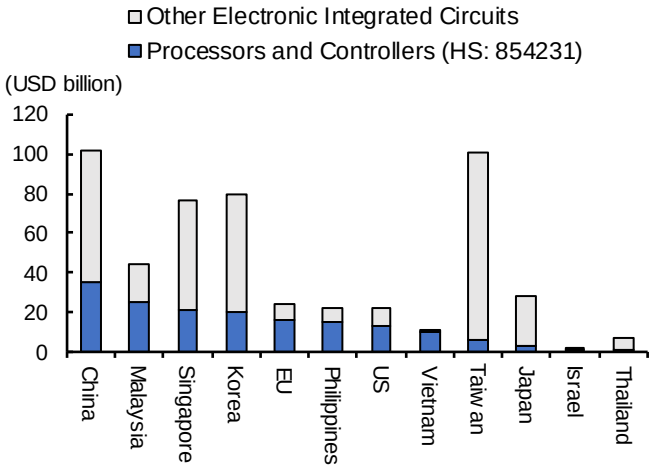
Finally, with regard to the stance of the Taiwan in 3), in 2020, the Taiwanese government announced the "Angstrom Semiconductor Initiative," a medium-term plan aiming to further enhance Taiwan's competitiveness by strengthening the development of next-generation semiconductors. According to the Taipei Times on April 29, 2021, Taiwan's Minister of Economic Affairs Wang Mei-hua (王美花) said, "Regardless of whether or not TSMC establishes production facilities or pursues cooperation in Europe, Taiwan will remain the home base for its most advanced technologies." The Taiwanese authorities are not expected to reject all requests from developed countries, but it is expected that each country and region will need to provide more large-scale support, such as subsidies to attract Taiwanese semiconductor companies.

All in all, it will not be easy for the global economy to significantly reduce its dependence on Taiwan's semiconductors. The global economy is likely to continue to face a high risk of a supply chain disruption from Taiwan's semiconductor industry over the coming years, and it remains necessary to brace for a crisis in the electronic products industry, mainly in China and Southeast Asia.

Appendix: Impact of Suspension of Semiconductor Supply on an Unpredictable Automotive Industry

We estimate in this paper that the impact on the automobile industry will not be significant even if a major problem arises in semiconductor production in Taiwan. In fact, Taiwan's contribution to global exports of processor controllers, including "microcontrollers, [10] " which are typical semiconductors used in automobiles, is small (Figure 12). In 2021, it was reported that governments in various countries had requested TSMC to increase production of semiconductors in order to solve the problem of a shortage of semiconductors for automotive use. [11] TSMC is required to expand the production of in-vehicle semiconductors, which is a product that it does not produce much.

Figure 12. Exports of Electronic Integrated Circuits (2019)

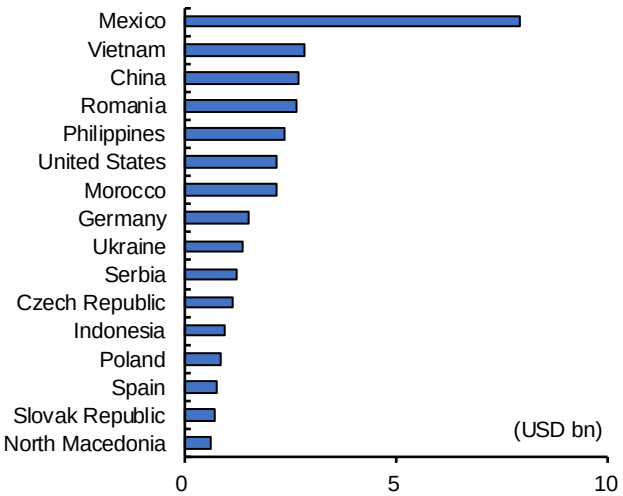


Source: JRI, based on WITS and Taiwan Ministry of Finance

Since production processes in the manufacturing industry are becoming more complex, the total production process may be affected by the lack of special parts even if the ratio of production to intermediate input is small. Automobiles in particular have many parts, and their production may be forced to stop due to the suspension of supplies of some parts.

In February 2020, because the Chinese government extended the Spring Festival holidays, the supply of wire harnesses for auto parts was halted, which caused Hyundai Motor's domestic production lines in Korea to be suspended. Wire harnesses are labor-intensive products, as opposed to those requiring high technology, and the export share of China is not large (Figure 13).

Figure 13. Exports of Wiring Harnesses for Vehicles (HS:85443) (2019)



Source: JRI, based on WITS and Taiwan Ministry of Finance

In August 2021, Toyota Motors temporarily suspended operations at three auto production

[10] The applications of a microcontroller (MCU: micro-control unit) incorporated in automobiles include engine control, electronically controlled suspension, anti-lock brake systems (ABS), power steering, power windows, airbag control, wiper control, keyless entry, and more.

[11] In the first half of 2020, orders of semiconductors from automakers reduced significantly after demand for automobiles sharply declined, which could be a factor behind the current severe shortage of automotive semiconductors. More lines now are used to produce semiconductors for smartphones and computers, which has greatly reduced the capacity to produce automotive semiconductors. Renesas Electronics Corporation, which has the world's largest share in the microcontroller market, diversified its production bases and adopted an alternative production system using external plants in response to the plant damage caused by the Great East Japan Earthquake in 2011 which disrupted global automobile production. Although the risk of natural disasters has been reduced in the case of microcontrollers, production control capability seems to have declined as seen in this case.

lines at two plants in Japan due to delays in parts supply from Vietnam caused by the spread of COVID-19. The ratio of imports of auto parts from Vietnam was 7% in 2020, which is smaller than China (38%) and Thailand (12%).

In addition to microcontrollers, there are various semiconductors used in automobiles, such as power semiconductors and sensors. Also, some models use more than 100 semiconductors. As the number of vehicles with advanced technologies such as electric vehicles and autonomous driving functions increases, it is likely that the number of vehicles which require Taiwanese semiconductors in their production processes will also increase. It should be noted that the risk of Taiwanese semiconductors in automobiles may become unexpectedly large.

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