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Commentary

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Taiwan is an ideal partner for Canada in the semiconductor sector

Matthew Fulco

Canada and Taiwan have long had a robust commercial relationship. Taiwan is Canada's 15th largest trading partner, while Ottawa is Taipei's 24th largest. In 2020, total bilateral trade between the two countries was US$5.53 billion, according to data compiled by the Taipei Economic and Cultural Office in Canada (TECO 2021).

Integrated circuits (ICs) are the No. 3 Taiwanese export to Canada (TECO 2021), while Taiwan Semiconductor Manufacturing Company (TSMC), the world's largest contract chipmaker, has a design centre in Ottawa that plays a key role in global research and development (R&D) efforts. As Canada moves to develop its domestic semiconductor industry and grow its presence in global supply chains, it should build on existing ties with Taiwan's chipmakers.

Taiwan is the world's preeminent manufacturer of semiconductors, accounting for more than 60 percent of global foundry revenue in 2020. Driving that dominance is TSMC, which held 53 percent of the global foundry market in the third quarter of 2021, according to Taipei-based research firm TrendForce (2021b). Other Taiwanese chipmakers among the world's leading foundries include United Microelectronics Corporation (UMC), which had a 7.3 percent share of the global foundry market in the third quarter, PowerChip Semiconductor Manufacturing (PSMC), which had a 1.9 percent

share, and Vanguard International Semiconductor, which had a 1.5 percent share (TrendForce 2021b). No other country has as many foundries in the top 10.

Taiwan is also a major player in IC design. In the second quarter (the most recent for which data are available), MediaTek, best known for its smartphone chips, was the world's No. 4 chip designer by revenue while Novatek was No. 6 and Realtek No. 9, according to TrendForce (2021a). Only the United States has more top 10 IC designers than Taiwan.

TSMC has special systemic importance in global supply chains because of its near monopoly on the most advanced chips – 10 nanometres (nm) and smaller in size. TSMC has mastered producing ever smaller and powerful chips that use less energy. These chips are used in everything from Apple (TSMC's largest customer) smartphones and artificial intelligence to high-performance computing and automobiles. In 2020, TSMC had a market share of about 85 percent, dwarfing that of South Korea's Samsung (about 15 percent), the only other producer of these advanced chips (Olcott 2021).

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TSMC has long been a household name within the technology hardware industry, but it was less well known otherwise – at least until a pandemic-induced chip supply crunch struck in 2020, which highlighted the company's importance as a supplier of automotive semiconductors. While the supply shortage has affected many industries, the auto sector has been hit especially hard. In ordinary times, chipmakers do not necessarily prioritize semiconductors for the auto industry because they must be built more robustly than those used in consumer electronic devices and thus have lower margins. As the pandemic has disrupted global supply chains, the auto industry has struggled to secure a stable chip supply. Assembly lines have been shut down and some vehicles are being shipped without chip-dependent features.

Amid growing calls for help from the US, Japan and Germany (the world's largest auto economies), TSMC said in May that it would take "unprecedented actions" to boost production of automotive microcontroller units (MCUs) by 60 percent this year, a 30 percent increase over the pre-COVID level (Wang 2021). TSMC is a major supplier to most major auto chip developers, among them Infineon, NXP, Sony and Renesas Electronics. MCUs are integral for the function of many car parts, including lighting systems, tire pressure monitors and motor controls.

For Canada, the automotive chip shortage has been especially painful given the importance of the auto industry to the country's economy. The auto sector is one of the largest of Canada's manufacturing industries, contributing $12.5 billion to GDP in 2020, according to data compiled by the Canadian government. The auto sector directly employs more than 117,200 people. Aftermarket services and dealership networks employ an additional 371,400. Globally, Canada is also a key player in the auto sector. It is one of the world's top 12 producers of light vehicles. The leading OEMs (original equipment manufacturers) Stellantis, Ford, GM, Honda and Toyota assemble more than 1.4 million vehicles annually in Canada. Canada's own Magna, Linamar and Martinrea are also top global auto parts suppliers (Government of Canada 2021b).

Amid the chip supply crunch, auto production in Canada in the 12 months to July 2021 fell 6.6 percent. That puts Canada on track to produce 1.2 million vehicles in 2021, down from the already low figure of 1.4 million in 2020 and just more than half of the yearly average in the decade to 2019, according to Scotiabank Economics. Auto production in Canada has not been this low since the nadir of 1982, when the country was hit by a deep recession, an oil crisis and increasing global competition (Bickis 2021).

Geopolitical and national security significance

The ongoing automotive chip shortage shows how a stable semiconductor supply is crucial for Canada's economic well-being, but ICs also have important geopolitical and national security value. Indeed, such considerations drove TSMC's decision to build a US$12 billion fabrication plant (or fab) in Phoenix, Arizona, the largest foreign investment by a Taiwanese company in eight years. From 2024, the plant will mass-produce chips made on TSMC's advanced 5-nanometre process. The facility is likely to create 1900 full-time jobs.

TSMC's investment resulted from the Trump administration's efforts to bring home high-end manufacturing for national-security reasons. TSMC is a key supplier to the US military; for instance, it provides chips for use in advanced fighter jets. Semiconductors have a broad array of defence and aerospace applications, from radars and jammers to signals intelligence, military communications and space capabilities.

In a November article in *The Diplomat*, Project 2049 Institute's Eric Lee (2021) put it bluntly: "Taiwan provides the steel in the spine for the U.S. defense industrial complex." Indeed, Taiwan has a dominant market share in gallium arsenide (GaAs) chips, the semiconductors most commonly used in military-specific applications. Led by WIN Semiconductors with a 79 percent market share, three Taiwanese manufacturers account for 90 percent of GaAs

foundry revenue (Lee 2021).

To be sure, Canada has a smaller need for semiconductors in defence applications than the US. But as market democracies move to work more closely together to build a clean semiconductor supply chain – free of components sourced from China – Canada should consider the role it can play. Of course, this would necessitate Canada first developing a more robust semiconductor ecosystem at home.

In "The Roadmap to 2050: Canada's Semiconductor Action Plan," published by Canada's newly formed Semiconductor Council, Tony Pialis, co-founder and CEO of Alphawave IP Group, notes that Western democracies are increasingly investing to bring semiconductor manufacturing onshore to give them better control over their supply chain. Yet, "there's not a peep coming out of Canada on this. It's a barrier" (Canada's Semiconductor Council 2021).

Ron Glibbery, founder and CEO of Peraso Technologies, says in the report, "The potential crisis for Canada is a situation where semiconductors become a national security issue. From a manufacturing perspective, we have minimal infrastructure to support that" (ibid.).

Canada's Semiconductor Council recommends that Canada focus on four key areas to enhance its competitiveness as a destination for the chipmaking industry: strengthen and diversify the supply chain, develop onshore manufacturing, establish a unique specialization and brand for Canada, and foster innovation and support market development.

Making the case for a chipmaking foray, Sarah Prevette, Chair of Canada's Semiconductor Council and CEO of the Future Design School, said in the report, "Canada has homegrown STEM talent, access to critical raw materials, and a strong foundation in research, innovation, and design" (ibid.).

Cultivating a rare earths niche

One way for Canada to both develop a stronger semiconductor industry at home and increase its importance in the global supply chain would be to tap its vast rare earth resources and reserves. Rare earth elements (REEs) are a group of 17 elements that are difficult to find and mine in most parts of the world. They include cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, promethium, samarium, scandium, terbium, thulium, ytterbium and yttrium. Canada has an estimated 15 million tons of rare earth oxides, among the most of any country globally (Government of Canada 2021a). The paramount use for rare earth elements is the manufacturing of magnets for mobile phones, computers, wind turbines and electric vehicles, according to Natural Resources Canada. REEs also have military applications, such as the guidance systems and sensors of missiles.

At present, China is the world's dominant rare earths player. It controls more than 80 percent of global output (National Bureau of Asian Research 2019), holds 36.7 percent of all deposits (Middendorf II 2021), and has a monopoly on separation of REEs built up over two decades. Beijing controls most of the world's processing facilities, to the extent that REEs extracted elsewhere still often must be sent to China for refining. For instance, since the US lacks refining capacity, ores it mines must be refined in China. One reason China has been able to dominate refining is that it is less concerned with the environmental impact than other countries.

The risks of reliance on China for rare earths became apparent as early as 2010, when due to an incident that occurred near the Senkaku Islands in the East China Sea – administrated by Japan but also claimed by China – Beijing blocked rare earth exports to Japan, which was then the largest buyer of Chinese rare earths. The export ban was de facto and administrative; China made no official proclamation but simply prevented the minerals from being loaded on ships bound for Japan. Thus, although Beijing's actions violated free trade rules, Tokyo was unable to file a complaint with the World Trade Organization (WTO).

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China's weaponization of its rare earths monopoly has had far-reaching repercussions. Market democracies, notably the United States and Japan, soon thereafter began working to reduce their reliance on China for the crucial minerals. However, given China's near stranglehold over the industry, results have been mixed at best.

Meanwhile, as Sino-US relations deteriorate, Beijing has reportedly mulled restricting rare earth exports to the US. In February, China's Ministry of Industry and Information Technology proposed draft controls on the production and export of 17 rare earth minerals. While nothing concrete has yet come to pass, China is clearly eyeing the importance of REEs to the US defence industry. For instance, rare earths are integral to the function of the electrical power systems and magnets of Lockheed Martin's F-35 fighter jets. Each aircraft requires 417 kilograms of rare-earth minerals, according to a Congressional Research Service report (Yu and Sevastopulo 2021).

Given China's rising aggression, it is time for market democracies to diversify their rare-earths suppliers. As a trusted partner of the US, Taiwan, Japan and other key semiconductor-producing nations, Canada has an opportunity to be at the forefront of a new, secure supply chain. Ottawa has already made progress in that endeavour with the establishment of the first Canadian REE processing facility in Saskatoon. First announced in August 2020, the $31 mil-

lion facility will be financed by the province of Saskatchewan, while owned and operated by the Saskatchewan Research Council (SRC). It should be fully operational by late 2022.

The REE processing plant could turn out to be significant indeed as there is just one other like it in North America. Located in California, that facility is only operational when the mine it is associated with in California is operating. In contrast, the Saskatoon processing plant currently faces no such constraints. In July, Canada's first rare earths mining project launched at Nechalacho mine, about 110 kilometres southeast of Yellowknife. The mine will focus on extracting minerals for use in technology manufacturing. Unlike mines in China, the Canadian mine will be environmentally friendly. It will not use any chemicals and there will be no tailings, e.g., residues that may contain harmful quantities of toxic substances.

Enhancing cooperation with Taiwan

As Canada moves to play a larger role in the global semiconductor industry, Taiwan is a natural partner. In fact, TSMC has a design centre in Ottawa's Kanata high-tech region that focuses on creating foundation intellectual property on TSMC's next-generation processes. TSMC Design Technology Canada works with other TSMC R&D groups around the world, including in Taiwan, Japan and the US.

"We are looking to continue to grow the current talents we have, which are in memory design and custom layout," Cormac O'Connell, director of TSMC's new design centre, said in a February post on the Invest Ottawa blog. The design centre had 20 employees when it launched in August 2007 and has since tripled in size to 60. With Ottawa's strengths as a tech hub and Canada's burgeoning semiconductor ambitions, there is potential for the design centre to grow much larger.

Given its dominance in the foundry segment, TSMC could potentially play a large role in helping Canada develop its semiconductor manufacturing capability. No other chipmaker is as accomplished in fabless wafer manufacturing. It is for this reason that the US and Japan both have lobbied TSMC hard to build chipmaking facilities on their respective territory. Germany is the latest market democracy to court TSMC. In September, Jorg Polste, director-general of the German Institute Taipei, said that Germany welcomes TSMC to establish a new fab in Saxony.

The US, Japan and Germany have several things in common that make them attractive to TSMC. All three countries have a strong industrial base, and are home to key TSMC customers. TSMC's biggest customer, Apple, is American. TSMC also has important American clients in the defence sector. Sony is another major TSMC customer and will invest together with the Taiwanese

chipmaking giant to build a US$8.8 billion fab in Japan. While TSMC has yet to confirm plans to build a fab in Germany, the European country is home to key customers such as chip designer Infineon Technologies and automakers Volkswagen and Daimler, whose electronics suppliers rely on the Taiwanese chipmaker.

Even so, due to the costs involved, it was not easy to persuade TSMC to set up shop outside of its home base of Taiwan, or China, where it has facilities specifically for its Chinese customers. In the case of the Arizona fab, local governments ultimately provided generous incentives to the Taiwanese chipmaker, including US$200 million to develop roads, sewers and other infrastructure. TSMC also will likely benefit from subsidies available under the Biden administration's US$50 billion semiconductor investment plan. For its part, the Japanese government plans to subsidize roughly one-half of TSMC's US$8.8 billion Kumamoto fab.

If Canada were interested in attracting TSMC, it would need to offer significant financial support. It would thus be worth considering setting up a national semiconductor development fund from which it could draw funding. Without robust government support, the Taiwanese chipmaker would not have a compelling reason to invest big in Canada even though other conditions important for semiconductor fabrication are excellent; for instance, Canada has

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a strong talent base, ample water supply and advanced infrastructure.

Canada's Semiconductor Council notes that Canada can leverage its participation in the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) for the purposes of its chipmaking ambitions. The Council suggests that Canada work with Japan, Malaysia and Singapore, who are all part of the pact. This advice is reasonable. Yet none of those countries is anywhere near as important a player in semiconductors as Taiwan.

With that in mind, Ottawa should fully support Taiwan's bid to join CPTPP while not losing sleep over China's feelings on the matter. Although China has also applied to join the pact, its market barriers make its prospects of joining CPTPP remote. At the same time, Beijing's relations with CPTPP members Canada, Australia and Japan are strained. While China has finally freed Michael Kovrig and Michael Spavor, their nearly three-year detention on questionable charges has damaged Beijing's reputation in Canada, perhaps irreparably. Beijing has also slapped economic sanctions on Australia due to its push for an independent inquiry into the origins of COVID-19 and continues

to routinely send ships and planes into Japan's respective waters and airspace to enforce its territorial claims, despite Tokyo's protests. Such bellicose behaviour should disqualify China from CPTPP membership if other things do not.

In contrast to China, Taiwan is an open market economy and vibrant democracy that has spent considerable time preparing its application and is prepared to meet all requirements. If it is able to join CPTPP, it will be a win for both Taiwan and Canada.

Canada and Taiwan would also benefit from expanding broader bilateral economic ties. To that end, the January 10 announcement that the two countries plan to initiate preliminary discussions about a Foreign Investment Promotion and Protection Arrangement (FIPA) is welcome, especially as the idea dates back to 2018.

According to the Canadian government's readout of the conversation between Mary Ng, Minister of International Trade, Export Promotion, Small Business and Economic Development and Taiwan's Minister Without Portfolio John Deng, in which the FIPA was mentioned, Ng "emphasized Canada's commitment to inclusive trade, ensuring that trade and investment agreements benefit all, including women, Indigenous peoples, small business owners and underrepresented communities" (Government of Canada 2022).

About the author

Matthew Fulco is a Taipei-based journalist who focuses on the transformative effect of technology on Asian economies and its intersection with geopolitics. His reporting work covers technology hardware supply chains, financial technology, internet companies and defense. He is a regular contributor to the Economist Intelligence Unit, *Taiwan Business TOPICS* and *The Taiwan Banker* and has also written for Nikkei Asia and CNET. Matthew holds a Master of International Affairs (MIA) from the School of International and Public Affairs (SIPA) at Columbia University and a BA in History from Kenyon College. He speaks Mandarin Chinese and French.

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