Taiwan—The Silicon Island

Lin Jones and Sarah Krulikowski, Office of Economics

This executive briefing provides information on the recent developments in the Taiwanese semiconductor industry. Taiwan achieved a prominent role in the global semiconductor industry by providing contract manufacturing services to third-party customers, capturing nearly 70 percent of global foundry revenue in recent years. With output almost doubling during 2018–22, the rapid growth of Taiwan's semiconductor industry is important to its economy and trade. Although Taiwan's government has implemented proactive policies to promote and strengthen the industry, Taiwan's semiconductor industry faces multiple vulnerabilities, such as natural disasters (e.g., typhoons and earthquakes), risks related to reliability and sustainability of energy and water supply, as well as potential regional geopolitical threats.

Taiwan is one of the key players in the global semiconductor industry. Taiwan—a small island of 35,980 square kilometers and separated from the Chinese mainland by the Taiwan Strait—has emerged as one of the leaders in the global semiconductor industry, which earned it the nickname of "the Silicon Island." In 2021, Taiwan captured an estimated 10 percent of total value created in the global semiconductor industry. It accounted for roughly 21 percent of global semiconductor manufacturing capacity, including 92 percent of manufacturing capacity for the most advanced chips. Taiwan has achieved this prominent role primarily through its foundries—providing contract manufacturing services to other companies. Taiwan is home to four of the world's top ten foundries, including Taiwan Semiconductor Manufacturing Company (TSMC), the largest foundry in the world. They jointly accounted for nearly 70 percent of global foundry revenue in the first quarter of 2023.

As the pillar of Taiwan's economy, the semiconductor industry has been growing rapidly. The semiconductor industry accounted for 13–15 percent of Taiwan's gross domestic product (GDP) in recent years. Between 2018 and 2022, the output of Taiwan's semiconductor industry, measured in gross terms, nearly doubled from $87.0 billion to $162.5 billion (Table 1). Within the semiconductor industry, "manufacturing" was the largest segment, producing 60 percent of Taiwan's semiconductor output in 2022. "Design" was the second largest segment with 25 percent. These two segments also recorded the largest growth in output—over 90 percent increase during 2018–22.

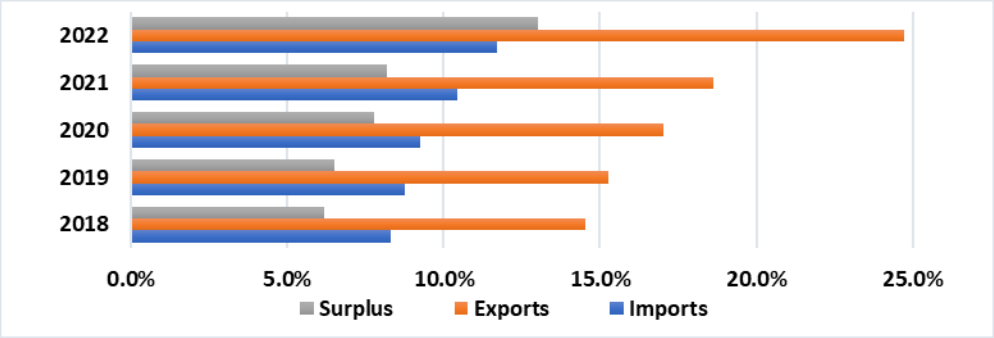
Table 1 Taiwan semiconductor industry outputs by segment, billions of dollars and percentage, 2018–22

Segment	2018	2019	2020	2021	2022	2018–22 percentage change (%)
Design	21.3	22.4	29.0	43.5	41.4	94.4
Manufacturing, including:	49.3	47.7	61.9	79.8	98.1	98.9
Foundry	42.7	42.5	55.4	69.5	90.2	111.4
Memory and other	6.7	5.2	6.5	10.3	7.9	18.9
Packaging	11.4	11.2	12.8	15.6	15.7	36.9
Testing	4.9	5.0	5.8	7.3	7.3	49.0
Total industry output	87.0	86.4	109.6	146.1	162.5	86.8

Source: Taiwan Semiconductor Industry Association, Newsletter 112.04.06, February 15, 2023. Note: Authors converted from New Taiwan dollar to U.S. dollar using annual average exchange rates. "IC manufacturing" includes two sub-segments: "foundry" and "memory and other."

Semiconductors are Taiwan's top traded merchandise and China is Taiwan's largest trading partner. In 2022, Taiwan exported $184 billion of semiconductors (HS 8542), accounting for 38.4 percent of its total merchandise exports. China and Hong Kong were the top destinations, together receiving 58.0 percent of Taiwan semiconductor exports, followed by Singapore and Japan with 11.1 and 8.5 percent, respectively. In the same year, Taiwan imported $88 billion of semiconductors, accounting for 20.6 percent of its total merchandise imports. China was the top source, providing 24.4 percent of Taiwan semiconductor imports, followed by South Korea at 22.0 percent. During 2018–22, Taiwan's semiconductor trade grew from 22.9 percent of GDP in 2018 to 36.4 percent of GDP in 2022, and its semiconductor trade surplus increased from 6.2 percent of GDP to 13.0 percent during this period (Figure 1).

Figure 1 Taiwan semiconductor exports, imports, and trade surplus as a share of GDP, 2018–22



Source: Taiwan Semiconductor Industry Association data retrieved via Statista, accessed 10/17/2023; IMF, "World Economic Outlook" database (October 2023), accessed 10/17/2023.

Taiwan has implemented proactive policies to promote and strengthen its semiconductor industry. Over the years, Taiwan's government has implemented several key policies to promote and strengthen its semiconductor industry, including the three described below. 1) Investing in research and development (R&D): agencies like the Ministry of Science and Technology and the Ministry of Economic Affairs have provided substantial funding and incentives (e.g., tax credits) to support semiconductor-related R&D activities. 2) Fostering collaboration between industry and academia: Taiwan encouraged the partnerships between semiconductor manufacturers and research institutions such as National Tsing Hua University and National Chiao Tung University to drive innovation and knowledge sharing. 3) Creating a conducive ecosystem: Taiwan established science parks (e.g., the Hsinchu Science Park) to create industrial clusters and synergy, providing infrastructure, regulatory support, and access to talent. These policies have helped Taiwan to maintain the leading edge in the global semiconductor industry.

Taiwan's semiconductor industry faces multiple vulnerabilities. Global reliance on Taiwan for semiconductor manufacturing heightens its geopolitical and economic importance. However, Taiwan's semiconductor industry faces multiple vulnerabilities. Given its location and geology, Taiwan is prone to natural disasters such as typhoons and earthquakes. Taiwan has had 96 catastrophic earthquakes since 1900. A magnitude 7.6 earthquake in 1999 caused an economic loss of $10 billion. Each year Taiwan experiences an average of 3.5 typhoons and dozens of torrential rainstorms with an estimated economic loss of $410 million. Taiwan also faces constraints relating to energy and water supply, as semiconductor manufacturing is resource intensive. Wafer fabrication uses a substantial amount of energy—as much as 100 megawatts per hour in a large factory—to power equipment, perform various chemical processes, and maintain a stable, clean production environment. It also consumes a large quantity of water in the process—to create an integrated circuit on a 30cm wafer requires an estimated 2,200 gallons of water. Geopolitical tensions in the region, including China-Taiwan relations, pose additional risks. Recognizing these vulnerabilities, the United States has stepped up the effort, including enacting the CHIPS and Science Act of 2022, to build resilience in semiconductor supply chain and boost domestic semiconductor production capacity.

Sources: CRS, *Semiconductors and the Semiconductor Industry*, April 19, 2023; CWR, "8 Things You Should Know About Water & Semiconductors," July 11, 2013; Government of Taiwan, Ministry of Finance, "Trade Statistics database," accessed October 17, 2023; IMF, "World Economic Outlook database (October 2023), accessed October 17, 2023; Government of Taiwan, International Trade Administration, "Trade Statistics," accessed October 17, 2023; Taiwan Semiconductor Industry Association, Newsletter 112.04.06, February 15, 2023; Jones et al. "U.S. Exposure to The Taiwan Semiconductor Industry," November 2023; Jones and Lotze, "Recent Development in Global Semiconductor Industry," November 2023; McKinsey, "Bring energy efficiency to the fab," accessed November 6, 2023; Jacono, "What the US Can Learn From Taiwan's Success," March 16, 2023; NAP, *Securing the Future: Regional and National Programs*, 2003; BCG and SIA, *Strengthening the Global Semiconductor Supply Chain*, April 2021, 35; TrendForce, "Top 10 Foundries Report Nearly 20% QoQ," June 12, 2023; Central Weather Administration, Seismological Center, "What is the frequency of earthquake occurrence in Taiwan?" accessed September 11, 2023; Feng, "Epic drought in Taiwan pits farmers against," April 19, 2023; Li, "Taiwan Braces for Drought in Key Chip Hubs Again," March 24, 2023; CIA, "The World Factbook: Taiwan," accessed November 20, 2023; EPRI, *Investigation of the 1999 Chi Chi Taiwan Earthquake*, 2001; Kuo et al., "Are the Rich Less Prone to Flooding?" February 9, 2022.