



## International Cooperation Towards Decarbonization, Originating from India - Case Analysis of Industrial Cooperation in the Semiconductor Sector between India, Japan, and Taiwan

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### ABSTRACT

**Background:** Climate change represents a global challenge that cannot be mitigated by any single nation. Notably, CO<sub>2</sub> emissions from the Southern Hemisphere are escalating rapidly, currently constituting two-thirds of the global total. The proactive efforts of India, which leads this group, are noteworthy.

**Purpose:** This study aims to elucidate the impact of international cooperation on decarbonization, with a specific focus on the semiconductor industry in India, a representative nation of the Global South. The current state of collaboration between Japan, Taiwan, and India serves as an exemplar of international efforts towards decarbonization. Furthermore, the strategic significance of industrial collaboration in the semiconductor sector among Japan, India, and Taiwan, and the potential for establishing a global semiconductor supply chain oriented towards decarbonization, are examined.

**Method:** This study employs a case study methodology to scrutinize the current status of international collaboration in the semiconductor industry among India, Japan, and Taiwan.

**Result:** The Japanese semiconductor industry, renowned for its advanced technical capabilities, necessitates the fortification of the global supply chain and technology transfer, with collaboration with India proving advantageous. Taiwan, actively expanding its presence in India, seeks to enhance the quality and efficiency of semiconductor manufacturing and to form diverse supply chains, thereby accelerating innovation through collaboration with Japan. A synergistic relationship in the semiconductor industry is being established among India, Japan, and Taiwan.

**Conclusion:** India possesses the potential to assume a pivotal role in the construction of a global semiconductor supply chain, with Japan and Taiwan identified as optimal partners. This collaboration is anticipated to bolster manufacturing capabilities aimed at decarbonization, contribute to international decarbonization efforts, and drive technological advancements as part of global next-generation technology management.



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## 1. Introduction

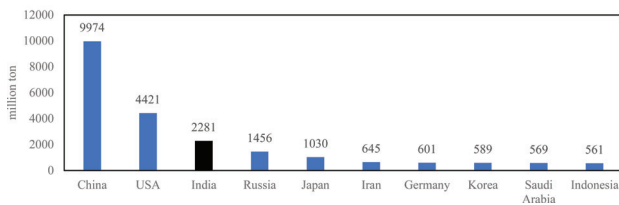
### 1.1. Trends of Various Countries Towards Carbon Neutrality

Climate change is a global issue that cannot be solved by one country alone. Not only developed countries, but also countries in the southern hemisphere need to tackle this issue. Many countries have pledged to achieve carbon neutrality, for example, India aims for 2070, and Japan and Taiwan aim for 2050.

The transformation of energy and industry plays a crucial role in achieving the goal of carbon neutrality. Climate change is closely related to the energy sector, which has relied on fossil fuels as its main source of supply, but is now transitioning to reduce the consumption of fossil fuels. It is also essential that the industrial sector eventually transforms into a low-carbon or zero-carbon footprint. Figure 1 shows the top 10 CO<sub>2</sub> emissions in the world.

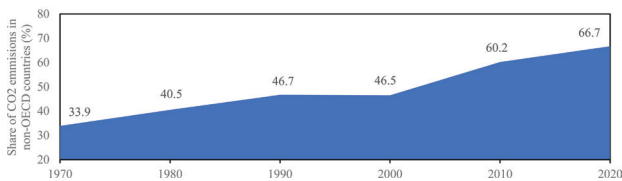
The CO<sub>2</sub> emissions from the Global South have rapidly increased, now accounting for two-thirds of the world's total

(Figure 2). India's proactive measures, aiming to lead this group, have garnered significant attention.



**Figure 1:** Top 10 CO2 Emitters in the World (2020)

**Source:** BP Statistics (2022).



**Figure 2:** Trends in CO2 Emission Shares of Non-OECD Countries (1970-2020)

**Source:** World Bank Data Indicators.

## 1.2. Trends of India as a Representative of the Global South

In the report by the Ministry of Environment, Forest and Climate Change (MoEFCC), the Indian government has set a goal to achieve carbon neutrality by 2070 (Ministry of Environment, Forest and Climate Change, 2022). However, the path ahead is extremely challenging, and achieving this goal is considered difficult. At the 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) in 2021, India announced its target of net-zero emissions by 2070. Additionally, at the 27th Conference of the Parties (COP27) in 2022, India submitted its Long-Term Low Emission Development Strategy (LT-LEDS). Furthermore, in its Nationally Determined Contributions (NDC), India stated that it would reduce the emissions intensity of its GDP by 45% by 2030. Moreover, India confirmed its commitment to generating 50% of its electricity from non-fossil fuel sources by 2030.

In response to these commitments, Suri (2023) argues that India needs to mobilize much more private capital than public funds. Suri also asserts that India's climate finance strategy must provide funding for climate-focused research and innovation.

According to a report by the International Energy Agency (IEA), India is currently the world's third-largest energy consumer, driven by rising incomes and improving living standards (International Energy Agency, 2021a). Energy use has doubled since 2000, with 80% of demand

still met by coal, oil, and solid biomass. On the other hand, India is a global leader in solar power, and the combination of solar power and batteries is expected to play a significant role in India's energy future. However, charting this new path requires various technologies and policies. Policies to accelerate India's transition to clean energy are considered essential for laying the foundation for economic growth and strengthening energy security.

## 1.3. Importance of International Collaboration

Achieving carbon neutrality requires a global transformation of energy and industrial practices. The International Energy Agency (2021b) outlines various pathways to achieve net-zero emissions by 2050. In the industrial sector, new clean technologies in heavy industry are expected to be demonstrated on a large scale by 2030. Additionally, all industrial electric motor sales should be best-in-class by 2035, and by 2040, about 90% of the existing production capacity in heavy industry will reach the end of its investment cycle. Ultimately, over 90% of heavy industry production is expected to be low-emission by 2050.

The transition to digitalization in industry and society is also deemed essential for achieving carbon neutrality. The World Economic Forum (2022) emphasizes that integrating digital solutions can accelerate the net-zero trajectory of high-emission sectors. The forum suggests that if digital technologies are adopted across industries, they could contribute up to 20% of the reductions needed to achieve the International Energy Agency's net-zero trajectory in the energy, materials, and mobility sectors. These industries are already capable of reducing emissions by 4-10% through rapid adoption of digital technologies.

In response to these international trends, India faces the urgent task of decarbonizing its manufacturing sector. Rapid economic growth and widening wealth disparities have become social issues in India. One cause is the disparity between India's world-class digital capabilities and the lagging development of its manufacturing sector. India's manufacturing weakness has been noted, and since the 2014 Make in India initiative, efforts to address this have been actively implemented. Developing the manufacturing sector, which can absorb a large workforce, is inevitable for uplifting the vast Indian market. However, the imbalance in manufacturing growth centered on digital transformation remains a challenge.

Currently, India is encouraging foreign direct investment and promoting collaboration with foreign companies through the "Make in India" policy to internalize advanced manufacturing technologies. This policy has led many foreign companies to increase their investments in India, and these outcomes are expected to contribute to India's decarbonization efforts.

The purpose of this paper is to recognize India's role in global decarbonization efforts highlighted by trends towards carbon neutrality, understand these efforts, and examine the strategic significance of international collaboration, particularly with Japan and Taiwan, focusing on semiconductors supporting decarbonization technologies.

Chapter 2 outlines India's efforts towards decarbonization and examines the effects of international collaboration. Chapter 3 discusses the current state of collaboration between Japan, Taiwan, and India as case studies of international collaboration towards decarbonization. Chapter 4 examines the strategic significance of industrial cooperation in the semiconductor field between Japan, India, and Taiwan, and its potential to build a global semiconductor supply chain for decarbonization. Finally, Chapter 5 summarizes the implications of international cooperation towards decarbonization starting from India.

## 2. India's Efforts Towards Decarbonization

### 2.1. Efforts and Challenges Towards Decarbonization

The Indian government is implementing the Digital India policy, which promotes digitalization to enhance overall efficiency across India, and the Make in India policy, which aims to attract direct investment and increase the manufacturing sector's share of GDP from 15% to 25% through improved investment environments. These policies are expected to play a crucial role in India's pursuit of a decarbonized society. The Digital India policy has the potential to improve energy efficiency and reduce carbon emissions through the spread of ICT and digitalization. On the other hand, the Make in India policy aims to reduce import dependence and cut carbon emissions by strengthening domestic manufacturing and producing high-value-added products. Pulicherla *et al.* (2022) introduce the efforts of the Indian government to revitalize the manufacturing sector and grow the Indian economy through the "Make in India" campaign. The paper emphasizes that the Indian government is focusing on green manufacturing, citing investments in green energy, green transportation, and green technology as examples. The argument is made that transitioning to green manufacturing is essential for India to reclaim its leadership in the manufacturing sector.

Additionally, the Production-Linked Incentive (PLI) scheme has been introduced alongside the Make in India policy. Through these policies, the goal is to nurture leaders in domestic manufacturing, create 600,000 new jobs, and achieve production worth 3 trillion crore over five years.

Furthermore, the Indian government is gradually adding sectors to the PLI scheme. In March 2020, the Department

of Pharmaceuticals introduced Key Starting Materials (KSM)/Drug Intermediates (DI) and Active Pharmaceutical Ingredients (API), and the Ministry of Electronics and Information Technology introduced large-scale electronics manufacturing. The Department of Pharmaceuticals also introduced medical device manufacturing. In November 2020, the Ministry of Electronics and Information Technology introduced electronics/technology products, the Department of Pharmaceuticals introduced pharmaceuticals, the Department of Telecommunications introduced telecom and networking products, the Ministry of Food Processing Industries introduced food, the Department for Promotion of Industry and Internal Trade introduced white goods (air conditioners and LEDs), the Ministry of New and Renewable Energy introduced high-efficiency solar PV modules, the Department of Heavy Industry introduced automobiles and auto components and Advanced Chemistry Cell (ACC) batteries, and the Ministry of Textiles introduced MMF segment textiles and technical textiles. In September 2021, the Ministry of Civil Aviation introduced drones and drone components.

It cannot be confirmed whether this is due to the success of these initiatives, however, the amount of foreign direct investment in India has increased since 2014 (Figure 3).

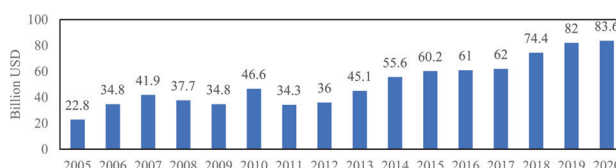


Figure 3: Trends in Foreign Direct Investment to India

The key to India's "Make in India" policy lies in the internalization of advanced foreign manufacturing technologies, aiming to achieve tangible results. However, currently, these activities have not contributed to the maturation of India's manufacturing sector or to decarbonization efforts.

Figure 4 shows that the proportion of India's research and development investment relative to GDP is significantly lower compared to other high CO<sub>2</sub> emitting countries. Moving forward, India needs to invigorate activities aimed at creating innovation, thereby advancing the manufacturing sector and promoting decarbonization.

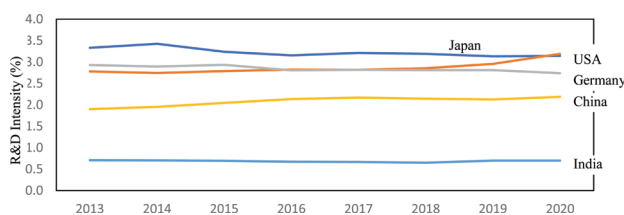


Figure 4: R&D Intensity of the Top 5 CO<sub>2</sub> Emitting Countries

## 2.2. Measures through International Collaboration

### 2.2.1. Core of Make in India Success – Building a Semiconductor Supply Chain

Hsieh *et al.* (2023) analyze how the semiconductor industry can contribute to achieving the United Nations' Sustainable Development Goals (SDGs). The study reveals that semiconductor research primarily contributes to SDG7 (Affordable and Clean Energy), SDG9 (Industry, Innovation, and Infrastructure), SDG3 (Good Health and Well-being), SDG6 (Clean Water and Sanitation), and SDG13 (Climate Action). In particular, semiconductors play a crucial role in enhancing energy efficiency across various applications. They improve power management in electronic devices, reducing energy consumption and greenhouse gas emissions. For instance, advanced semiconductors enhance the performance of electric vehicles, making them more environmentally friendly and energy-efficient. Additionally, data centers, which consume large amounts of energy, are significant sources of carbon footprints. Advanced semiconductors are necessary to improve the energy efficiency of servers and data storage systems. Optimizing data centers can significantly reduce carbon footprints, especially as the demand for cloud computing and data processing continues to grow.

Thus, semiconductors are essential for developing efficient electrical systems and components, such as power electronics for EVs and electrified industrial equipment. For example, smart grids utilize advanced semiconductors for monitoring and control. High-performance semiconductors enable more efficient and decentralized energy distribution, effectively integrating renewable energy sources and reducing overall energy consumption. Furthermore, carbon capture and utilization technologies use advanced sensors, control systems, and monitoring to optimize carbon capture processes across various industries. However, it is important to note that semiconductor production requires substantial amounts of electricity. In many cases, consideration should be given to using green power.

Optimizing these core semiconductor supply chains promotes the efficient distribution of these critical components, reduces CO<sub>2</sub> emissions from shipping and transportation, and minimizes waste and resource use during semiconductor manufacturing. A robust semiconductor supply chain also fosters the growth of environmentally friendly technologies.

On the other hand, complex supply chains carry various risks. Yu *et al.* (2024) investigates the structural resilience and vulnerabilities of the semiconductor material supply network in the global semiconductor industry, revealing that the supply network for key semiconductor materials is

susceptible to external risks. Yu's paper argues that promoting the sustainability of the global semiconductor industry requires strategic stockpiling and risk management of materials, integration of supply chains through international cooperation, and technological innovation and deployment.

Countries around the world recognize that securing this supply chain is essential for achieving carbon neutrality goals and promoting green technology innovation. Therefore, by building semiconductor supply chains with key players, arrangements are made to ensure immediate access to these critical components, promoting further innovation in sustainable technologies and manufacturing methods.

### 2.2.2. International Collaboration for Building Semiconductor Supply Chain

India holds the potential to become a global semiconductor production hub. A comprehensive SWOT analysis is necessary to evaluate the strengths, weaknesses, threats, and opportunities of Indian semiconductor manufacturers. HIS Markit conducted a SWOT analysis of India's semiconductor industry. According to the analysis, India has a large mobile phone manufacturing base and abundant human capital in IT, design, R&D, and engineering sectors, which are considered strengths. However, heavy reliance on imported semiconductors for consumer electronics manufacturing, limited manufacturing capacity focused on final assembly of printed circuit boards, and limited investment in design and ultra-large-scale integration are considered weaknesses. Government incentives for establishing new manufacturing plants are the biggest consideration for opportunities, while threats include vulnerabilities in the environmental ecosystem and infrastructure for semiconductor manufacturing, such as water shortages.

In this environment, the motivations for foreign companies to invest in India include the following:

- India is an attractive investment destination for foreign companies considering investment in human resources. India boasts a highly skilled workforce with many graduates from prestigious institutions such as the Indian Institutes of Technology. India has strengths in technology and software, making it particularly advantageous for foreign companies looking to leverage these skills. The Indian workforce is a valuable asset, possessing advanced expertise and knowledge in technology and software development, which is a significant attraction for foreign investors.
- Foreign companies recognize India as a vibrant emerging market. With a population exceeding 1.3 billion, India has experienced rapid economic growth in recent years. As a result, the importance of the domestic market in India is increasing for foreign companies considering investment in India.



- India's strategic location between Southeast Asia, Europe, and Africa makes it a prime destination for foreign companies aiming to establish production bases in the global supply chain. India's central position on the world map provides unique advantages, enabling it to play a crucial role in the global value chain.
- Additionally, policies promoting the digitalization of India as a whole are expected to enable citizens to access e-government services and enjoy the latest ICT. This allows foreign companies to explore new business opportunities by leveraging India's digital infrastructure. Particularly, the growth support for startups through policies is generating new business models and technologies, offering new investment opportunities for foreign companies. Thus, government-led initiatives in India are key factors enhancing the motivation for foreign companies to invest in India.
- According to a survey conducted by Japan Bank for International Cooperation (2022), India is cited as the most promising country as a potential investment destination. The surveys revealed that 85.5% of respondents chose India due to the expected growth of the local market. However, it is important to note that the survey also highlighted several challenges related to investing in India, such as legal uncertainties cited by 38.8% of respondents and infrastructure issues cited by 32.8% of respondents.

In this context, the participation and leading role of India in the semiconductor supply chain are expected, given the importance of the semiconductor industry as a cornerstone of manufacturing and the emphasis on improving the current reliance on imported semiconductors.

### **3. International Collaboration Towards Decarbonization – Case Studies of Collaboration between Taiwan, Japan, and India**

As demonstrated above, semiconductors play a crucial role in reducing carbon emissions and promoting sustainability. The trilateral collaboration between Taiwan, a notable player in the semiconductor industry, Japan, with its advanced manufacturing technologies, and India, can leverage their respective strengths to advance decarbonization efforts led by semiconductor technology. Currently, Taiwan is leading the world in semiconductor manufacturing and aims to expand beyond its borders. India, with its growing economy and strategic location, could potentially be one of the destinations for this expansion. Furthermore, India's position as a hub in the Global South is crucial for achieving carbon neutrality globally. Japan, with its advanced research and development capabilities, can provide essential support

for semiconductor manufacturing and development. In this section, the impact of international collaboration between Japan, Taiwan, and India on decarbonization will be examined, focusing on the semiconductor industry.

#### *3.1. Current State of Collaboration between Taiwan, Japan, and India*

##### *3.1.1. Current State of Collaboration between Taiwan and Japan*

The Institute of Developing Economies (IDE), a research institute of the Japan External Trade Organization (JETRO), and the Taiwan Institute of Economic Research (TIER) conducted a joint study from 2012 to 2015 to explore the potential for bilateral industrial cooperation between Japan and Taiwan (Institute of Developing Economies & Taiwan Institute of Economic Research, 2013-2015). However, it later shifted its focus to investigating the potential for such cooperation in third countries, particularly in Southeast Asian countries. While this research did not focus on semiconductor cooperation, it instead focused on other potential areas of cooperation, such as manufacturing and technology, to identify opportunities for mutual benefit. Overall, this research provides valuable insights into the potential to enhance economic cooperation between Japan and Taiwan, suggesting the possibility of expanding into the semiconductor field.

Furthermore, there is a long history of industrial cooperation between Japan and Taiwan. In a 2020 webinar by JETRO, a representative from Taiwan's Ministry of Economic Affairs emphasized that the business relationship between the two countries has been built on mutual trust over more than half a century. The webinar discussed the strengths of Japanese and Taiwanese companies. Japanese companies were highlighted for their advanced technical capabilities, quality control abilities, and strong brand power. On the other hand, Taiwanese companies were noted for their management capabilities in technology integration, cost control, and mass production of precision products. Also highly rated were their quick strategic decision-making, sensitivity to business opportunities, and adaptability to environmental changes. In addition, several values have been pointed out as being born out of the collaboration between Japanese and Taiwanese companies. The first value is the improvement of product price competitiveness. The second value is the promotion of product development that meets market demand through collaboration. Lastly, the use of Taiwanese companies' networks for market development promotion has been pointed out.

The internationalization of Taiwanese companies has also been noted, with investments being made in China and Southeast Asia. The 2023 white paper recently published

by the Taipei Japanese Chamber of Commerce emphasizes the importance of promoting cooperation between Japanese and Taiwanese companies as part of the Southbound Policy. This white paper emphasizes the need for specific and meticulously crafted policies to promote such cooperation, ultimately bringing significant economic benefits to both countries. The proposed policies aim to create a mutually beneficial business environment that promotes innovation, growth, and market share expansion.

In this way, Japan and Taiwan regard each other as important partners. This is no exception in the semiconductor industry. Both countries are cooperating to ensure a stable supply, advance technology, expand production capacity, and overcome challenges in semiconductor production and supply chain management.

The success of this partnership is extremely important for the economic competitiveness of both countries and their technological leadership in the global semiconductor market. Taiwan is a global pioneer in semiconductor production and has advanced manufacturing facilities. By partnering with Japan's manufacturing expertise, Taiwan can improve the precision, efficiency, and quality control of semiconductor manufacturing. This partnership could potentially lead to the development of advanced semiconductor manufacturing technologies that benefit these countries and the world's technology industry. Taiwan's semiconductor industry occupies an important part of the global supply chain. By cooperating with Japan and India, it is expected to diversify the supply chain and reduce dependence on a single region. This diversification improves resilience against disruptions such as natural disasters and geopolitical tensions, ensuring a stable supply of critical components. In addition, it is expected that Taiwan's semiconductor industry will contribute to the integration of Japan's manufacturing strength and India's digital transformation excellence. It is believed that the integration of Taiwan's semiconductor industry and Japan's manufacturing strength, and India's

digital transformation expertise, can create significant contributions and synergies in various fields.

### 3.1.2. Current State of Collaboration between Japan and India

Over the years, the relationship between Japan and India has become robust. Frequent visits by the leaders of both countries have deepened their diplomatic and economic ties. The leaders of both countries have been closely working on various issues of mutual interest, such as security, trade, and cultural exchange. With each visit, a more productive and harmonious bilateral relationship is being built, as they gain a deeper understanding of each other's priorities and needs.

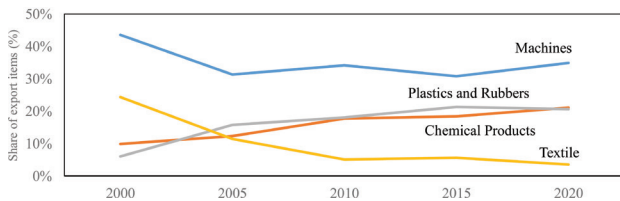
The development of bilateral cooperation between India and Japan includes collaboration across various fields, such as semiconductor supply chains, digital technology, startups, hydrogen and fuel ammonia, energy technology, and transition finance. These industries are extremely important in promoting industrial and social transformation in India and around the world. In summary, over the past several decades, Japan and India have built a strong bilateral relationship. India's foreign investment attraction policy is linked to the cooperative relationship between Japan and India. In particular, the Japan-India Industrial Cooperation Initiative focuses on industries such as semiconductors, digital technology, and energy. These industries are extremely important in leading the world towards digital transformation and energy transition to achieve carbon neutrality. In addition, notable exchange relationships can be seen in private collaborations, and Table 1 shows the selected companies from the group of companies indicated in the JICA survey report, which have large sales scales in each industry. These Japanese companies are bringing about innovation-led corporate growth through collaboration with Indian companies.

**Table 1:** Representative Examples of Japanese Companies Expanding into India

Japanese companies	Indian companies	Field	Japanese companies	Indian companies	Field
Nippon Steel Corporation	AM/NS India	Steel	Hitachi	Hitachi Digital Payments	Finance
Toray	Toray Industries India (TID)	Chemical fiber	Panasonic	Panasonic India	Home appliances, electrical materials
Kansai Paint	Kansai Paint	Chemicals (paints)	Sony	Sony G	Video/Broadcast
Daiichi Sankyo	Daiichi Sankyo	Pharmaceuticals	Fujitsu	Fujitsu Consulting India Ltd. (FCIL)	ICT
Suzuki	Maruti Suzuki India	Cars	Mitsubishi Electric	Mitsubishi Electric India Pvt. Ltd.	Electrical
Kubota	Escorts Kubota	Agricultural machines	Daikin	Daikin Airconditioning India Pvt. Ltd.	Home appliances (air conditioning)

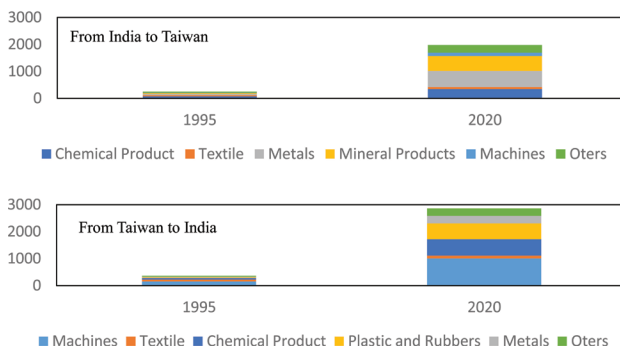
### 3.1.3. Current State of Collaboration between India and Taiwan

Compared to the bilateral relations between Japan and India, the economic relationship between India and Taiwan was relatively weak. However, exports from Taiwan to India have grown significantly in the 2000s. Looking at the share of export items from Taiwan to India over the past 20 years, it can be seen that the share of textiles has rapidly decreased, while the share of chemical products and plastics has increased (Figure 5).



**Figure 5:** Transition of Export Item Composition from Taiwan to India

Exports from Taiwan to India and from India to Taiwan are both increasing, and the main items are changing (Figure 6).



**Figure 6:** Export Item Composition between Taiwan and India

Taiwan has formulated and implemented a policy called the ‘New Southbound Policy’. This policy aims to strengthen and expand economic, cultural, and social ties with Southeast Asia, South Asia, Australia, and New Zealand. The policy emphasizes promoting trade and investment, encouraging tourism, and promoting academic and cultural exchanges between Taiwan and the target countries. Taiwan aims to build a new mutually beneficial cooperative relationship with these countries by sharing resources, talent, and markets. This is expected to create a sense of economic community and enable Taiwan to integrate more fully into the regional economy.

Taiwan has narrowed down the areas of cooperation with partner countries to four and is implementing a plan to build new economic trade partnerships through the export of infrastructure construction services, support for

Taiwanese SMEs to enter target countries, and financial assistance to Taiwanese companies. In addition, it aims to strengthen ties with the supply chains and domestic demand of target countries and cooperate on infrastructure projects. Secondly, Taiwan aims to share talent and complement the strengths of partner countries by expanding exchange and training programs for young scholars, students, and industry experts. This includes bilateral academic exchange programs, a New Southbound Talent Matching website, and an information platform for Taiwanese companies to register their businesses and search for talent. Thirdly, Taiwan aims to create opportunities for bilateral and multilateral cooperation by leveraging its soft power in culture, tourism, healthcare, technology, agriculture, and SMEs. The strategy includes promoting agricultural cooperation, increasing two-way tourism with other countries, and attracting residents of New Southbound countries to Taiwan to provide the highest quality healthcare. Finally, Taiwan aims to strengthen official and private exchanges, sign and renew trade agreements, institutionalize multilateral and bilateral cooperation with partner countries, and enhance negotiations and dialogue to improve regional connectivity.

In this context, Taiwan currently positions India as a promising frontier for business cooperation. As part of its efforts to build stronger relations, Taiwan is exploring various opportunities to engage with Indian companies and entrepreneurs, nurturing mutually beneficial partnerships, and aiming to promote economic growth for both sides.

### 3.2. Strengths and Challenges of Japan, India, and Taiwan

The strengths of Japanese companies have been found to align with their recent image. According to the 2022 JETRO Survey on the Actual Conditions of Japanese Companies Expanding Overseas (Asia and Oceania), Japanese companies are highly rated for their track record, product and service quality, brand, and after-sales service. However, many companies perceive weaknesses in pricing, marketing, and sales. In terms of logistics, many companies excel in delivery times, but there are challenges in business models within the manufacturing industry.

On the other hand, Taiwanese companies are renowned for their global reach and influence. These companies, which focus on innovative technology and high-quality manufacturing, are expanding their operations worldwide. Hon Hai (also known as Foxconn) is a global company operating in multiple countries, primarily in India. The company adopts a 3+3 strategy, dealing with three industries (electric vehicles, digital health, and robotics) and three technologies (artificial intelligence, semiconductors, and next-generation communication technologies). Hon Hai

offers two types of services: electronic manufacturing services for ICT customers and contract design and manufacturing services for EV customers. The company emphasizes collaboration with customers, local governments, and industries, adopting a BOL (Build, Operate, Localize) business model to create opportunities and ecosystems. It is expected that cooperation between Japanese and Taiwanese companies in India can enhance India's potential for digitalization and industrial transformation.

Japan and Taiwan have a long history of cooperation in the semiconductor industry. Taiwan is a crucial hub for semiconductor manufacturing, and Japan plays a significant role in the electronics industry. In building the semiconductor supply chain, Japan has certain expectations of Taiwan.

Taiwan is particularly renowned for its technical expertise in semiconductor manufacturing. Japanese companies actively seek partnerships with Taiwanese semiconductor manufacturers to access the latest technology and production capabilities. Japan expects Taiwan to continue pushing the boundaries of semiconductor innovation, helping Japanese companies maintain their competitiveness on the global stage. Thus, Taiwan is highly regarded for its expertise in semiconductor manufacturing technology, and Japanese companies frequently partner with Taiwanese semiconductor manufacturers to access their advanced technology and production capabilities. Japan expects Taiwan to continue advancing semiconductor technology, thereby helping Japanese companies maintain their international competitiveness.

In contrast, India is known for its capabilities in software development and digital transformation. By joining forces with Taiwan's semiconductor industry, it becomes possible to design innovative chips that meet the needs of emerging technologies such as 5G, artificial intelligence (AI), and the Internet of Things (IoT). This collaboration enables the development of more efficient and powerful semiconductor solutions.

However, there are some concerns regarding trilateral cooperation in the semiconductor field between India, Japan, and Taiwan.

One concern is the geopolitical risk in Taiwan. Hostile actions by China in the Taiwan Strait could disrupt the supply of semiconductors from Taiwan, potentially destabilizing the semiconductor supply chain.

Next is the issue of technology transfer. Vedanta Foxconn Semiconductors Limited (VFSL), a joint venture between Vedanta Group and Hon Hai Precision Industry, which is attracting attention as India's first semiconductor manufacturing project, is negotiating a technology partnership. However, there are said to be stumbling blocks regarding the scope of technology transfer, the duration of the joint venture, and the inclusion of sunset clauses.

There is also the issue of investment amounts. The JETRO report states, "VFSL submitted an estimated capital investment of \$10 billion to the Indian government, but the government considers this figure to be an overestimate and suggests that \$5 billion may be closer to the actual cost."

Concerns about these uncertainties could affect the progress of trilateral cooperation. Therefore, to promote trilateral cooperation, the Indian government needs to further advance:

- Infrastructure Development,
- Strengthening of Supporting Industries, and
- Improvement of the Business Environment.

#### **4. Strategic Significance of Industrial Cooperation in the Semiconductor Field among Japan, India, and Taiwan**

Today, the strengthening of the global supply chain for semiconductors has become a global issue. For this reason, the strategic importance of industrial cooperation in the semiconductor field among Japan, India, and Taiwan, which has developed from the bilateral cooperation between Japan and India, India and Taiwan, and Japan and Taiwan, is rapidly coming into focus.

Japan and India concluded a comprehensive economic partnership agreement in 2011, and in March 2022, Prime Minister Kishida appealed for the importance of merging the strengths of Japan's manufacturing industry and India's DX power. On the other hand, India, which wants semiconductor technology as a strategic material, and Taiwan, which positions India as a candidate for the transfer destination of the supply chain in place of China, are rapidly approaching each other as their interests coincide. In addition, Japan and Taiwan are developing close cooperation in the advanced semiconductor field, starting with the joint development of TSMC in Kumamoto.

Considering potential opportunities, Japanese companies are actively exploring investment options in India. Similarly, Taiwanese companies are considering entering the Indian market. And envisioning the collaboration of these two industrial sectors in India could potentially lead to mutually beneficial results.

In this chapter, the effects of leveraging each other's strengths and cooperating to draw out the great potential of this emerging market are examined.

##### *4.1. Strategic Significance of Industrial Cooperation in the Semiconductor Field among Japan, India, and Taiwan*

Japan has strong research and development capabilities in various fields, including semiconductors. By cooperating in



research and development projects related to semiconductor materials, manufacturing processes, and emerging technologies, it is expected to accelerate innovation in the semiconductor industry and create new products and technologies that can be applied beyond the technology field. In this regard, the collaboration of Taiwan's semiconductor manufacturing capabilities and India's expertise in digital transformation could potentially open up new markets not only in consumer electronics but also in healthcare, automotive, and industrial sectors. This partnership is expected to give birth to customized semiconductor solutions for these industries, leading to market expansion and economic growth.

Such inter-state cooperation leads to the exchange of knowledge and skills. For example, Taiwan can share its expertise in semiconductor manufacturing with Japan and India. Similarly, Japan can provide advanced manufacturing methods, and India can provide skills in digital transformation. This exchange of knowledge and skills is expected to enhance the capabilities and skill sets of the workforce in all three countries. These joint initiatives aim to reduce the environmental impact of semiconductor manufacturing by developing environmentally friendly materials, processes, and recycling methods. This is in line with the global trend towards green technology and responsible manufacturing.

With the cooperation of India, Japan, and Taiwan, these countries are expected to establish their position as leaders in semiconductor technology, become capable of joint competition with other global semiconductor majors, and be able to influence industry standards and policies.

Furthermore, the collaboration of Taiwan's semiconductor industry, Japan's manufacturing expertise, and India's digital transformation capabilities can create a powerful synergy. This partnership is expected to bring about innovative semiconductor manufacturing, market expansion, global leadership, and ultimately contribute to the development of fusion technology. This collaboration is also expected to enhance the competitiveness of these economies in the global technology industry.

As such, it is expected that promoting industrial cooperation in the semiconductor field among Japan, India, and Taiwan will promote technological innovation in the semiconductor field and improve global competitiveness. The innovations that are created in this process are not just improvements in integration and processing capabilities, but also the development of high-performance, energy-efficient semiconductor products through efforts to develop semiconductor technology, such as the introduction of finer process technologies and new materials. In addition, it is conceivable to improve the efficiency of the supply chain, which enables the efficient production process and

parts supply of semiconductors. In particular, as a concrete configuration of a resilient supply chain, it is possible to distribute the production bases and parts supply sources of semiconductors to multiple regions through cooperation among the three countries, which can disperse natural disasters and geopolitical risks. At that time, a mechanism that can flexibly adjust the production system is necessary, and at the same time, the resolution of quality control and safety assurance is required.

#### *4.2. Building a Global Semiconductor Supply Chain for Decarbonization*

In the context of global decarbonization, there are several areas where cooperation between India, Japan, and Taiwan can be extended to the Southern Hemisphere. Firstly, advanced semiconductor technologies developed by India, Japan, and Taiwan can be transferred to countries in the Southern Hemisphere. This transfer could enable these partners to transition to cleaner and more efficient technologies, thereby reducing carbon emissions. Secondly, the three partners can collaborate on capacity building in semiconductor production and usage in the Southern Hemisphere. This includes training programs, technical assistance, and the establishment of research and development centers. Additionally, the three partners can invest in the semiconductor industry in the Southern Hemisphere, stimulating economic growth and promoting the use of cleaner technologies. Furthermore, the three partners can work with the Southern Hemisphere to align policies related to semiconductors and decarbonization. This includes harmonizing standards, promoting best practices, and advocating for supportive policies at the international level.

However, achieving strategic and ambitious climate goals in the Southern Hemisphere requires an understanding of the economic impacts of decarbonization. The challenge of achieving ambitious climate goals and sustainable development cannot be addressed without significant efforts from the Southern Hemisphere. Decarbonizing energy systems requires substantial investment expenditures. Additionally, decarbonization leads to job losses in the fossil energy sector and job creation in the green sector. Therefore, careful planning and coordination are necessary to ensure that this cooperation benefits all stakeholders and contributes to global decarbonization goals.

### **5. Conclusion and Discussion**

Trilateral cooperation between India, Japan, and Taiwan can promote the transformation of energy and industry towards carbon neutrality. Semiconductors are particularly essential

for digitalization and decarbonization because, although the manufacturing process may consume a significant amount of energy, the resulting products and services are expected to greatly contribute to promoting carbon neutrality and socio-economic transformation.

International efforts towards decarbonization require the integrated advancement of energy-saving technologies, the adoption of renewable energy, technological development, and information sharing. In this regard, the incorporation of energy-saving technologies and renewable energy technologies in semiconductor manufacturing, as well as active technological development and information sharing for decarbonization, are expected to advance international cooperation. Currently, Japan's semiconductor industry focuses on in-house research and development activities, but there is room for more proactive engagement in building a global supply chain and technology transfer. Additionally, as a supporting industry for the semiconductor sector, it is necessary to establish information systems through DX and disseminate technology to local industries in the Global South, including India, which are more environmentally conscious.

On the other hand, Taiwan is expected to contribute to improving the precision, efficiency, and quality control of semiconductor manufacturing by cooperating with Japan's manufacturing expertise. Furthermore, cooperation with Japan and India is expected to diversify supply chains, accelerate innovation in the semiconductor industry, expand markets, and drive economic growth.

As described above, Taiwan can share its expertise in semiconductor manufacturing with Japan and India, Japan can contribute with advanced manufacturing technologies, and India can provide DX skills, enabling the partners to complement each other's technological gaps. Particularly, Japan, currently experiencing significant economic stagnation, needs to strengthen its manufacturing capabilities, including the semiconductor industry and its supporting industries, towards decarbonization. Spreading Japan's manufacturing capabilities to the Global South, starting with India, is an urgent task for Japan's next-generation technology management. The participation and contribution of Japanese companies to Taiwan's semiconductor industry model for India, utilizing India's DX capabilities, are expected to help address these challenges.

This paper focuses on the impact of international cooperation between Japan, Taiwan, and India on decarbonization, with a focus on the semiconductor industry. India has the potential to play a leading role in building a global semiconductor supply chain. Japan and Taiwan are considered optimal partners in this endeavor. Japan's semiconductor industry, with its high technology, requires strengthening the global supply

chain and technology transfer, making collaboration with India beneficial. Taiwan, actively expanding into India, can improve the quality and efficiency of semiconductor manufacturing through cooperation with Japan, forming diverse supply chains and accelerating innovation. Japan contributes with manufacturing technology, and India provides DX skills, aiming for mutual complementarity. This cooperation is expected to enhance manufacturing capabilities focused on decarbonization, contributing to international decarbonization efforts and technological progress as global next-generation technology management.

In the future, it is necessary to conduct more specific case studies and make recommendations on the efforts of the Global South related to semiconductors and decarbonization, with a perspective of expanding cooperation between India, Japan, and Taiwan to the Southern Hemisphere in the context of global decarbonization.

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