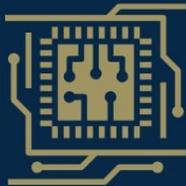


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Friend-shoring in the Indo-Pacific



BY AKHIL RAMESH
& ROB YORK





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Friendshoring in the Indo-Pacific

By
Akhil Ramesh & Rob York

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Friend-shoring in the Indo-Pacific

The COVID-19 pandemic and Russia's invasion of Ukraine highlight the challenges of increased economic interconnectedness with adversarial states. The shortages in critical sectors such as pharmaceuticals, semiconductors, and other industries significant for technological advancement in the fourth industrial revolution have revealed the importance of select supply chains to the American public and the broader global community. As the strategic competition between the US and China accelerates, understanding of their importance will only grow.

The Biden administration, to its credit, realized early on the importance of four critical sectors for the future of US supply chain security: pharmaceuticals, critical minerals, large-scale batteries, and semiconductors. Alarmingly, through the research presented here by Akhil Ramesh and myself, we see that the People's Republic of China has deeply embedded itself in three of these four sectors, and still seeks to strengthen its position in the fourth (semiconductors). Also, one of the recurring problems highlighted in this research is the tendency of the administration to consider the job done once it sources a critical technology from somewhere other than China—not realizing that the PRC serves as a source for that country elsewhere in the supply chain.

A deeper set of solutions to this problem is required. The United States cannot onshore each of these products and services—it simply does not have all of the natural resources required. That is why the concept of “friend-shoring” is essential. In these papers, we identify alternative markets for all four sectors the US can support:

- For pharmaceuticals—India
- For critical minerals—Australia, Canada, and Chile
- For electric vehicle batteries—Japan and South Korea
- For semiconductors—Japan, Malaysia, and South Korea, as well as taking steps to increase domestic production.

We are indebted to the Hinrich Foundation for their support for this research, and for publishing the first versions of each of these papers earlier in 2023:

- Friend-shoring pharmaceutical supply chains: The road to India, on Feb. 21
- Friend-shoring critical mineral supply chains, on April 4
- Friend-shoring battery supply chains, on June 20, and
- De-risking semiconductor supply chains on Sept. 26

Through them, we hope that a clearer picture of the challenge ahead has emerged, as well as the necessary steps to meet them.

Rob York
Director of Regional Affairs, Pacific Forum

1

Friend-shoring pharmaceutical supply chains: The road to India

BY AKHIL RAMESH AND
ROB YORK



Executive Summary

Akhil Ramesh and Rob York

In March 2022, iodinated contrast media chemicals used in medical X-rays were in short supply globally. China primarily makes these chemicals, but production was crimped due to Covid-related lockdowns across the nation.

A key compound for the chemical, iohexol, is made in a single factory in Shanghai. That plant shut down, resulting in an 80% reduction in global supplies. As a result, facilities across the US had to postpone the bulk of their computerized tomography, or CT, scans.

As the world economy emerges from the Covid-19 pandemic, national leaders no longer appear convinced of the wisdom of free trade, especially when it results in the concentration of crucial supply chains of vital industries in certain geopolitically risky geographies. Among US officials “friend-shoring” – supporting the development of supply chains in friendly nations – has emerged as an strategic pivot away from the costs and perceived drawbacks to both unrestricted foreign investment and “onshoring” industries. Pharmaceuticals, a sector of the economy whose importance was reinforced by the pandemic, represents a strong candidate given the Indian economy’s recent liberalization measures, the growing partnership between New Delhi and Washington, and India’s status as the “pharmacy of the world.” India’s domestic industry faces challenges, however, over its lax regulatory oversight, its dependency on China for components, and issues arising from environmental damage associated with their manufacture. This paper assesses that if US were to friend-shore the pharmaceutical supply chain to India, Delhi would bring greater accountability to its pharmaceutical industry, by holding companies whose drugs have not met appropriate standards accountable in court – much as it has done in other sectors – while also stepping up monitoring of subsidies to prevent inefficiency. It further recommends that the US take advantage of its status as the world’s largest pharmaceuticals market, working with partners and other large markets such as Japan, and France to coordinate the supply chain diversification process.

Introduction

The term “friend-shoring” has come into popular parlance recently as nations and businesses become aware of supply chain vulnerabilities exposed by the Covid-19 pandemic and the Russia-Ukraine conflict among other major geopolitical disruptions. “Reshoring” or “onshoring” – working to restore domestic industries once sent abroad – have been actively considered in sectors such as automobiles, semiconductors, renewable energy production, and even mining due to the rise of populism around the world. However, discussions on not just reshoring but “friend-shoring” – to move sourcing and manufacturing sites to the shores of allies and partners – in sectors such as active pharmaceutical ingredient (API) manufacturing and pharmaceuticals predate the pandemic and the rise of populism. The once-in-a-century pandemic, along with the rise of populism, increased awareness surrounding the risks associated with geographical concentration of supply chains in industries vital for national security.

In the case of APIs and pharmaceuticals, many viewed the risks associated with a highly geographically concentrated in a geopolitically risky region as a highly probable “Grey Rhino” future event rather than a rare Black Swan. Industry stalwarts and regulatory bodies in the Western world – such as the Centers for Disease Control and Prevention (CDC) and the Food and Drug Administration (FDA) in the US – and multilateral organizations such as the World Bank have sounded the alarm for more than a decade over the risks associated with the geographical concentration of supply chains.¹ The pandemic and associated geopolitical rifts provided the impetus for governments to act on the challenge.



The pandemic, along with the rise of populism, increased awareness surrounding the risks associated with geographical concentration of supply chains in industries vital for national security.

Emergencies such as a pandemic or biological warfare could create demand for products known as medical countermeasures (MCMs) as an immediate response. The US houses 11% of API sites for biological MCMs, 29% of chemical MCMs, 11% of influenza MCMs, and 46% of radiation MCMs. Tomorrow, were Americans to be exposed to harmful radiation through an event such as nuclear attack, the US government would have sufficient stockpiles to immediately address the crisis. However, it does not house adequate API manufacturing sites for the countermeasures needed to address biological or chemical warfare, or even influenza on a massive scale. Covid-19 brought to light this stark reality for policymakers in Washington as they scrambled for supplies of hydroxychloroquine, a drug historically prescribed for treating malaria but which gained new relevance as an experimental treatment option for the Covid-19 virus. At the height of the pandemic, the Trump administration had to pressure the Indian government to release its supply of hydroxychloroquine. Scientists have yet to conclusively prove the drug’s efficacy in preventing or treating Covid.

Supporting partners through friend-shoring can assist in preventing such thorny diplomatic situations and create resilient supply chains in the process. Around 72% of registered API facilities supplying the US market are overseas. This poses the biggest challenge to building a resilient supply chain for the US. While the European Union is home to around 26% of the world’s API facilities, it has a cost disadvantage of 30-40% compared to states such as

¹ <https://www.fda.gov/news-events/congressional-testimony/safeguardingpharmaceutical-supply-chains-global-economy-10302019>

India and over 50% to China. In the pharmaceutical value chain, APIs can make up around 40% of the total cost, so a significant jump in API prices will likely lead to inflated drug prices in the US. India houses 18% of global API manufacturing facilities² and offers a price advantage of an estimated 30-40% over its Western peers through lower labor and input costs, making it an attractive destination to site pharmaceutical products. Sometimes nicknamed the “pharmacy of the world”, India is the largest producer of generic drugs, exporting roughly 20% of total generics.

Over 40% of generics in America originate in India.³ At the height of the pandemic, India was able to leverage the indigenous Serum Institute of India, the world’s largest vaccine manufacturer, both for its own billion-plus population and for the world. Such comparative advantages make India the strongest friendly-shore contender to reduce reliance on China and diversify supply chains.

Nonetheless, India’s dominance in the pharmaceutical field has Chinese sources. India imports around 50% of its pharmaceutical sector’s annual demand from abroad, and, of that, 68% is from China.⁴ The number is as high as 90% in certain APIs used in antibiotics. Despite India’s large global

share of API facilities, both the raw chemicals that go into them and APIs for several generics such as penicillin G and streptomycin are sourced from China.⁵

India’s reliance on China is acute in APIs that require fermentation, such as penicillin G, amoxicillin, and tetracycline, which are used as base chemicals for most antibiotics. To complicate the issue, even the 50% of APIs manufactured in India require key starting materials (KSM) for APIs such as caffeine, chloramphenicol, azithromycin, and sulfadoxine that need to be sourced from China. The Indian government has over the last two years taken several measures and enacted policy reforms to address the issue. This paper will explore the opportunities, complex challenges, and measures taken by governments in response them, as well as offer policy recommendations for success.

Supply Chain Mapping

The authors’ interview with supply chain risk consulting firm Resilinc revealed that North America experienced the most supply chain disruptions in 2021 (3,645), followed by Europe (1,247), and Asia (719). Asia experienced the least number of supply chain disruptions, even during Covid-19 lockdowns.

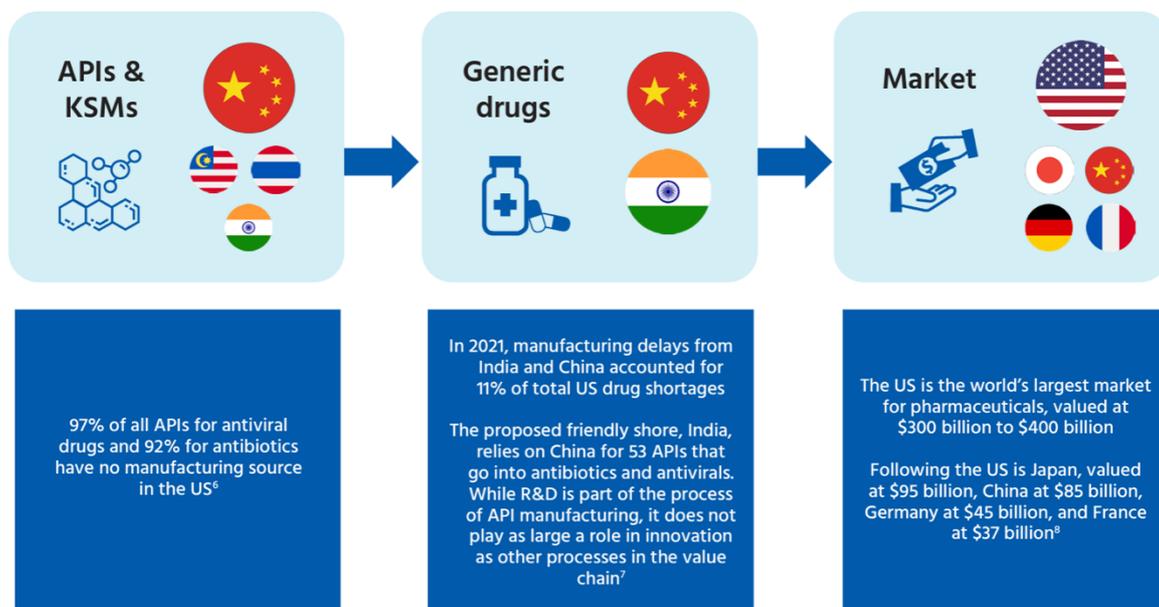


Figure 1. Major developments affecting the pharmaceutical supply chain. Source: Author’s compilation.

² <https://www.fda.gov/news-events/congressional-testimony/safeguarding-pharmaceutical-supply-chains-global-economy-10302019>

³ <https://www.deccanchronicle.com/business/in-other-news/210720/india-seeks-concession-from-us-for-generic-drugs-export.html>

⁴ <https://www.cnbc.com/2022/05/27/india-needs-to-fill-china-gaps-to-become-the-pharmacy-of-the-world.html>

⁵ <https://www.pwc.in/assets/pdfs/industries/pharmaceuticals-and-life-sciences/reviving-indias-api-industry.pdf>

Disruptions in Asia caused chaos and challenges for the end-consumer worldwide.

Opportunities for Friend-Shoring

Foreign Relations and the Geopolitical Environment

Geopolitics and foreign relations play a central role in diversifying supply chains as friend-shoring boils down to the nation's political structure and relations with the rest of the world. The US and India have not had any major conflict and, besides policy divergences over Russia and Pakistan, both democracies have fostered solid diplomatic relations over the last 75 years. In fact, over the last two decades the two nations have expanded the relationship's scope, historically grounded in information technology trade and the Indian diaspora to include defense and security.⁶ The historically non-aligned India has expanded its defense and security partnership with the US from Hawaii to the Himalayas, participating in naval exercises in the Pacific and army exercises at the India-China border. Diplomats have avoided any explicit language targeting China, yet most foreign and security policy analysts concur that these military exercises are convened to plan for a conflict with China.

Moreover, while neither openly classify groupings such as the Quadrilateral Security Dialogue ("Quad") as an anti-China alliance, the geo-economic components of the grouping indicate that there is a concerted effort to use tools of economic statecraft to limit China's growth in Asia and its ability to weaponize interdependence through acts of economic coercion. Policy divergences remain, both US and India share concerns over China's expansionism. US Treasury Secretary Janet Yellen, in a trip to New Delhi in late 2022, highlighted these concerns by referring to India as a "friendly shore" for supply chain diversification.⁷

Macro-Economic & Political Environment

India has been on a steady path of economic reforms since its implementation of liberalization, privatization, and globalization (LPG) measures following a 1991 economic crisis due to simultaneous fiscal and trade deficits. However, remnants of the "license raj"⁸ were widely prevalent in the newly liberalizing economy. Red tape and bureaucracy slowed implementation of the LPG. Compounding the challenge, New Delhi could not establish a stable one-party majority government until 2014. The instability and policy paralysis associated with coalition governments in New Delhi were a barrier to transformative reforms. Since Narendra Modi's rise to power with a single-party majority in 2014, the Indian government has had a better opportunity to accelerate the LPG process across a swath of industries. Capitalizing on these opportunities, New Delhi has reduced corporate tax rates, cut red tape around foreign investments, simplified labor laws and the indirect tax structure, and fast-tracked the bankruptcy process.

Notably, the Modi administration embarked on the "Make in India" and Atmanirbhar Bharat ("self-reliant India") drive to increase the share of manufacturing in its GDP and reduce its reliance on imports, especially in sectors deemed significant to national security. The government has primarily used production-linked incentive (PLI) schemes – initiatives aimed at enhancing manufacturers' competitiveness for specific industries, import substitution, and increasing the share of domestic manufacturing.⁹ For example, the Indian government has offered targeted PLI schemes to domestically produce 53 APIs otherwise primarily sourced from China. Among the 53 APIs, Indian pharmaceutical companies have already started manufacturing 35 in India.¹⁰

The relative success of these initiatives is apparent in export data from the last two years. Pre-Covid, India's manufacturing exports grew in the range of 5-10%. However, during the Covid-19 years, compound annual growth rate of exports reached 15%, a significant rise. This is not exclusively a product of sound macroeconomic reforms. Capital

⁶ <https://cc.pacforum.org/2022/09/relations-at-75-hawaii-to-the-himalayas/>

⁷ <https://www.supplychainbrain.com/articles/35347-yellen-touts-friend-shoring-as-global-supply-chain-fix>

⁸ The Licence Raj or Permit Raj was the system of licenses, regulations, and accompanying red tape, that hindered the set up and running of businesses in India between 1947 and 1990.

⁹ <https://www.scmp.com/economy/china-economy/article/3188733/india-needs-chinacritical-medicine-ingredients-ambitious>

¹⁰

<https://economictimes.indiatimes.com/industry/healthcare/biotech/pharmaceuticals/local-manufacturing-of-35-apis-started-after-pli-scheme-mandaviya/articleshow/90519863.cms?from=mdr>

infusion into manufacturing sectors, increased M&A activity, and private equity deals in the manufacturing space complement the government's policy reforms in the manufacturing sector.

A combination of factors such as macroeconomic reforms and the global environment since the pandemic have spurred investment interest from private equity and venture capitalists in the Indian growth story. Supply chain diversification pushes by Western economies revived global investor interest in the Indian manufacturing sector. Analysts generally forecast a rising role and global market share for India's pharmaceutical industry.

Yet, the industry faces a dilemma. Thanks to deregulation, Indian pharmaceutical producers have increasingly moved to the higher end of the value chain of manufacturing, producing formulations for the global market.

Furthermore, to comply with the global Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), India amended its patent law in 2005, forcing the industry to spend more on research and development.¹¹

While the policy reform pushed the Indian pharmaceutical sector up the value chain in the global generic-drug market, it induced greater reliance on imports for the production of bulk drugs at the lower end of the value chain.¹²



The Modi administration embarked on the "Make in India" and Atmanirbhar Bharat ("self-reliant India") drive to increase the share of manufacturing in its GDP and reduce its reliance on imports.

The industry moved away from intermediate APIs and KSMs, and focused on formulations and manufacturing of generics at the higher end of the value chain.

As a result, India in 2022 imported around 70% of its APIs from China, up from 1% in 1991.¹³ While the LPG measures and amendments to the 2005 patent law assisted in transforming India into the world's largest exporter of generic drugs, it simultaneously created an import dependency for APIs.

Interestingly, this is neither a sector-specific issue nor a country-specific one. In the 1990s China increased spending on infrastructure for large-sized industrial parks (including 7,000 drugs and chemical parks) such as treatment plants, and dedicated resources to attain economies of scale by providing subsidies in resources such as power and water.¹⁴ Those industrial policies bore global market share within a decade. China's accession to the World Trade Organization in 2001, coupled with Indian pharmaceuticals distracted by R&D post-TRIPS, supplemented China's API manufacturing advantage, turning it into the world's largest producer and exporter of APIs, accounting for 20% of global API production.

In the same period, the Indian domestic pharmaceutical market's growth outpaced the growth of the overall Indian economy by two or three percentage points every year.¹⁵ Expanding its welfare policies, the Indian government – in order to provide affordable health care to the nation's needy – introduced the Ayushman Bharat Yojana¹⁶ (People's Health Scheme). This provided the impetus to support the domestic pharmaceutical sector. While market economics tend to force manufacturers to move up the value chain as they mature, New Delhi's import substitution policies are designed to prod the sector to move in the opposite direction, away from higher-end generics and R&D.

¹¹ <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8842623/>

¹² <https://www.epw.in/journal/2012/18/special-articles/policy-reforms-indianpharmaceutical-sector-1994.html>

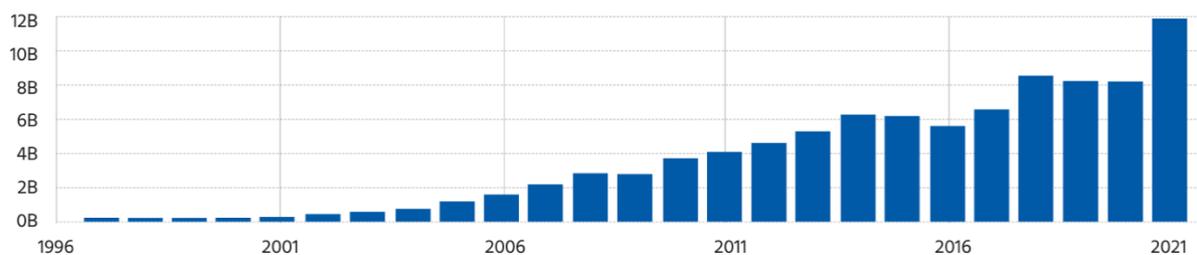
¹³ <https://www.fiercepharma.com/manufacturing/india-hoping-to-challenge-chinesedominance-plans-drug-ingredient-production-push>

¹⁴ <https://www.cnbc.com/2022/05/27/india-needs-to-fill-china-gaps-to-become-thepharmacy-of-the-world.html>

¹⁵ <https://www.wilsoncenter.org/blog-post/indias-economic-ambitions-pharmaceuticalindustry>

¹⁶ Ayushman Bharat Pradhan Mantri Jan Arogya Yojana is a national public health insurance fund of the Government of India that aims to provide free access to health insurance coverage for low-income earners in the country. Roughly, the bottom 50% of the country qualifies for this scheme.

India's total pharmaceutical and chemical imports from China



India's imports of antibiotics from China

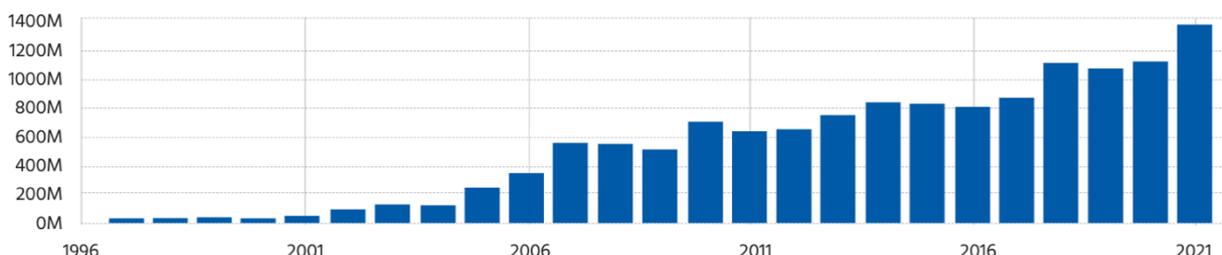


Figure 2. India pharmaceutical imports from China. Source: tradingeconomics.com; Comtrade

India as the Gateway to the Global South

Positioning India as a friendly shore for pharmaceutical supply chains will not be limited to securing supplies for the US or Europe. The scope of the diversification will not be limited to serving Western markets nor Western companies capitalizing on the growing Indian market but could serve global markets traditionally not on the radar of Western pharmaceutical companies, namely the Middle East and North Africa, Sub-Saharan Africa, and Latin America. India's non-alignment throughout the Cold-War and its relatively agnostic foreign policy have assisted it in maintaining strong ties with countries as destabilized as Syria and diplomatically isolated as Cuba. At the height of the pandemic, it was among the first countries (along with China and Russia) to provide vaccines to the Global South. It supplied over 201 million doses to over 100 countries¹⁷, both as grants and as exports. Moreover, 50% of generics in Africa originate in India.¹⁸ Indian External Affairs Minister S. Jaishankar visited South America in 2022 to launch new embassies in the region¹⁹ (Paraguay and the Dominican Republic) and discussed increasing cooperation and trade in pharmaceuticals, among other industries. India

provided drugs to Brazil at the peak of the South American nation's HIV/AIDS crisis, and its vaccine diplomacy initiatives further spurred bilateral ties. India is the largest supplier of antiretroviral drugs to combat AIDS, with Indian pharmaceutical firms supplying more than 80% of the demand.²⁰ A couple of months prior, India had signed a trade agreement with the Philippines aimed at increasing generic drug exports.²¹ As the Nikkei Asia noted²², Indian diplomats act as business development managers and promote Indian industries as a plank of the nation's foreign policy. India's recent openness to free trade agreements with nations such as the United Arab Emirates and Australia indicates its willingness to sign on to bilateral trade agreements over multilateral ones. As a Doctors Without Borders report highlighted²³, India's supply of generics plays an instrumental role in reducing fatalities associated with AIDS. Using India as the gateway to the Global South could provide Western countries an opportunity to compete with Chinese industries in markets where they have little to no foothold.

¹⁷ <https://www.cnbc.com/2022/05/27/india-needs-to-fill-china-gaps-to-become-the-pharmacy-of-the-world.html>

¹⁸ <https://www.investindia.gov.in/sector/pharmaceuticals>

¹⁹ <https://www.financialexpress.com/defence/india-on-a-diplomatic-spreet-to-expand-its-footprints-in-south-america-with-opening-of-new-missions-in-2021/2161645/>

²⁰ <https://www.cnbc.com/2022/05/27/india-needs-to-fill-china-gaps-to-become-the-pharmacy-of-the-world.html>

²¹ <https://www.fitchsolutions.com/pharmaceuticals/trade-agreement-between-india-and-philippines-will-shape-generic-drug-maker-opportunities-16-08-2022>

²² <https://asia.nikkei.com/Opinion/Modi-is-turning-India-s-nonalignment-policy-into-a-business-model>

²³ <https://www.doctorswithoutborders.org/latest/why-indias-generic-medicines-industry-so-important>

Commercial Viability

India houses more than 500 FDA approved facilities, the highest number outside the US. Furthermore, while China has three times the number of API manufacturing facilities, India is home to more API facilities approved by the FDA and has a better track record of avoiding contamination in pharmaceutical supply than Chinese facilities.²⁴ Since 2011, the FDA and the US government have signaled concerns over APIs manufactured in China. The US Department of Commerce’s Office of Technology Evaluation’s 2011 report highlighted these concerns. For example, in 2015, FDA alerted drug compounders that certain lots of baclofen API manufactured by Chinese manufacturer Taizhou Xinyou Pharmaceutical & Chemical Co., were at risk for contamination with particulates. Taizhou manufactures APIs for repackages and distributors, some of which sell these products to compounding facilities in the United States. Similarly, in 2018, FDA issued a warning that a Chinese API manufacturer, Sichuan Friendly Pharmaceutical Co. Limited, was recalling certain lots of porcine thyroid API since it had inconsistent levels of the API. This thyroid API comes from thyroid glands of pigs and is used to make a medicine to treat hypothyroidism. FDA laboratory testing confirmed that the Sichuan Friendly API had inconsistent levels of active ingredients.

Several European and American pharmaceutical companies such as Pfizer, Bayer, Merck, AstraZeneca, and GlaxoSmithKline²⁵ have successful joint ventures with Indian companies.

Overall, cost of production for APIs in China is an estimated 20% to 30% lower than India.²⁶

India’s comparative advantages in pharmaceutical and API manufacturing include:

- **Low cost of manufacturing** – Friend-shoring to India over onshoring to the US or Europe will reduce costs for American and European companies by 30-40%.
- **High projected CAGR** – Exports of pharmaceuticals are forecast by whom? to grow between 16-18% up until 2028.²⁷
- **Industrial policies/production-linked incentives** – The Indian government has unveiled several production-linked incentive schemes targeting API and intermediates production in its phase 1.0 of the PLI outlay. In its second phase, it has provided subsidies to increase R&D efforts in the pharmaceutical value chain.

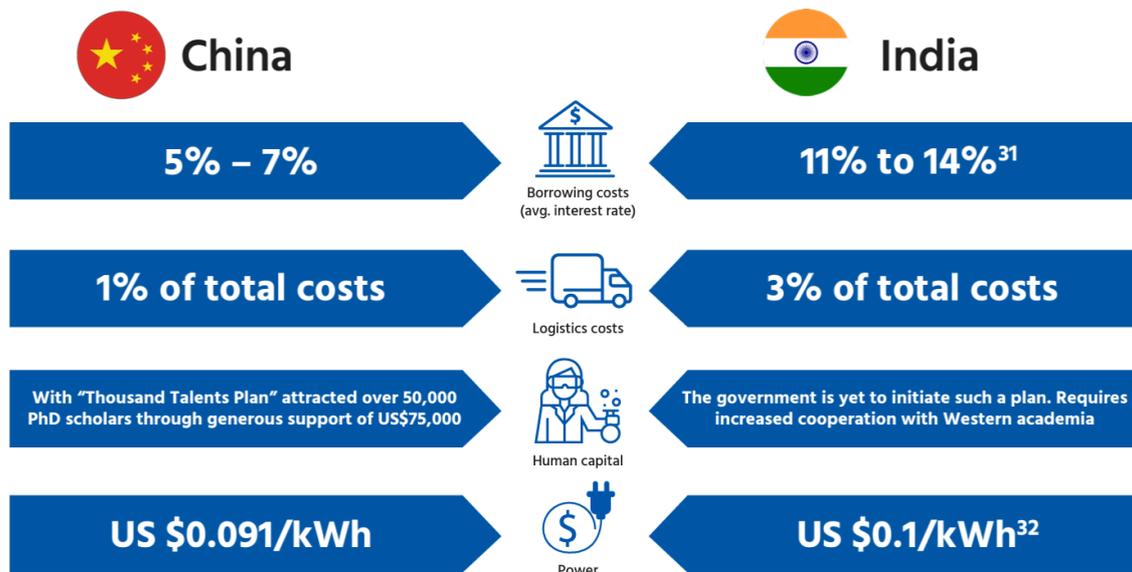


Figure 3. Cost of production in India vs China. Source: Author’s complication

²⁴ <https://www.pharmaceutical-technology.com/news/us-pharmacopeia-report-highreliance-indian-manufacturers-api/>

²⁵ <https://www.wilsoncenter.org/blog-post/indias-economic-ambitions-pharmaceuticalindustry>

²⁶ <https://www.livemint.com/industry/manufacturing/fresh-push-for-apis-under-plischeme-11667847957826.html>

²⁷ <https://www.bain.com/insights/the-trillion-dollar-manufacturing-exportsopportunity-for-india/>

- **Increased FDI** – The Indian government has removed direct trade barriers such as limits on foreign ownership by allowing 100% FDI in the pharmaceutical sector, and not forcing foreign corporations to take on a local partner.
- **Existing strong manufacturing ecosystem** – Over the course of the last three decades, the private sector has created an ecosystem for generic drug manufacturing.

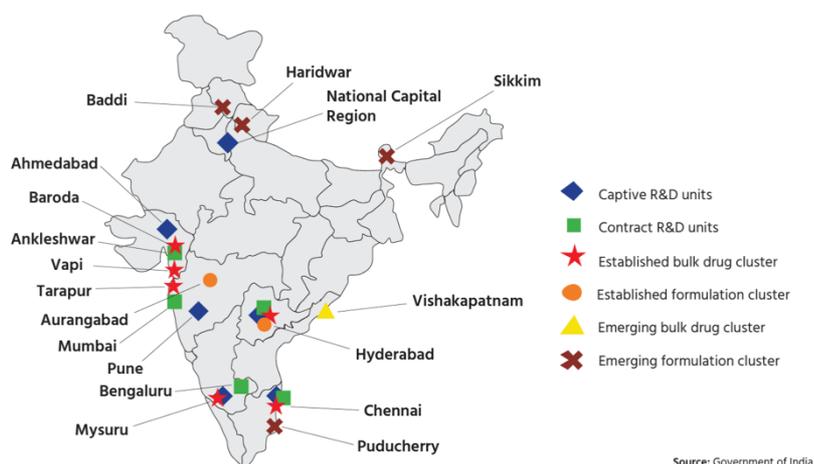


Figure 4. Pharmaceutical clusters in India. Source: Government of India.

- **Capex-led growth** – The Indian government has budgeted a 35% year-over-year capex for FY23 to US\$100 billion.
- **Cost-efficient R&D** – According to Bain & Company, the cost of R&D in India is 87% less than in developed markets.²⁸
- **CO2 emissions** – As of 2021, Indian CO2 emissions were around 1.4% (30 metric tons) of 2019 levels versus China’s 6% (500 metric tons) of 2019 levels.
- **Established relationships and markets** – As a pioneer in generic drug exports, India holds the single largest market share among consumers in key economies across Africa, North America, and parts of Eastern Europe.
- **FDA compliant facilities** – India houses the most FDA-compliant facilities outside the US and around 18% of FDA-approved API facilities.

Moreover, since the onset of the Covid-19 pandemic and the clash between Indian and Chinese troops in Galwan valley in 2020, there has been a renewed interest in India to move away from economic reliance on China.²⁹ The hard conflict resulted in policies targeted at decoupling. New Delhi has used strategic PLI schemes to limit India’s reliance on Chinese imports, both as a countermeasure to its

conflict at the border and to reduce its ballooning trade deficit.

In the first phase of PLI schemes, subsidies amounting to 69 billion INR (US\$850 million) were catered to supporting the production of KSMs, APIs, and intermediates. In the second phase, the subsidies of 150 billion INR (US\$1.8 billion) went toward supporting R&D and high valued-added manufacturing.³⁰ Furthermore, New Delhi is emulating Beijing’s industrial policy of the 1990s by building similar clusters for drugs and APIs, as shown in Figure 4.

Over the last five years, the Indian pharmaceutical industry has witnessed a sudden spurt in interest from global investors.³¹ Big private equity players such as Carlyle Group, Bain Capital, and PAG have increased their investments in the sector and the industry, cognizant of this investor sentiment, has resorted to a fundraising drive through initial public offerings (IPOs). For example, in a single month in 2021, five Indian pharmaceutical companies (including one backed by Bain Capital) raised over 80 billion INR (US\$1 billion).

²⁸ <https://www.bain.com/insights/the-trillion-dollar-manufacturing-exportsopportunity-for-india/>

²⁹ <https://www.cnbc.com/2022/05/27/india-needs-to-fill-china-gaps-to-become-the-pharmacy-of-the-world.html>

³⁰ <https://www.investindia.gov.in/sector/pharmaceuticals#:~:text=The%20pharmaceutical%20industry%20in%20India%20is%20currently%20valued%20at%20%2450,all%20medicine%20in%20the%20UK%20.>

³¹ <https://www.ibef.org/blogs/indian-pharma-industry-to-touch-us-130-billion-by-2030>

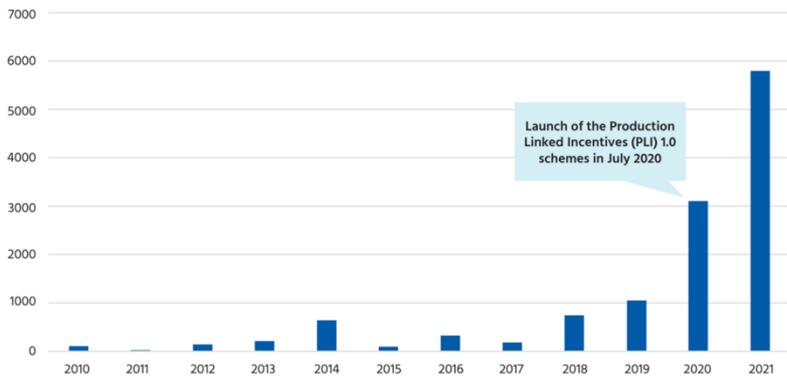


Figure 5. Private equity & venture capital investments in the Indian pharmaceutical & healthcare industry (in \$ millions). Source: <https://pharmabiz.com/>

Risk Assessment

For the US

- The Indian pharmaceutical industry's bitter and poisonous pill** – Like the Chinese API industry, the Indian pharmaceutical industry has had its share of mishaps. The Indian domestic market and at times its exports are flooded with drugs classified as not of standard quality (NSQ) drugs.³² This has led to severe health complications in adults and even deaths among infants and children. Around mid-2022, in Gambia, more than 70 children died of acute kidney injury after consuming cough syrup produced by an Indian pharmaceutical company. While the Gambian government has not officially confirmed that it was the Indian cough syrup responsible for the death of 70 children³³, the Indian government had halted the production of that syrup by a private corporation. Cases like Gambia raise the specter of doubt on the reliability of Indian regulatory oversight; moreover, scenarios like the infant formula shortage in the US, wherein, the nation was facing an acute shortage of infant formula and the government decided to address the emergency by sourcing it from Europe over India undergird doubts on the trust governments have on the quality of Indian pharmaceutical products.



The Indian domestic market and at times its exports are flooded with drugs classified as not of standard quality (NSQ) drugs. In some cases this has led to deaths among infants and children.

For India

- Labor-intensive manufacturing vs advanced manufacturing** – Citing the first risk, European and American companies could choose to onshore their supply chain over friend-shoring to a developing economy with lower quality standards. While the increase in production costs is a major impediment, the industry's move toward advanced manufacturing could aid in offsetting that cost, partially if not completely.

- Failures to reduce dependency on China** – The Indian government, riding on the success of PLI measures in mobile phone manufacturing, is hoping for a similar success story with PLI in other industries. However, unlike mobile assembly, the cap-ex required for establishing large-scale drug parks is large and the government's PLI targeting API manufacturing is essentially asking pharmaceutical firms to climb down the value chain – a not-so-enticing proposition for most leading pharmaceuticals. This mismatch in priorities and the long, drawn-out process of reviving an entire API ecosystem in India may lead to failures in industrial policies.

³² <https://www.hindustantimes.com/books/review-the-truth-pill-the-myth-of-drugsregulation-in-india-bydinesh-s-thakur-and-prashant-reddy-t-101668184185862.html>

³³ <https://www.bbc.com/news/business-63476025>

- **The threat of ESG** – Manufacturing of APIs has a detrimental effect on the environment and ineffective processing of the chemicals could lead to increased pollution. In the 1990s China invested in large treatment plants. Despite making those investments, the environment continued to be damaged by the industry. In the 21st century, environmental, social, and corporate governance (ESG) is rapidly gaining relevance for global investors and the substantial increase in pollution resulting from new API facilities may not bode well for environment-conscious investors.
- **Trade disputes** – The biggest risk for the industry is an increase in trade disputes between nations representing their corporations on trade or patent rule violations. The industry is no stranger to these disputes. Several Western firms have cases pending or have had adjudicated in Indian courts on patent disputes.



ESG is rapidly gaining relevance for global investors and the substantial increase in pollution resulting from new API facilities may not bode well for environment-conscious investors.

Policy Recommendations/Going Forward

For India

The Modi administration is credited with fast-tracking the process of bringing several inefficient companies carrying billions in debts to the bankruptcy court; in essence clearing the bad debts off the books of nationalized banks and as a result providing room to lend to efficiently run companies. The pharmaceutical industry in India requires a similar clean-up measure, wherein companies accused of supplying NSQ drugs be held accountable

by fast-tracking the cases pending in the Indian judicial system.

Delhi should also employ mechanisms to regularly monitor the efficiency of subsidies to prevent industrial policies from acting as an easy way for companies to clear their balance sheets of debt. Free-market economists have attributed industrial policies to inefficient companies and unproductive use of resources. India has a history of sick government entities that straddle debt and unproductive assets. The Indian government should prioritize preventing a repeat of the “license-raj” era of socialist economic policy and the rent-seeking opportunities it presented to corrupt government officials.

Furthermore, despite New Delhi implementing the above policy recommendations, as highlighted in Figure 3, India does not enjoy the economies of scale for API production as China does. To change that variable, the Indian government and private sector may have to dedicate cap-ex and subsidize power and water. As highlighted earlier, the Indian private sector, while keen on capitalizing subsidies, may not be inclined to invest down the value chain.



Delhi should employ mechanisms to regularly monitor the efficiency of subsidies to prevent industrial policies from acting as an easy way for companies to clear their balance sheets of debt.

For the US

In 2022, national security policymaking and trade policymaking intersect at a variety of points and inviting the security apparatus to support diversification efforts will only be in character with this current state of global trade.

If the US, Europe, and Japan were to proceed on friend-shoring the pharmaceutical supply chain, our opinion is that India is among the strongest

contenders. The global pharmaceutical sector lacks similar candidates to meet such strategic goals.

However, for India to attain economies of scale and be cost competitive in the global market place it would have to significantly subsidize the industry and increase capital expenditure multifold while moving down the value chain.

The supply chain review commissioned by the Biden administration prominently featured pharmaceuticals and APIs and emphasized the need to secure supply chains along with other sectors such as critical minerals for renewable energy and semiconductors. Following the review, the Biden administration invoked the Defense Production Act (DPA) and authorized subsidies strengthening the industrial base for critical minerals in America. The administration was able to execute this policy through the existing provisions in DPA Title III.³⁴ However, the DPA is restricted to domestic concerns. Due to strict stipulations, it cannot be extended to foreign countries.

Nevertheless, the US Department of Defense (DOD) has made a special request to the US Congress to amend the Act so that the intelligence and security apparatus can fund projects abroad.

The DOD opined that the DPA was limited in scope and had to be extended to support partners and allies abroad. Similarly, our understanding is that DOD will have to consider assisting the pharmaceutical industry to bridge the gap of few percentages point in various production cost variables between India and China by investing in clusters across India. These measures can be targeted to support fermentation plants and clusters that manufacture KSMs and APIs such as penicillin G, amoxicillin and tetracycline, that go into major antibiotics.

Conclusion

Over the last two decades the US has brought a knife to a gun fight – China subsidized pharmaceutical industries with generous economic support while the US was not bringing industrial policy planning to bear on its pharmaceutical and API industries to a similar extent. The US has since stepped up a pivot toward such industrial policies. America's position as

the world's largest buyer of pharmaceuticals remains a strategic advantage. The US could weaponize its market for pharmaceutical consumption to alter the supply chain. If the US can bring Japan and France into the fold of friend-shoring, these key markets could add to the American advantage in supply chain diversification. The US has already initiated a similar partnership for critical minerals such as the Mineral Security Partnership (MSP) and the CHIP4Alliance for semiconductors.

As Farrell and Newman defined in their paper on weaponized interdependence, "highly asymmetric networks allow states with (1) effective jurisdiction over the central economic nodes and (2) appropriate domestic institutions and norms to weaponize these structural advantages for coercive ends."³⁵

To that end, the US could first, employ the "panopticon effect"³⁶ to gather strategically valuable information from the Indian government and pharmaceutical industry. Second, it could encourage the involvement of the security establishment.



If the US can bring Japan and France into the fold of friend-shoring, these key markets could add to the American advantage in supply chain diversification.

³⁴ <https://www.wita.org/atp-research/initiatives-advance-friend-shoring/>

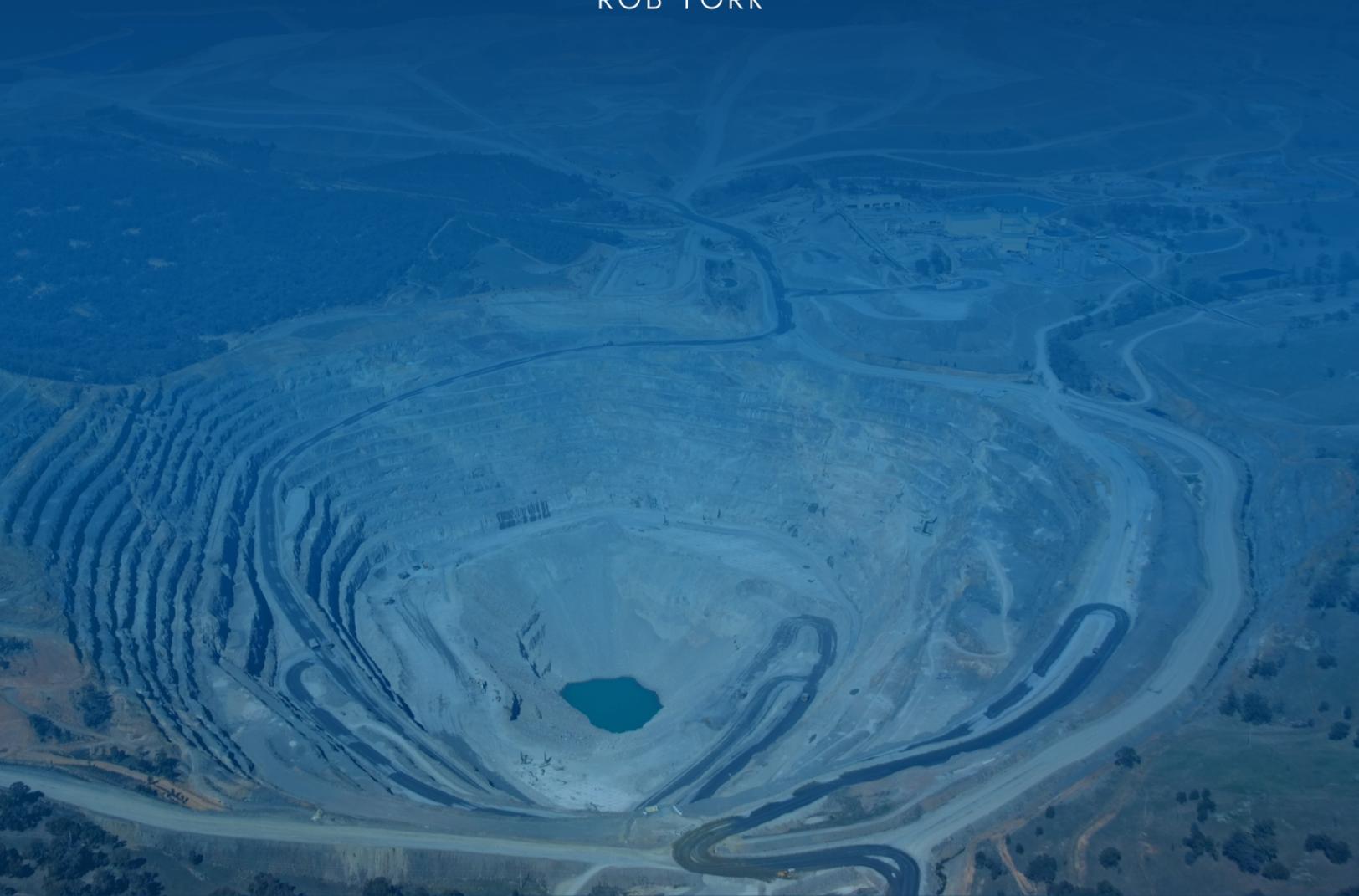
³⁵ <https://direct.mit.edu/isec/article/44/1/42/12237/Weaponized-Interdependence-HowGlobal-Economic>

³⁶ Panopticon effect is the method of gathering strategically vital information using a central node of surveillance.

2

Friend-shoring critical mineral supply chains

BY AKHIL RAMESH AND
ROB YORK



Executive Summary

Akhil Ramesh and Rob York

Critical minerals go beyond “rare earths”, constituting the key ingredients in a wide variety of high-end technology we use every day, from appliances to entertainment to the tools of our trades. Quietly, steadily, over the past two decades, China has built up its leadership status in this field, and the US and its partners are just waking up to the disruptive potential of this reliance. This study maps the critical minerals that have become part of daily life, shows how China assumed a central role in harvesting and distributing them, and offers suggestions on how to diversify. Based on a variety of factors – from availability to friendliness toward the US to capacity for processing – it recommends Canada, Australia, and Chile as ideal alternatives to China for meeting modern critical mineral needs.



Quietly, steadily, over the past two decades, China has built up its leadership status in this field, and the US and its partners are just waking up to the disruptive potential of this reliance.

Introduction

The Austrian Chancellor Klemens von Metternich once famously said, “When France sneezes, Europe catches a cold.” Cathie Wood, chief executive and investment officer of asset management firm ARK Invest, has updated this phrase to fit modern times – “When China catches a cold¹, the commodities markets catch a pneumonia” – to summarize the economic connectivity between the Middle Kingdom and the world. This paradigm is glaringly apparent in the critical mineral industry.

Over the last two decades, China has steadily become the leader in mining most of the world’s critical minerals and in processing all major critical minerals. Given its rapid technological advancements and rapid transition to clean energy sources in the last decade, China’s demand for critical minerals soared. As a result, China exerts significant control over the critical mineral value chain, both upstream and downstream mining and as a market.

But first: Nations across the world have defined “critical minerals” differently. Unlike rare-earth elements – a broadly accepted nomenclature for a group of seventeen metallic elements – nations have identified minerals to be critical to their national security based on analysis of their own economy’s supply chain vulnerabilities. For example, the US Geological Survey defines critical minerals as “mineral commodities that have important uses and no viable substitutes, yet face potential disruption in supply, and critical to the nation’s economic and national security.” Geosciences Australia defines them as a “metallic or nonmetallic element” with two characteristics: “It is essential for the functioning of our modern technologies, economies or national security” and “There is a risk that its supply chains could be disrupted.”² Nonetheless, five minerals – lithium, cobalt, manganese, nickel, copper, and rare earth elements – broadly make up the critical minerals in most advanced economies.

These minerals by and large go into advanced, critical, and renewable energy technologies such as fighter jets, solar panels, and advanced batteries; and into most everyday technologies of the 21st century such as smartphones, electric shavers, motorbikes, and automobiles (conventional and EVs), among other

things. Critical minerals have thus become omnipresent in modern-day societies and their significance has expanded in scope. In particular, as nations work toward their climate change goals, access to these minerals becomes essential to the production of clean energy.

The race against climate change goals coupled with the geopolitical tensions brewing between different nations exacerbate the challenges associated with accessing, refining, and processing minerals to become part of the end-product. With this complexity, some critical minerals, such as nickel, are much more finite in supply than others. Such limitations and supply constraints mean that scientists must explore different chemistries for batteries and substitutes for other products that use nickel.

In this environment, the weaponization of interdependence by countries at the top of the hierarchical network of value chains will significantly impact climate change goals, affect innovation in industries such as new battery chemistries, and potentially hamper advancements in technologies should one country (such as China) or just a few economies control the entire value chain. The impact on innovation will in turn lead to inefficient use by limiting progress in clean mining processes, leading to the destruction of natural resources and even environmental destruction, such as in forestry and water aquifers, as observed in nickel and lithium mining, respectively.

This provides the impetus for assessing the potential for friend-shoring supply chains in the critical minerals sector amongst like-minded nations of the US that possess these minerals and ones that have the capital, and technological know-how to successfully mine, process and get them to the market for the end product.

Nations such as Australia, Indonesia, Chile, Canada, and South Korea can play different roles in addressing this challenge.

¹ Tech Sell Off, Bubble Comparisons, China, ARK Invest: https://www.youtube.com/watch?v=EamI_Eg1OW4

² Critical Minerals at Geoscience Australia, GeoScience Australia: <https://www.ga.gov.au/scientific-topics/minerals/critical-minerals>



As nations work toward their climate change goals, access to critical minerals becomes essential to the production of clean energy.

Supply Chain Mapping

While semiconductors have become ubiquitous in society, with most modern technologies, personal electronics, and automobiles running on them, critical minerals make the building blocks of all those technologies. They have widespread applications in energy storage systems, electric mobility, power generation, aerospace, and data transmission software. In day-to-day use, they can be found in mobile phones, tablets, computers, batteries, and automobiles. The amount of a critical mineral needed for a given end differs. Figure 1 illustrates the importance of critical minerals to our devices in our

day-to-day use by portraying them in a single smartphone.

The vast difference in the amount of minerals required for a device as small as a smartphone vs an electric vehicle exacerbates the challenge. For example, one Tesla Model S uses 140 pounds/63.5 Kg of lithium, equivalent to the lithium found in 10,000 smartphones.³ As of 2023, most clean automobiles use lithium-ion batteries rather than hydrogen or other chemistries. The vagaries in critical mineral supply chains are closely tied to the developments in the end-use in the value chain, such as technological advancements and changes in battery chemistry. In particular, minerals such as lithium are predominantly used in batteries rather than other end products. Around 70% of the lithium mined goes into batteries and only the remaining 30% goes into ceramics, glasses, and medicines.⁴

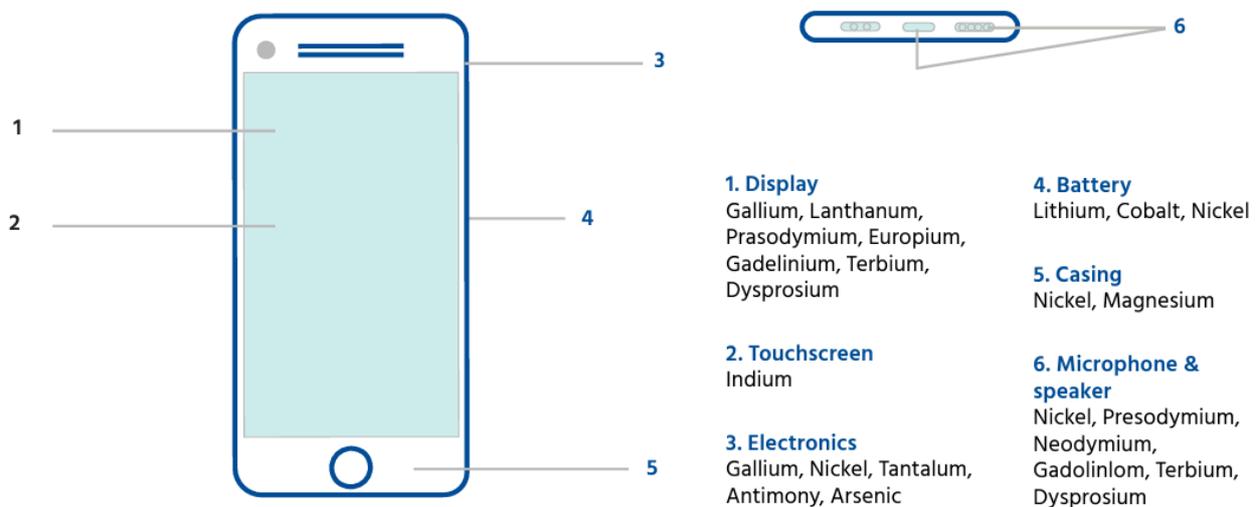


Figure 1. Critical minerals in a smartphone. Source: Data collected by authors.

³ Lithium is 'new oil' as the electric vehicle market expands, Hinrich Foundation: <https://www.hinrichfoundation.com/research/article/sustainable/lithium-new-oil-as-electricvehicle-market-expands/>

⁴ Visualizing 25 Years of Lithium Production, by Country, Visual Capitalist: <https://www.visualcapitalist.com/visualizing-25-years-of-lithium-production-bycountry/#:~:text=The%20Future%20of%20Lithium%20Production,tonnes%20of%20LCE%20in%202021>



Figure 2. Critical minerals in a giga factory. Source: Data collected and graphic designed by authors.

China's steady economic growth over the last three decades and the parallel technological advancements made it the largest market for various high-technology end products that use critical minerals. Capitalizing on economies of scale, the Chinese government embarked on building its indigenous value chain for these critical minerals. For example, much like in semiconductors and many other industries, the US was once the market leader in the production of several critical minerals. In 1995, the US share of lithium production was at 37%, while in 2021 it was a meager 1%.⁵ While the uses and purposes of several minerals, including lithium, have evolved over the last three decades and found new significance, the US and its allies are playing catch-up now that China has successfully captured entire value chains in all the major critical minerals. Furthermore, China is a leader in the production of cathodes and anodes that go into batteries. Figure 3 lays out the value chain.⁶

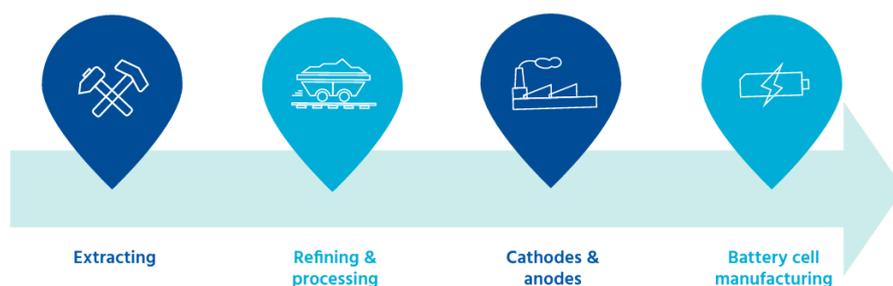


Figure 3. China's control of the entire value chain to end-use.

Demand

China

The ebbs and flows in the Chinese economy have a direct impact on the prices of most commodities. Volatility brought on by Covid lockdowns and the

subsequent lifting of the same has proven that as one of the major sources of global demand for commodities, China has a vital role to play in the supply chains of most minerals. Critical minerals that go into advanced technologies and renewable energy are no exception. The demand for critical minerals is fueled by the surging demand for end-use goods such as EVs, mobile phones, solar panels, and wind turbines. As a result of China's rapid economic transformation, the demand for advanced technologies skyrocketed, and, by 2021, China overtook the US and the EU in demand for these goods. Cognizant of this development, the Chinese government used targeted industrial policy to strengthen midstream and downstream processes in the critical minerals sector. While resource-rich nations such as the Democratic Republic of Congo (DRC), Chile, Argentina, Bolivia, Indonesia, and Australia engage in the upstream activity of extracting minerals, over the last two decades China

has steadily grown its comparative advantage in midstream and downstream processes. For emerging markets, the development of midstream and downstream activities was out of reach due to its capital-intensive nature and for wealthier nations such as Australia, the limitations associated with its market size and therefore economy of scale

made the development of these parts of the value chain inefficient.

⁵ Why The U.S. Has A Massive Lithium Supply Problem, CNBC: <https://www.youtube.com/watch?v=3epceXRIxkM>

⁶ The Anode is the negative or reducing electrode that releases electrons to the external circuit and oxidizes during and electrochemical reaction. The

Cathode is the positive or oxidizing electrode that acquires electrons from the external circuit and is reduced during the electrochemical reaction.



Biden's CHIPS Act, the Bipartisan Infrastructure Law, and the IRA are all different legislation designed for one overarching goal of making up ground lost to China in manufacturing competitiveness.

The US: The New Vortex of Demand

In August 2022, the Biden administration embarked on an ambitious industrial policy drive through the Inflation Reduction Act (IRA). The administration initially proposed the Build Back Better plan to transform the American economy into a green economy, one that runs on renewable energy while simultaneously reducing its overreliance on China for critical goods that go into creating that power and, lastly, reviving domestic manufacturing in that process. The IRA was designed to address a host of immediate challenges such as inflation and funding the Internal Revenue Service (IRS), long-term goals such as catalyzing investments in domestic manufacturing capacity, incentivizing procurement of critical supplies domestically or from free-trade partners, jump-starting research and development, and commercializing leading-edge technologies such as carbon capture, energy storage, and clean hydrogen. While initially there was discontent⁷ about the proposed Build Back Better plan amongst American allies with existing free trade agreements, as of 2023, companies have begun to capitalize on the benefits offered by the Inflation Reduction Act. The private sector has highlighted the challenges associated with onshoring entire value chains, particularly since most components for batteries and other parts cannot be sourced in the US. President Biden's CHIPS Act, the Bipartisan Infrastructure Law,

and the IRA are all different legislation designed for one overarching goal of making up ground lost to China in manufacturing competitiveness. This emphasis on reviving manufacturing through both nearshoring and friend-shoring for parts with no source in America in Washington DC has trickled down to local elections. Even Democratic contenders, who otherwise would be against reviving old mines, let alone sanctioning new ones, are voicing support for increasing American competitiveness by supporting the mines affected by environmental regulations over the last few decades. For example, the Democratic candidate Rep. Catherine Cortez Masto in the western state of Nevada voiced support for mining operations in her state during the elections in 2022.⁸ This bipartisan consensus on improving American manufacturing competitiveness, at times even at the cost of environmental standards, indicates a bipartisan resolve in America for both "America First" economic policies and competition with China. The US and China have been the largest sources of demand for advanced technologies over the last few years, with Europe trailing at third.

IRA Comes with a Catch but Transforms Rust Belt into EV Belt

Several IRA tax incentives contain a sliding scale of incentives encouraging domestic production and procurement. In order to unlock the full EV consumer credit (US\$4,000), 40% of critical minerals and 50% of components in the battery are required to have been recycled in North America or been extracted or processed in a country with a free trade agreement (FTA) with the United States. This requirement is designed to progressively increase to more than 80% in the critical minerals sector and 100% in the battery sector by 2029 (see figure 4). Furthermore, the battery must have also been manufactured or assembled in North America.⁹

This has in turn incentivized companies to move the entire or part of their supply chains to the US, stimulating manufacturing activity in states that had lost manufacturing competitiveness since China's accession to the WTO. Companies such as Hyundai, Toyota, and American household names such as Ford

⁷ <https://www.cnn.com/2022/11/07/us-inflation-reduction-act-eu-raises-concerns-risks-wto-dispute.html>

⁸ Cortez Masto stands up for Nevada mining jobs, Catherine Cortez Masto: <https://www.cortezmasto.senate.gov/newsroom/press-releases/at-senate-hearing-cortez-mastostands-up-for-nevada-mining-jobs-ensures-that-house-anti-mining-provisions-will-not-move-forward-in-the-senate>

⁹ <https://bipartisanpolicy.org/blog/ira-ev-tax-credits/>; The critical mineral requirement will be met if the percentage of the value of the critical

minerals¹ in the vehicle's battery were extracted or processed in the United States, or in any country with which the United States has a free trade agreement in effect, or recycled in North America,² is equal to or greater than 40 percent for a vehicle that is placed in service in 2023 after the date on which Treasury and the IRS issue proposed guidance. This required percentage increases annually to 50 percent in 2024, 60 percent in 2025, 70 percent in 2026, and 80 percent after 2026.

and GM, have already begun rushing to make investments so that they might capitalize on these benefits. And, notably, states in the Midwest, South, and Southwest have the most to gain from the legislation.

The IRA will stoke around US\$400 billion in federal funding to address climate change over the next five to ten years. Of the US\$400 billion, more than US\$250 billion is allocated for energy production, US\$48 billion for manufacturing, and US\$24 billion for EVs.¹⁰

Supply

Australia – Australia is one of the strongest contenders to friend-shore critical mineral supply chains. Australia houses all the critical minerals required for advanced technologies. It is blessed with critical minerals and has decades of experience mining, not just hydrocarbons but critical minerals such as lithium, nickel, and cobalt as well. It is a leading exporter of lithium and houses one of the cleanest sources of cobalt. Unlike emerging markets such as Indonesia or Bolivia, Australia does not face an infrastructure deficit. The critical mineral mining sector in Western Australia has successfully raised capital from global markets and built infrastructure

	2023	2024	2025	2026	2027	2028	2029 and beyond
Minimum percentage of battery components to be produced in North America	50%	60%	60%	70%	80%	90%	100%
Minimum percentage of critical minerals extracted, processed, and/or recycled in nations with free trade agreements	40%	50%	60%	70%	80%	80%	80%

Figure 4. Share of domestic manufacturing of battery components and critical minerals. Source: Bipartisan Policy Center.

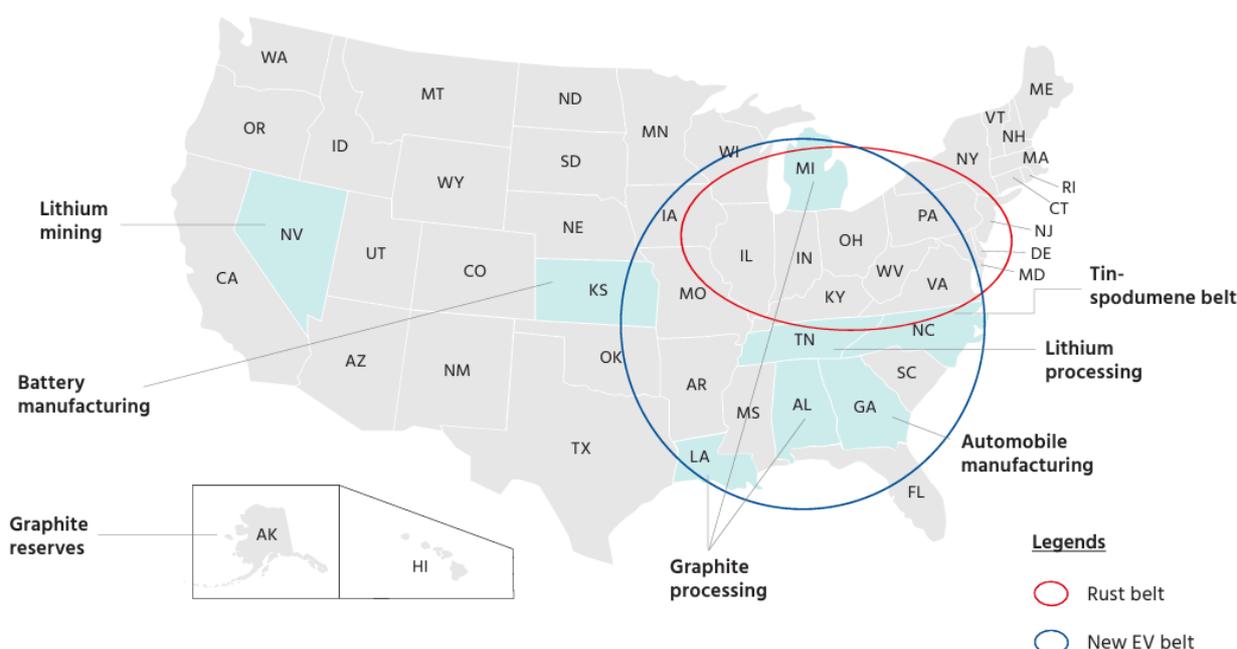


Figure 5. Critical minerals, batteries, and EV ecosystem in the US. Source: Data collected and graphic designed by authors.

¹⁰ The Inflation Reduction Act: Here's what's in it, McKinsey: <https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-inflation-reduction-act-hereswhats-in-it>

to sustain mining operations without delays in the upstream sector if not as much in the downstream.

Indonesia – Indonesia holds the world’s largest reserves of nickel.

Chile – Chile is the largest producer of copper and is among the largest suppliers of lithium with production increasing multifold thanks to the Biden administration’s IRA.

EV and through the FTA with the US, it can attract companies to set up operations in North America.

South Korea – While South Korea is not a critical mineral-rich country, like the other four referenced nations, its companies have rapidly advanced to the top of a hierarchical network of value chains in the critical mineral industry. Over the last decade, Korea has successfully developed an indigenous lithium-processing industry.

Opportunities for Friend-Shoring

The IRA provides a basic definition of friend-shoring – procuring supplies from nations with an FTA that do not pose an immediate national security threat to the US. While this definition has multiple leaks to plug – such as defining “friendly” and addressing Chinese capital in American companies – the overarching goal of legislations in the US has been to limit exposure to Chinese monopolies and increase supply chain resiliency.

The Pentagon in the US has been the most vocal proponent for closing the gap between trade and national security policymaking in the critical minerals sector. Defense leadership has consistently

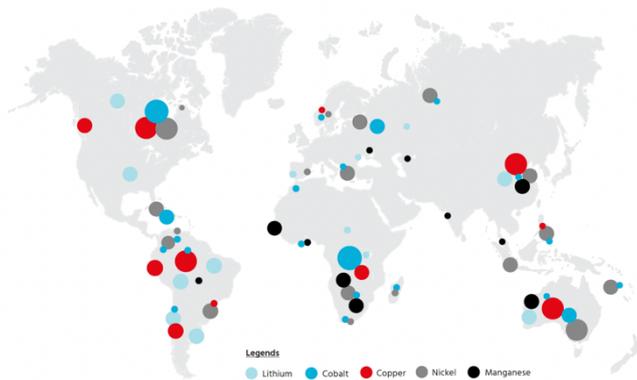


Figure 6. Concentration of critical minerals around the world.¹¹

Canada – Canada is another strong contender for friend-shoring critical mineral and EV supply chains. The country houses all the minerals required for an

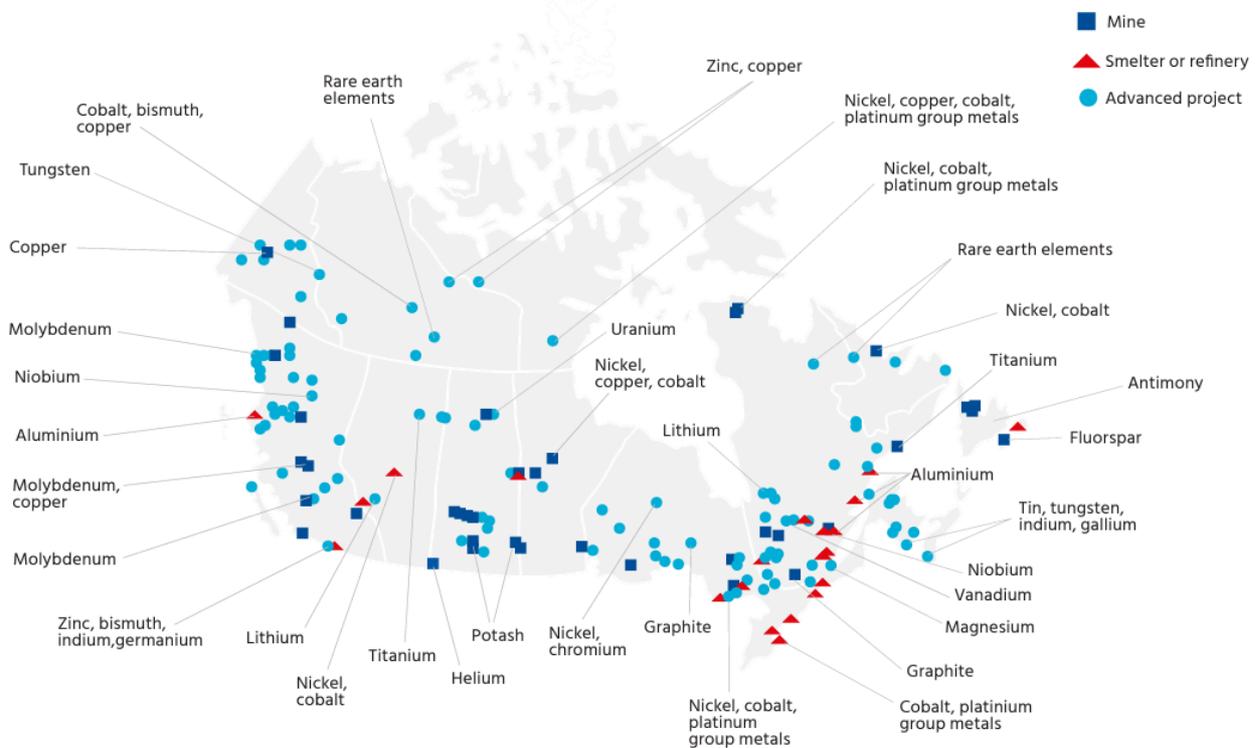


Figure 7. Canada’s critical minerals. Source: Government of Canada (data and image).

¹¹ Australia has rich deposits of critical minerals for green technology, but we’re not making the most of them, Monash University: <https://lens.monash.edu/@technology/2022/05/24/1384678/australia-has-rich-deposits-of-critical-minerals-for-green-technology-but-we-are-not-making-the-most-of-them-yet>

rich-deposits-of-critical-minerals-for-green-technology-but-we-are-not-making-the-most-of-them-yet

advocated for expanding the scope of the Defense Authorization Act to fund projects abroad and not just in the US.¹² As shown earlier, in the critical minerals sector select countries possess large reserves. This forces even ardent advocates for protectionism and onshoring to consider friendly shores.

The economic and political environments are crucial for expanding mining operations and subsequently creating an ecosystem for either battery component manufacturing or exports. There are challenges unique to emerging markets such as Indonesia and broader challenges to developed markets such as Canada and Australia. For example, Indonesia is highly reliant on foreign capital for its indigenization of the EV ecosystem. Not to mention its reliance on Chinese capital even for its new capital city. Nonetheless, the US, Japan, and the EU have committed between US\$15–\$20 billion for Indonesia to transition to cleaner energy and away from its reliance on coal for its energy needs.¹³ Furthermore, there is no reason to believe that Indonesia will weaponize the growing interdependence with the US or its allies as China has done with the Japanese on rare earth minerals¹⁴ and its recent export controls on components going into solar panels.¹⁵

Australia is a developed market that faces the same challenge. However, Canada and Chile have FTAs with the US and friendly nations as export destinations, limiting their vulnerability to the weaponization of interdependence by China.

Political and Economic Policies Shaping the Industry

Australia – Australia has offered tax offsets to increase battery cell production and capitalize on its FTA with the US to reduce reliance on its small domestic market and China.

Chile – Chile is the world's largest producer of copper and one of the leading suppliers of processed lithium carbonate and hydroxide. The Chilean government has incentivized the local processing of

minerals by offering companies processing in Chile the option to buy 25% of lithium production at special rates.

Indonesia – The Indonesian government under President Joko Widodo has implemented several import substitution measures to curb the raw material outflow from the country. To transform the raw material exporting economy into a value-added exporting economy, the Jokowi administration has implemented successive policies between 2009 and 2019, and as of April 2022, banned the export of nickel ore, requiring nickel to be processed domestically for export.¹⁶ However, the domestic processing of nickel is done through industrial parks and facilities created and financially supported by Chinese state-owned enterprises as part of China's Belt and Road Initiative. On the Indonesian islands of Sulawesi and Halmahera, Chinese mining companies have built refineries, smelters, a new metallurgy school, and even a nickel museum to secure nickel for Chinese companies' demand for the critical mineral. The metal primarily used for stainless steel comes with a warning attached that it is much more finite than its peers going into EVs. This compounds the challenge of friend-shoring to Indonesia. Furthermore, the quality of nickel found in Indonesia will not satisfy the requirements for batteries in EV production, though it will for stainless steel production. This has kept many Western players out of the mix and environmental costs remain a concern for those companies. Chinese mining giants along with CATL have used techniques such as high-pressure acid leaching to access new supplies in the country and explore higher-grade nickel for lithium batteries.¹⁷

Canada – Canada has joined the US in its trade tussle with China. In November 2022, the Canadian government forced Chinese companies to divest from three Canadian-listed lithium companies.¹⁸

Earlier in 2022, the Canadian government announced a slew of economic incentives, "To enable the exploration of critical minerals, a new 30 percent Critical Mineral Exploration Tax Credit is being

¹² The Pentagon sets its sights on Australia's critical minerals, Mining Technology: <https://www.mining-technology.com/features/the-pentagon-sets-its-sights-on-australias-critical-minerals/>

¹³ US, Japan-Led Climate Pact Set to Offer Indonesia \$15 Billion, Bloomberg: <https://www.bloomberg.com/news/articles/2022-11-11/us-japan-led-climate-pact-set-to-offer-indonesia-15-billion#xj4y7vzkg>

¹⁴ Japan's global rare earths quest holds lessons for the US and Europe, Quartz: <https://qz.com/1998773/japans-rare-earths-strategy-has-lessons-for-us-europe>

¹⁵ China is trying to strangle the world's solar panel industry, The Spectator: <https://www.spectator.co.uk/article/china-is-trying-to-strangle-the-worlds-solar-panelindustry/>

¹⁶ Prohibition of the export of nickel ore, IEA: <https://www.iea.org/policies/16084prohibition-of-the-export-of-nickel-ore>

¹⁷ Nickel miner Vale Indonesia signs HPAL deal with China's Huayou, Reuters: <https://www.reuters.com/article/indonesia-nickel-idUSKBN2QE1C6>

¹⁸ Canada orders three Chinese firms to exit lithium mining, Reuters: <https://www.reuters.com/markets/commodities/canada-orders-three-foreign-firms-divest-investments-critical-minerals-2022-11-02/>

introduced that would be available to investors under certain flow-through shares agreements to support specified exploration expenditures incurred in Canada”.¹⁹ This tax credit is applicable to specific

critical minerals including nickel, lithium, cobalt, graphite, copper, rare earth elements, vanadium, and uranium, among others.

Country	Critical mineral	Advantage	Disadvantage
Australia	Cobalt Lithium Manganese Graphite	<ul style="list-style-type: none"> - Higher ESG standards - Established infrastructure - Security partnership with the US (Five Eyes) - Significant upstream operations - The US and Australia have an FTA making it eligible for benefits under IRA 	<ul style="list-style-type: none"> - Industry reliant on the Chinese market²⁰ - Lacks economies-of-scale to grow an indigenous midstream and particularly downstream operations - Private sector is reliant on Chinese capital
	Nickel	<ul style="list-style-type: none"> - Emerging market with lower cost of labor - Generous government subsidies - Large market size provides opportunities to scale upstream, midstream, and downstream - Possesses the world’s largest nickel reserves 	<ul style="list-style-type: none"> - Lacks established infrastructure for mining operations - Highly reliant on foreign support, particularly from China - Participant in China’s BRI and most mineral processing industrial parks fall under the initiative - Is averse to choosing sides between the US and China and does not endorse bifurcation of the world
Chile	Lithium Copper	<ul style="list-style-type: none"> - US-Chile FTA provides Chile the benefits offered under IRA - Largest producer of copper in the world - Unlike Australia’s dependence on China, Chile’s market dependence is on two US allies – South Korea and Japan 	<ul style="list-style-type: none"> - Chinese SOE’s stake in its largest lithium mining company – Chinese company Tanqui acquired a 24% stake in Sociedad Quimica y Minera (SQM)²¹ - Active participant in China’s Belt and Road Initiative - Due to BRI and increased Chinese investments, Chile may not be enticed into a grouping against China
Canada	Cobalt Lithium Nickel	<ul style="list-style-type: none"> - Ottawa has joined Washington in addressing the economic threats from China. Banned Chinese investments in Canadian lithium – announced under the Investment Canada Act on October 28, 2022, the government stated that “investments by SOEs and foreign-influenced private investors in Canadian entities in the critical minerals sectors would be scrutinized more closely”²²) - Through the USMCA, FTA with the US making it eligible for benefits under IRA - Potential to capitalize on the market size of the US to attain economies of scale - Higher ESG standards - Several bilateral critical mineral-related exchanges – Canada-U.S. Joint Action Plan on Critical Minerals; Canada-EU Strategic Partnership on Raw Materials; Canada-Japan Sectoral Working Group on Critical Minerals 	<ul style="list-style-type: none"> - High ESG standards and civil society (indigenous lands) opposition to mining - Lacks midstream and downstream mining capabilities - Critical mineral mining is a work in progress and not as established as uranium, gold, and diamonds
Korea	Lithium	<ul style="list-style-type: none"> - Fastest growing processor of minerals (midstream) - Seoul has an active FTA with Washington - Excluding upstream, Korean companies are the strongest competitors to Chinese near-monopolies 	<ul style="list-style-type: none"> - Does not possess critical minerals - Will not be keen to become part of any anti-China coalition

Figure 8. Advantages and disadvantages of different friendly-shores. Source: Author’s complication.

¹⁹ The Canadian Critical Minerals Strategy, Government of Canada: <https://www.canada.ca/en/campaign/critical-minerals-in-canada/canadian-critical-minerals-strategy.html>

²⁰ Lithium majors Tianqi and SQM make a swoop for Australian juniors, Benchmark Source: <https://source.benchmarkminerals.com/article/lithium-majors-tianqi-and-sqm-make-swoop-for-australian-juniors>

²¹ Lithium Monopoly in the Making? Beijing Expands in the Lithium Triangle, Geopolitical Monitor:

<https://www.geopoliticalmonitor.com/lithium-monopoly-in-the-making-beijing-expands-in-the-lithium-triangle/>

²² Chinese investors ordered to divest interests in the critical minerals sector, Dentos:

<https://www.dentos.com/en/insights/articles/2022/november/25/chinese-investors-ordered-to-divest-interests-in-critical-minerals-sector>

Furthermore, the government has repeatedly prioritized funding for critical mineral projects:

- US\$1.5 billion for the Strategic Innovation Fund (SIF) to support critical minerals projects, with preference given to advanced manufacturing, processing, and recycling applications.
- US\$40 million to support northern regulatory processes in reviewing and permitting critical minerals projects.
- US\$21.5 million to support the Critical Minerals Centre of Excellence (CMCE) to develop federal policies and programs on critical minerals and to assist project developers in navigating regulatory processes and federal support measures.

The SIF is the most significant direct funding mechanism in Canada’s toolkit presented under its critical mineral strategy. It aims to support projects that decrease or remove reliance on foreign critical mineral inputs across a range of priority industrial sectors or technologies. As a result, it could help grow Canada’s critical mineral value chains in areas of research, development, extraction, processing, manufacturing, and/or recycling.

Commercial Viability

While Australia, through the sheer magnitude of its critical mineral reserves, constitutes a strong candidate for friend-shoring, it has nonetheless become largely dependent on the Chinese market for its exports across sectors, including critical minerals. This level of export reliance has made it vulnerable to acts of economic coercion.

In an address to the National Press Club in late February 2023, Australian Prime Minister Anthony Albanese used AUKUS and critical minerals supply chains in the same sentence, ending the divide between national security policymaking and trade policymaking in Australia. “It’s about

our sovereign capability, it’s about our defense,” Albanese said of AUKUS and local manufacturing. “But it is also about our industry policy, about our economy, about jobs here.” “We need to not just dig it up. I want to make sure we use lithium and nickel and other products. We must make batteries here,” he continued, adding “that’s part of the vision of protecting our national economy going forward. I think we should be making solar panels here. I think we should be making so many more things here in order to protect our national sovereignty.”²³

Albanese administration’s push for setting up midstream operations within its borders through the National Reconstruction Fund of A\$15 billion is a meager amount compared to China’s investments in the sector over the last two decades. Notably, while the leadership was speaking of protectionism and new industrial policies, the private sector had different plans. Core Lithium started exporting lithium to China as recently as January 2023. Furthermore, continuing the trend of the last two decades, Chinese companies have sought a stake in West Australian mining firms. While the overall investment had dropped significantly from A\$477 billion to less than A\$300 billion between 2021 and 2022, the M&A (mergers and acquisitions) in Australia witnessed a A\$136 million bid by Chinese company Tianqi Lithium for Australian lithium developer Essential Metals.

Over the last three years, Chinese state-owned mining companies have acquired stakes in the largest major mines outside China, such as 51% in the Greenbushes in Australia, a 23.8% stake in Chile’s SQM, and a 50% stake in the Cauchari-Olaroz mine in Argentina.

Albeit the M&A data and investment inflow into China portrays a strong interconnectedness and persisting overreliance on China, companies such as Piedmont – a lithium processing company that

Location	Name of company (country of origin)	Capacity (in tons per year)
 Mount Holland, Australia	SQM (Chile), Wesfarmers (Australia)	45,000
 Xuxa, Brazil	Sigma Lithium (Canada)	60,000
 Sal de Vida, Argentina	Galaxy Resources (Australia)	15,000

Figure 9. Mining expansion by friendly shores. Source: Nikkei Asia.

²³ Albanese: Keep critical minerals in Australia, make our own batteries, The Sunday Morning Herald:

<https://www.smh.com.au/politics/federal/albanese-keep-criticalminerals-in-australia-make-our-own-batteries-20230222-p5cmnn.html>

redomiciled to the US from Australia – demonstrate the plausibility of Western companies being enticed by generous government support.

Furthermore, several Australian and Canadian companies are making investments in other parts of the world while not foregoing the Chinese market in its entirety, as shown in Figure 9.

In the US, the Midwest, South, and Southwest have capitalized on Washington’s industrial policies. Particularly, companies such as Tennessee Lithium have planned lithium hydroxide production facilities in small-town America such as Etowah in McMinn County in Tennessee.²⁴ Once fully operational, the plant will produce 30,000 MT of lithium hydroxide per year – double the amount of total lithium hydroxide currently produced in the US. Not very far from this production facility (see Figure 5), another lithium project in Gaston County, North Carolina, is planned to be a fully integrated site.²⁵ This facility is located within the renowned tinspodumene belt in North Carolina. These companies have moved their facilities or revived production since their end-customers, such as EV manufacturers, have been left with no choice but to move their production to the US to avoid losing the market. For example, Toyota has announced that Rutherford County, North Carolina, will be the home of its new EV battery plant. VinFast and Forza have chosen Chatham County and McDowell County for their electric-powered cars and boats, respectively.²⁶ Battery manufacturing in Kansas, automobile manufacturing in Georgia, graphite processing in Louisiana, and semiconductor manufacturing in Ohio, Arizona, and Texas jump-start the revival of American manufacturing – both through American companies and companies from partners and allies.

With LG chemicals and Piedmont signing a deal for access to lithium,²⁷ the value chain is rapidly changing from an overreliance on a state-owned company or a single country.

The US’s northern neighbor, Canada, has also witnessed several such private sector initiatives. To name a few, American GM and Korean POSCO have established a joint venture to produce cathode materials in Becancour, Quebec.²⁸ LG Energy solutions and Stellantis have set up a joint venture for a US\$5 billion EV plant in Windsor, Ontario.

Indonesia has taken a similar approach to establish an indigenous ecosystem for mineral processing and EV manufacturing. However, as mentioned earlier, the sector is largely dependent on Chinese capital, dismissing benefits from friendshoring. Nevertheless, its private sector has raised funds from venture capitalists in California, complicating the trade relationship. Figure 10 shows a list of Indonesian companies across the value chain that started in the last decade or so.

Challenges Closer to Home

American mining giant Albemarle’s case could prove to be the biggest challenge for friend-shoring critical mineral supply chains and reducing the reliance on China. The North Carolina-headquartered lithium mining giant has invested heavily in the production of lithium in China. As recently as 2021, Albemarle signed investment agreements with the Pengshan Economic Development Park in the Pengshan District in Sichuan province, as well as the Yangtze River International Chemical Industrial Park in the Zhangjiagang Free Trade Zone in Jiangsu province.²⁹ While market dependence is one challenge to overcome, the near monopoly of Chinese companies in the upstream of the critical mineral mining value chain such as batteries has proven to be a harder challenge to overcome.

²⁴ Piedmont Lithium plans to manufacture lithium hydroxide in the US, Nation World: <https://nationworldnews.com/piedmont-lithium-plans-to-manufacture-lithiumhydroxide-in-the-us-electrical-com/>

²⁵ Piedmont Lithium: <https://piedmontlithium.com/projects/carolina-lithium/>

²⁶ Forza: <https://edpnc.com/forza-x1-announcement/>

²⁷ <https://www.automotivelogistics.media/battery-supply-chain/lg-chem-secureslithium-supply-in-north-america-with-piedmont-deal/43934.article#:~:text=LG%20>

[Chem%20has%20signed%20an,6%25%20stake%20in%20the%20company](https://www.automotivelogistics.media/battery-supply-chain/lg-chem-secureslithium-supply-in-north-america-with-piedmont-deal/43934.article#:~:text=LG%20)

²⁸ GM Expands its North America-focused EV Supply Chain with POSCO Chemical in Canada, GM: <https://news.gm.com/newsroom.detail.html/Pages/news/us/en/2022/mar/0307-posco.html>

²⁹ Albemarle breaks ground to mark the start of construction of new lithium conversion facility, Albemarle: <https://www.albemarle.com/blog/albemarle-breaks-ground-inchina-to-support-the-expansion-of-lithium-conversion-capacity>



 Electric two-wheelers	 Battery materials	 Commercial EVs
<ul style="list-style-type: none"> - Bike Smart Electric - Energi Kreasi Bersama - Gaya Abadi Sempura - Ilectra Motor Group - Smoot Motor 	<ul style="list-style-type: none"> - Adaro Minerals Indonesia - Aneka Tambang - Bukaka Teknik Utama - Ceria Metalindo Prima 	<ul style="list-style-type: none"> - Bakrie & Brothers - Indika Energy

Figure 10. Indonesian companies across the critical mineral value chain. Source: Author’s complication.

Critical mineral	Company	Country of origin
Lithium	Albermale Corp	US
Cobalt	Glencore	Switzerland
Nickel	Norlisk Nickel	Russia
Graphite	Syrah Resources	Australia
Manganese	South32	Australia

Figure 11. Leading critical mineral mining companies and their countries of origin. Source: Author’s complication.

Risk Assessment

In June 2021, the White House released the National Blueprint for Lithium Batteries report,³⁰ essentially outlining the future of the industry from 2021 to 2030. Subsequently, in a report released in early 2023, Li-Bridge³¹, the public-private alliance convened by the US Department of Energy (DOE) and managed by Argonne National Laboratory, addressed outstanding questions on the feasibility of reshoring supply chains and offered 26 recommendations. However, upon reviewing the report, private consulting firms such as supply chain risk consulting firm, Resilinc, have highlighted that the US cannot reshore entire supply chains all by itself as the report suggests.³² Resilinc recommended a PanAmerican approach, suggesting friend-shoring in the region as a final plug for achieving supply chain resiliency. However, the pathway to friend-shoring critical

mineral supply chains near or afar has several short-term challenges and requires consideration of long-term impacts.

1. Near Monopoly at the Top of a Hierarchical Network of Value Chains – CATL

As Farrell and Newman identified in their paper on weaponized interdependence,³³ countries at the top of the hierarchical network of value chains can weaponize their position against the ones below them. In the critical minerals sector, China not only enjoys the top position in the critical mineral value chain but also in the end-use battery value chain. China’s CATL has the largest market share³⁴ for a single company, with only Korean battery makers trailing behind. While Korean and even Japanese battery makers trail CATL, for immediate needs American companies have at times chosen CATL.

³⁰ National Blueprint for Lithium Batteries: https://www.energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf

³¹ Bridging the U.S. Lithium Battery Supply Chain Gap, Argonne: <https://www.anl.gov/li-bridge>

³² https://www.resilinc.com/blog/li-bridge-domestic-lithium-batteries/?utm_campaign=Oktopost-Blogs&utm_content=Oktopost-LinkedIn&utm_medium=social&utm_source=LinkedIn

³³ Carolina lithium, Piedmont Lithium: <https://direct.mit.edu/isec/article/44/1/42/12237/Weaponized-Interdependence-How-Global-Economic>

³⁴ CATL dominates the global EV battery market for sixth straight year, Electrek: <https://electrek.co/2023/02/08/catl-dominates-global-ev-battery-market-sixth-straight-year/#:~:text=Based%20on%20battery%20usage%20in,market%20drop%20by%20over%206%25.>

Ford's move from Virginia to Michigan is a case in point. Post-IRA, American automobile pioneers such as Ford have sought Chinese partners such as CATL for their battery-powered vehicles. When Republican Governor Glenn Youngkin of Virginia rejected Ford's proposal to set up a plant in his state citing its partnership with Chinese battery maker CATL,³⁵ Ford, instead of canceling their proposed partnership, moved to Michigan and proceeded to license the technology from CATL.

There is increased awareness and concern over this monopoly – more than US\$80 billion in federal spending is allocated for batteries in the IRA and BIL. However, in the near term, CATL is the market leader and companies (including American) due to cost concerns may continue to use CATL through loopholes in the IRA.

2. Without “Rules of Origin” Mandates Friend-Shoring Becomes Frenemy-Shoring

Mandates pertaining to “rules of origin³⁶” will distinguish between friend-shoring and “frenemy-shoring” as friendly nations have been used by countries to rout their goods averting trade tariffs, anti-dumping, and other countervailing duties. The case of solar panels coming from China via Southeast Asia is a case in point. In mid-2022, the Department of Commerce opened an investigation into solar cell and module imports after the California-based solar manufacturer, Auxin Solar, raised the issue.³⁷ The company alleged that the parts were made by Chinese companies operating out of Malaysia and other Southeast Asian nations. The critical mineral industry is highly vulnerable to this challenge as the entire value chain and note processing of minerals is undertaken by China or by Chinese companies. These companies are operating in third countries such as Indonesia, as part of the Belt and Road Initiative. Alternatively, given the dominance of Chinese state-owned companies in the field and their M&A deals, companies in Australia and Chile are not immune to this challenge either.

³⁵ Youngkin Says Ford Has ‘Trojan Horse’ Relationship With Chinese Battery Maker, Bloomberg: <https://www.bloomberg.com/news/articles/2023-01-20/youngkin-callsford-catl-battery-plant-plan-a-trojan-horse>

³⁶ Technical Information on Rules of Origin, WTO: https://www.wto.org/english/tratop_e/roi_e/roi_info_e.htm#:~:text=Definition,upon%20the%20source%20of%20imports.

³⁷ Department of Commerce Issues Preliminary Determination of Circumvention Inquiries of Solar Cells and Modules Produced in China,

3. Race to Climate Change Goals and ESG

The Indonesian documentary From Dreams to Dust about the coastal community of Tapunggaeya, a mining town in Indonesia, brought to light the ugly side of mining for lithium-ion batteries. Sulawesi's mines have a devastating impact on the environment and people's lives.³⁸ As automobiles move away from the internal combustion engine to the electric vehicle, mining for nickel, lithium, and cobalt increases multifold. From Congo to Indonesia, the progression in the value chain comes at the cost of regression in environmental protection. While in Indonesia it is the local communities and the wild forests that are damaged, in places such as Chile, aquifers have been damaged with the country losing a few of its most needed freshwater reserves (in the Atacama Desert). As countries move away from the internal combustion engine and towards cleaner technologies, the damage done by these “cleaner” sources will witness further scrutiny. This will subsequently slow down the process of friend-shoring and attaining supply chain resiliency. Moreover, these environmental challenges are not limited to foreign shores. The US has grappled with this challenge since the founding of the Environmental Protection Agency (EPA). More recently, the work on the Rhyolite Ridge deposit, home to one of two known lithium-boron deposits, has stalled its approval due



From Congo to Indonesia, the progression in the value chain comes at the cost of regression in environmental protection.

US Department of Commerce: <https://www.commerce.gov/news/press-releases/2022/12/department-commerce-issues-preliminary-determination-circumvention>

³⁸ Mining turned Indonesian seas red. The drive for greener cars could herald a new toxic tide, The Washington Post: https://www.washingtonpost.com/world/asia-pacific/mining-turned-indonesian-seas-red-the-drive-for-greener-cars-could-herald-a-new-toxic-tide/2019/11/19/39c76a84-01ff-11ea-8341-cc3dce52e7de_story.html

to its proximity to a site with the endangered wildflower Tiehm's buckwheat.³⁹

However, this is no recent phenomenon. Across the US, from Minnesota to Arizona to Alaska, mining operations and local communities have been at odds. Native American tribes have opposed mining operations on the reservations. Given the history of protests associated with Standing Rock and others, US administrations, particularly Democratic ones, may not be able to so easily kickstart mining operations.

Since the Obama years, the EPA through climate-related regulations has been an impediment to operating mines in the US. While the Trump administration deregulated and worked toward reopening mines, the Biden administration is in a quandary as it champions inclusivity, environmental protection, reviving manufacturing, and competition with China.⁴⁰

While the China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters (CCCMC) lays out guidelines for responsible mining operations, several independent watchdogs have raised questions about its mining practices abroad.⁴¹ Moreover, European nations have clamped down on their corporations that engage in unethical practices in nations such as the DRC. Regulations such as Switzerland's Conflict Minerals and Child Labor Due Diligence Legislation, France's Corporate Duty of Vigilance Law, Germany's Supply Chain Act, and Norway's Transparency Act are tailored to address violations in the critical mineral sector.

4. Bifurcation of the World into Democracy Vs. Autocracy

The US has time and again sought to divide the world based on ideological groupings. However, natural resources are not always located in democracies. This complicates measures toward reducing reliance on

China. While the Trump administration initiated the study and analysis of the extent of overreliance on China for critical minerals, the Biden administration built on it. Nevertheless, the distinction is the Biden administration's focus on democracy promotion and building partnerships based on ideologies over strategic interests. This provides countries such as China that invest in high-risk projects in autocracies and nations with unstable governments such as Zimbabwe, Bolivia, etc. more opportunities. For example, the US-led Mineral Security Partnership is a coalition of nations based on their roles in the mineral supply chain and their ideological alliance. Similarly, US efforts to bring the UK and South Korea into an alliance for the securitization of critical mineral supply chains are efforts at restricting the partnerships to existing relationships. Traders in China had a similar initiative, however, limited to Chinese companies that controlled the manganese trade.⁴²

5. Changes in Battery Chemistry from Technological Advancements

Technological advancements in the battery sector have disrupted capital investments in the industry. Innovation provides batteries of various compositions that are viable in the long term due to their chemistry. They efficiently use scarce minerals such as nickel and hard-to-access minerals such as cobalt.⁴³ This has incentivized companies to seek alternate chemistries such as manganese in place of cobalt⁴⁴, sodium-ion batteries, and even zinc-based batteries. This poses a unique challenge to the highly capital-intensive industry. Hence market intervention through industrial policies could lead to inefficient use of taxes. The end use battery determines the fate of critical minerals. Lastly, nations that do not possess viable mines nor have resources to access minerals may choose green hydrogen and other engines for their clean energy transition.

³⁹ BLM issues trespass notice to lithium developer Ioneer for unauthorized use of Tiehm's buckwheat habitat, Green Car Congress: <https://www.greencarcongress.com/2023/01/20230121-blm.html>

⁴⁰ ESG Watch: Biden's 'made-in-America' climate legislation ruffles feathers with trading partners, Reuters:

<https://www.reuters.com/sustainability/esg-watch-bidensmade-america-climate-legislation-ruffles-feathers-trading-partners>

⁴¹ China's Role in Supplying Critical Minerals for the Global Energy Transition, LTRC: https://www.brookings.edu/wp-content/uploads/2022/08/LTRC_ChinaSupplyChain.pdf

⁴² China Hones Control Over Manganese, a Rising Star in Battery Metals, The Wall Street Journal: <https://www.wsj.com/articles/china-hones-control-over-manganese-a-risingstar-in-battery-metals-11621597490>

⁴³ Manganese demand rising as alternative cathode chemistries gain popularity, Benchmark Source: <https://source.benchmarkminerals.com/article/manganesedemand-rising-as-alternative-cathode-chemistries-gain-popularity>

⁴⁴ Manganese Replaces Cobalt Helping Tesla Benefit from it's New Technology - Report by Manganese X Energy Corp, Globenewswire: <https://www.globenewswire.com/news-release/2020/12/29/2151098/0/en/Manganese-Replaces-Cobalt-Helping-TeslaBenefit-from-it-s-New-Technology-Report-by-Manganese-X-Energy-Corp.html>

Conclusion

The US, Europe, and Japan have become patently aware of the risks associated with a single closed economy controlling entire value chains – particularly as China’s ability to weaponize its hegemony against the West’s own clean energy transition and progress in the fourth industrial revolution becomes evident with its export control measures and securitization of commodity trade, such as the closed loop in manganese supply chains and bilateral deals through the BRI. While the US has used the IRA, BIL, and other legislations and Europe has unveiled its Critical Raw Materials Act, these legislation are not immediate fixes. Moreover, industrial policies in the US and Europe are limited by external and internal factors, respectively. In the US, legislation has been amended and tailored to assuage the concerns of allies and partners, resulting in watered down bills. In Europe’s case, the CRM Act itself is limited in scope and not as ambitious as the IRA or other legislation in the US. While the US has set a target of 80% indigenization by 2029, the European Union through the CRM Act has proposed only 10% of the raw critical minerals consumed to be mined in the region, 15% of needs met by recycled sources, and 40% of all critical minerals be processed within the EU.⁴⁵ Furthermore, Europe has not taken as antagonistic an approach as the US toward China and its corporations, particularly as automakers count on the Chinese market for exports. This limits European policymakers’ options in limiting imports from foreign markets such as China.

In 2023, it takes ten-plus years to build and finance a lithium mine in most parts of the world, whereas a gigafactory can be built in less than two years.⁴⁶ As it stands, permissions for a mine in the US take more than a decade’s time.⁴⁷

The success of friend-shoring relies on supply quickly meeting demand. Governments should accelerate measures toward supporting friend-shoring of different parts of the supply chain for mining while also rapidly transforming the attainable end-use industry of battery manufacturing. Rather than deregulating environmental standards, governments could ease the burdens of doing

business by efficiently approving mining permits. Such compromises will not offer the highquality and standard of agreements and operations that the US champions against China’s practices.

“Lithium is the new oil” has become the new catchphrase. Unfortunately, this reality is as geopolitically inflammatory as the oil wars were. For example, the economic competition between Chile and Bolivia, or the recent discovery of lithium in Kashmir, could quickly evolve into a larger security challenge. While securing resources from partners, knowledge of pre-existing disputes is crucial to avoiding flaring geopolitical tensions.

The USMCA provided a template for high-quality trade agreements by mandating vehicle manufacturers produce at least 75% of automobile components in the trade zone.⁴⁸ Similarly, friend-shoring of critical minerals will be a success only if “rules of origin” are mandated and provisioned in all security and trade partnerships.

In conclusion, Canada, followed by Chile and Australia present the most viable options for friend-shoring critical mineral supply chains in the Indo-Pacific region.

⁴⁵ Critical Raw Materials: ensuring secure and sustainable supply chains for EU’s green and digital future, European Commission: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1661

⁴⁶ The ‘land grab’ for lithium is just getting started with GM deal, says EV materials expert, CNBC: <https://www.cnbc.com/2023/01/31/land-grab-for-lithium-is-justgetting-started-with-gm-expert-says.html>

⁴⁷ Push to shorten U.S. mine permit review process gains steam, Reuters: <https://www.reuters.com/business/autos-transportation/push-shorten-us-mine-permit-reviewprocess-gains-steam-2022-09-01/>

⁴⁸ USMCA, Trump’s new NAFTA deal, explained in 600 words, Vox: <https://www.vox.com/2018/10/3/17930092/usmca-mexico-nafta-trump-trade-deal-explained>

3

Friend-shoring battery supply chains

BY AKHIL RAMESH AND
ROB YORK



Executive Summary

Akhil Ramesh and Rob York

The production of electric vehicle batteries is among the greatest vulnerabilities in the global supply chain, and among the most reliant on friend-shoring away from China’s industrial policies since the early 2010s, when it emerged as an industry leader internationally. This study finds that the most likely sources for increased battery production are Japan and South Korea, as technologically savvy countries that have accomplished similar successes in moving up high-tech value chains. To adequately counter China’s dominance over the sector, Tokyo and Seoul’s current and prospective partners must not only support the development of these countries’ battery manufacturing sectors but also apply more stringent standards for companies interested in manufacturing domestically and demonstrate greater concern for what the future of EV production means for their security.



The most likely sources for increased battery production outside of China are Japan and South Korea, as technologically savvy countries that have moved up the high-tech value chain in similar fashion.

Introduction

In the second paper of our four-paper series on friend-shoring on critical mineral supply chains, we concluded with the policy assessment that private sector participation is key to friend-shoring and that the Australian and Canadian governments and enterprises have a large role to play in the process.¹

Since then, successive developments have advanced friend-shoring of critical mineral supply chains. In the US, for example, the Australia-United States Climate, Critical Minerals, and Clean Energy Transformation Compact, and Japan-US Critical Minerals Agreement show how the Quadrilateral Security Dialogue has expanded the supply chain security initiative to include critical minerals.² The Canadian government has also taken the lead, announcing ambitious plans to anchor the US-Canada partnership in critical minerals and technology, while Washington has also released new emissions standards and the Department of the Treasury outlined the parameters to make available tax credits for EV purchases. And in an interesting turn of events, American oil giant (now energy giant) Exxon Mobil announced exploration of lithium mining in Alaska.³

These developments reiterate the need for, and the active role played by, different governments and private entities in friend-shoring mining operations. While these are positive developments to friend-shore critical mineral supply chains, the set of challenges in the next step in the value chain of battery manufacturing is a whole different beast.

Global battery production is set to surpass one terawatt-hour (a unit of energy equal to producing 1 trillion watts for one hour) for the first time in 2023. Much of that growth is in China. Unlike in sectors such as active pharmaceutical ingredients (APIs) and pharmaceuticals, semiconductors or even critical minerals – the American auto sector has repeatedly failed (see Figure 1) to develop a viable mass market for electric vehicles (until Elon Musk’s Tesla began commercial production in 2008) and, as a result, much of the value chain, including lithium-ion

batteries, resides in China or other parts of East Asia. In the US, car producers focused on ever more powerful internal combustion engines and the lead-acid battery. Japan, once a leader in this sector, has seen its market share in the battery market erode over the last decade, and South Korea, while rapidly growing, cannot compete with a market as big as China’s without support from an equally large market such as the United States.

The lead-acid battery was invented by French chemist Gaston Plante in 1859.⁴ Interestingly, in the early years of its invention, neither the inventor nor businesses foresaw its applicability to the automobile sector. While Elihu Thomson and Edwin Houston foresaw its potential applications in lighting systems and general electrical systems, it remained a “laboratory curiosity” for decades after its invention.

Since the 1900s, American automobile manufacturers tested the EV in the American market only to face repeated failures.

The dawn of the automobile industry in the late 1800s saw the advent of the first electric cars, and by 1900 electric vehicles made up a third of total cars, giving gasoline cars a healthy competition. However, with the advent of high-speed railways and long-distance travel, by 1942 the electric car had its first death. Almost 100 years later in 1996, General Motors introduced EV1, the reimagined electric vehicle to the American automobile market. Once again, due to its limited range of 70 to 90 miles, and poor complementary public infrastructure (limited to California), demand was low, and less than 1,200 cars were manufactured.⁵

While American manufacturers and consumers were disillusioned with the promises of the EV, the demand for the vehicle picked up elsewhere. However, this took place much later – and vastly reformed.

The fatal flaw in experiments to diversify EVs away from China has been the batteries. American auto majors, for example, used lead-acid batteries to power them. These are too heavy, inefficient, and

¹ Friend-shoring critical mineral supply chains, Hinrich Foundation: <https://www.hinrichfoundation.com/research/wp/tech/friend-shoring-critical-mineral-supplychains/>

² Signing of the Japan-U.S. Critical Minerals Agreement (CMA), Ministry of Foreign Affairs, Japan: https://www.mofa.go.jp/press/release/press1e_000400.html

³ Exxon Joins Hunt for Lithium in Bet on EV Boom, Wall Street Journal: <https://www.wsj.com/articles/exxon-joins-hunt-for-lithium-in-bet-on-ev-boom-1d72cdd6>

⁴ SCIENTIST OF THE DAY - GASTON PLANTÉ, Linda Hall Library: <https://www.lindahall.org/about/news/scientist-of-the-day/gaston-plante#:~:text=In%201859%2C%20he%20invented%20the%20lead%2Dacid%20battery>

⁵ The General Motors CEO who killed the original electric car is now in the electric car business, Quartz: <https://qz.com/952951/the-general-motors-gm-ceo-who-killed-the-ev-1-electric-car-rick-wagoner-is-now-in-the-electric-car-business>

environmentally harmful to play a pivotal role in the transition to a clean energy economy.

With the nickel-hybrid batteries and later with the nickel cobalt manganese oxide batteries (NCMs), certain distance and range limitations were partly addressed. Nevertheless, American interest in EVs was limited to the West Coast of the US until the second half of 2010 because of climate-friendlier policies in some US states. Around that time, China acted swiftly and implemented targeted economic and trade policies to build out its indigenous industry. Furthermore, in the US, the debate surrounding EVs was caught in the crossfire of partisan US political bickering. As a result, despite North American scientists being at the forefront of most innovations in the battery sector, including the latest lithium iron phosphate (LFP) battery chemistry, the industry did not adequately capitalize on nor commercialize it.⁶

A decade earlier, the arguments favoring EVs were driven by climate and environmental activism. But in 2023, the bipartisan support for industrial policies for EV and aligned industries is anchored in the bipartisan consensus on the perceived “China threat”.

In the eastern hemisphere, the forward-looking and prudent industrial policies of the Chinese government gave Chinese industries a significant leg up. In 2011, when Bloomberg’s Betty Liu asked Elon Musk whether he foresees Chinese auto major BYD as a major competitor to Tesla, Musk laughed and replied, “Have you seen their car?”⁷

Fast-forward to 2022: BYD and Tesla are partners, and the Chinese auto giant sold 900,000 EVs in 2022, surpassing Tesla in the Chinese market.⁸

Such underestimation of competitors, combined with repeated market failures and China’s own successful industrial policy made it a major EV manufacturer

and, by extension, a battery manufacturer. The Chinese government enacted policies that assisted in the complete vertical integration of the EV supply chain.⁹

Since battery manufacturing depends on the end-use sector, i.e. automobiles and energy storage systems, China rapidly monopolized the sector with little to no competition in cathode and anode manufacturing and battery production. Market dominance in the automobile end-use sector gives an economy a significant comparative advantage, especially if they have a large domestic market to attain economies of scale in the sectors preceding it in the value chain.

Year	1907 – 1942	1996 – 1999	2008 – Ongoing
Product	<p>Detroit Electric</p> 	<p>EV1</p> 	<p>Tesla</p> 
Result	Failure	Failure	Success

Figure 1. The market speaks. Source: Author’s complication.

US National Security Advisor (NSA) Jake Sullivan, in his address at Brookings Institute in late April 2023, said:

“Now, no one—certainly not me—is discounting the power of markets. But in the name of oversimplified market efficiency, entire supply chains of strategic goods—along with the industries and jobs that made them—moved overseas. And the postulate that deep trade liberalization would help America export goods, not jobs and capacity, was a promise made but not kept. ... the People’s Republic of China continued to subsidize at a massive scale both traditional industrial sectors, like steel, as well as key industries of the future, like clean energy, digital infrastructure, and advanced biotechnologies. America didn’t just lose manufacturing—we eroded our competitiveness

⁶ Stanford R. Ovshinsky, Invent.org:

<https://www.invent.org/inductees/stanford-rovshinsky>

⁷ Elon Musk laughed at BYD in 2011. Warren Buffett’s Berkshire Hathaway has made nearly 40 times its money on the Chinese EV stock., Yahoo: <https://www.yahoo.com/now/elon-musk-laughed-byd-2011-125241496.html>

⁸ Tesla & BYD Confirm Powerful NEW EV Partnership, YouTube: <https://www.youtube.com/watch?v=i88MYsh0cCQ>

⁹ In microeconomics, management, and international political economy, vertical integration is a term that describes the arrangement in which the supply chain of a company is integrated and owned by that company. In this case, a group of Chinese companies work together to integrate their operations. How Does Vertical Integration Work? Pros, Cons and Examples, Oracle Netsuite: <https://www.netsuite.com/portal/resource/articles/erp/vertical-integration.shtml#:~:text=In%20economics%2C%20vertical%20integration%20is,also%20sell%20directly%20to%20customers.>

in critical technologies that would define the future.”¹⁰

As Figure 1 highlights, the American market did not favor EVs. The battery sector is one where the private sector failed to match the competition with global peers. Recognizing this limitation, the Biden administration included the battery sector as one of the “national security interests” in its supply chain review and, not surprisingly, the sector is one of the largest recipients of government benefits under the Inflation Reduction Act (IRA) and Bipartisan Infrastructure Law (BIL).¹¹

Changing the Batteries

The size of the US market means it will play a substantial role in diversification efforts, but a disconnect is clear: The US houses the world’s largest lithium mining and processing companies, and even the largest automobile manufacturers making EVs. However, the US does not house any of the world’s top 10 battery manufacturers to bridge the minerals to end-use EVs and energy storage systems (ESS).

Critical minerals are minerals that are essential to the economy and any disruption in their supply has broader national security implications. Processed critical minerals have a variety of uses from medicines to scientific research. However, over 70% of the critical minerals mined go into the manufacture of cathodes and anodes that go into batteries for mobile devices and consumer electronics and of late, a significant portion to EVs and energy storage systems (ESS). The lithium-ion battery largely in use for EVs and ESS can be developed using various chemistries such as NCM and LFP, among others.

Batteries are the highly value-added part of the value chain and moving up is a much more daunting task, particularly when there are no major American companies to take the lead. While in the case of critical mineral supply chains, large American mining corporations could partner with corporations in friendly nations to friend-shore supply chains, in the case of battery manufacturing there isn’t a single

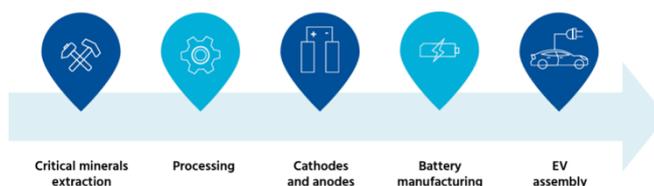


Figure 2. Battery supply chain. Source: US Steel Import Trends, International Trade Administration, US Department of Commerce, last accessed June 5, 2023.

American company among the top battery manufacturers of the world to ease the rapid transition to renewable energy or catch up to China’s dominance in the sector.

Cathode and Anode

In simple terms, a lithium-ion battery is made up of several individual cells connected to one another. Each cell contains three main parts: a positive electrode (a cathode), a negative electrode (an anode), plus a separator. Lithium is highly reactive in its elemental form and as a result, various combinations of the metal are used in batteries. Furthermore, batteries have a separator to prevent fires. When the cathodes and anodes touch, the highly reactive nature of the element can cause a build-up of heat, eventually leading to a fire or an explosion. These make the production process a capital-intensive process, often one concentrated amongst a few large corporations. China manufactures around 70% of cathode material for NMC batteries and over 99% for the cheaper alternative LFP batteries, plus 90% of anode material and 60% of battery cells for LFP batteries.¹²

Battery anodes contain a blend of natural and synthetic graphite. Fortunately for China, it is blessed with one of the world’s largest graphite reserves and is also a leading producer of the material. It mines over 65% of the graphite in the market and has a monopoly on converting it into spherical graphite. More than two-thirds of synthetic graphite produced from petroleum coke is produced in China. As a result, the global supply of naturally occurring and synthetic graphite vital for anode production is controlled by China.¹³

¹⁰ Remarks by National Security Advisor Jake Sullivan on Renewing American Economic Leadership at the Brookings Institution, White House: <https://www.whitehouse.gov/briefing-room/speeches-remarks/2023/04/27/remarks-by-national-securityadvisor-jake-sullivan-on-renewing-american-economic-leadership-at-the-brookingsinstitution/>

¹¹ FACT SHEET: Biden-Harris Administration Announces Supply Chain Disruptions Task Force to Address Short-Term Supply Chain Discontinuities, White House: <https://www.whitehouse.gov/briefing-room/statements-releases/2021/06/08/fact-sheet-bidenharris-administration-announces-supply-chain-disruptions-task-force-to-address-short-term-supply-chain-discontinuities/>

¹² Can the world make an electric car battery without China?, New York Times: <https://www.nytimes.com/interactive/2023/05/16/business/china-ev-battery.html>

¹³ Graphite poised to do a lithium, Mining.com: <https://www.mining.com/graphitepoised-to-do-a-lithium/>

Unlike pharmaceuticals, critical minerals, or even semiconductors, the room for maneuvering is limited. China enjoys a near monopoly at the top of the hierarchical network of value chains in battery manufacturing. The US, on the other hand, is counting on start-ups or mid-cap companies in its reshoring and friend-shoring projects. This becomes a David vs Goliath competition without the assistance of allies and partners in East Asia.

David Vs. Goliath

In the battery sector, corporations with strong government support and generous subsidies have found success around the world. Of note, Chinese battery manufacturers have grown exponentially over the last decade. Amongst the top ten battery manufacturers of the world by multiple measures (including existing capacity, planned production, market share, etc.), five are Chinese conglomerates. Leading the pack is Contemporary Amperex Technology Co. Limited (CATL), followed by BYD, Gotion, and China Aviation Lithium Battery Co., Ltd (CALB).¹⁴

Companies such as Ganfeng Lithium are highly integrated with the entire value chain, from lithium extraction to the production of solid-state batteries (see Figure 3). CATL is a leader in the latest battery chemistry LFP and the largest producer of lithium-ion batteries with 180 GWh of production in 2022.¹⁵

China's dominance in vertical integration across the EV value chain backed by rapid growth in the domestic EV market, and its recent technological advances increase the possibility of SVolt and Sunwoda joining the club of the world's top battery manufacturers.¹⁶

Interestingly, unlike its success with critical minerals, China's lead in battery manufacturing is only a recent development. A decade prior, China did not have a monopoly over the manufacturing of cathodes, anodes, or battery cells. Targeted industrial policies gave preferential treatment to domestic champions in

the early 2010s that jumpstarted the indigenous industry while simultaneously replacing foreign competition. For example, until 2015, Japanese and Korean battery manufacturers were the leading suppliers of batteries in China. As a result of the Chinese government's whitelisting of domestic companies, Korean and Japanese battery manufacturers were undercut by Chinese companies. Notably, akin to the current situation in the US, wherein it is counting on its start-ups and small-scale battery manufacturers to catch up to market leaders through the incentive-laden IRA, the Chinese state in the early 2010s generously supported what is today the behemoth CATL and BYD to take on foreign competition.¹⁷



In China, targeted industrial policies gave preferential treatment to domestic champions in the early 2010s that jumpstarted the indigenous industry while simultaneously replacing foreign competition.

lithium/#:-:text=Chinese%20control&text=The%20country%20supplies%2064%25%20of,90%25%20of%20the%20world's%20anodes

¹⁴ Top 10 Lithium-ion Battery Manufacturers in China 2023, Tritexbattery: <https://tritekbattery.com/lithium-ion-battery-manufacturers-in-china/>

¹⁵ China's energy storage lithium battery shipments are expected to reach 180GWh in 2025, AOT: <https://www.aotbattery.com/new/China-energy-storage-lithium-batteryshipments-are-expected-to-reach-180GWh-in-2025.html>

¹⁶ With net profit up 93%, China's CATL is so far ahead in the global EV battery race President Xi just told them to pull their heads in, MSN: <https://www.msn.com/en-au/money/markets/with-net-profit-up-93-china-s-catl-is-so-far-ahead-in-the-global-evbattery-race-president-xi-just-told-them-to-pull-their-heads-in/ar-AA18wSpl>

¹⁷ China Continues Support For New-Energy Vehicles Despite Subsidy Phaseout, S&P Global: <https://www.spglobal.com/marketintelligence/en/news-insights/research/china-continues-support-for-new-energy-vehicles-despite-subsidy-phaseout>

Global resources



Chinese production bases

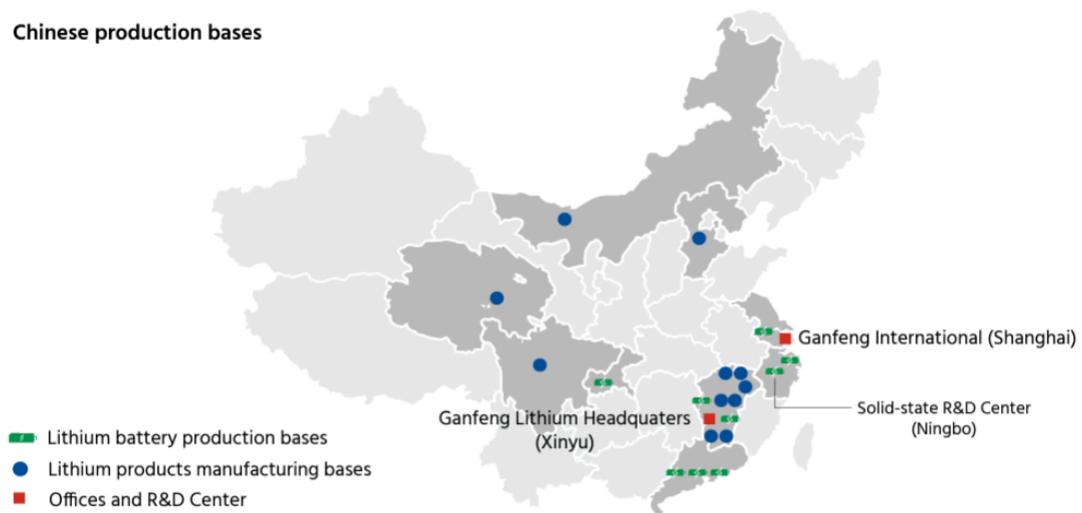


Figure 3. China's Ganfeng Lithium vertical integration across the global EV value chain. Source: Ganfeng Lithium.

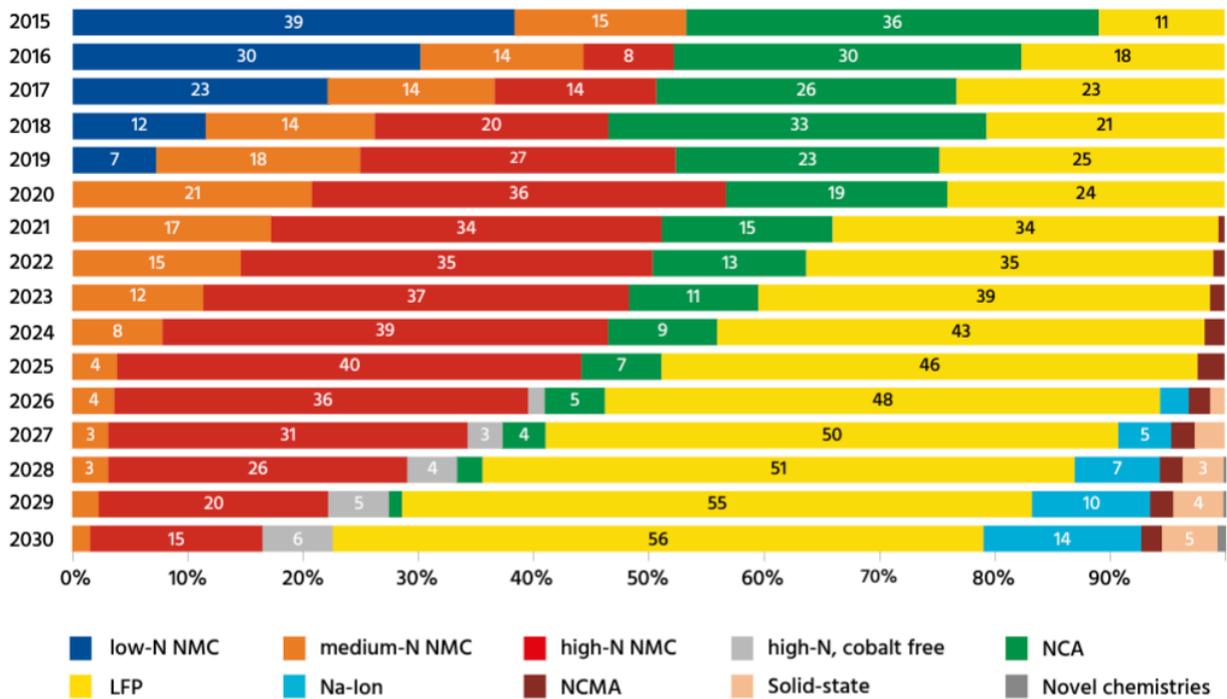


Figure 4. Forecast of battery chemistry usage. Source: Rystad Energy.

Nonetheless, while China made progress only in the second decade of the 21st century, the Chinese government had dedicated funds since 2001 for an indigenous battery sector under its 863 Program.¹⁸ Strong government support assisted the battery industry in rapidly transitioning to new chemistries. For example, CATL is rapidly moving away from NCMs to LFP battery cells, and the industry is forecasted to follow suit (see Figure 3). LFP batteries are more efficient, and the minerals used in them are more easily accessible than those used in NCM batteries. This has had consequences beyond China's domestic market. American auto majors have lost out to their Chinese peers in emerging markets such as Thailand, Vietnam, and other Southeast Asian countries.¹⁹ Chinese auto majors have expanded auto exports to Southeast Asia and have announced the setting up of new plants in the region.

Friendly Shores

The Biden administration's industrial policy, particularly for the battery sector, while covered under the IRA, heavily relies on America's partners to execute its ambitious plans. For partners such as Korea and Japan that have lost significant market share to China's whitelisting practices on the mainland, America's IRA provides an opportunity to increase their share of manufacturing in the global market and contest a more equally poised competition with their Chinese competitors. As referenced earlier, most American companies involved in the battery material value chain are in their nascent stages and do not have the capital-raising ability to take on large corporations in a rapidly evolving and technologically changing industry. Korean companies such as LG Energy Solution (LGES), SK On, and Samsung SDI, plus Japan's Panasonic are investing in the battery sector in the North American market as a direct result of the subsidies offered under the IRA.

This, in part, is a product of the Biden administration's diplomatic offensive in getting historical rivals South Korea and Japan under one umbrella via the CHIP4 alliance and other groupings. The recent revival of Seoul-Tokyo relations bodes

well for future cooperation between these parties with frequently tense relations but who both have a history of successful state-led technological innovation. Furthermore, both countries have recently shown more interest in economic security as a topic, as well as concern about China.

Japan

Until the early 2000s, Japan was the market leader in lithium-ion battery manufacturing with a 90% market share.²⁰ Companies such as Sony leveraged their highly automated manufacturing processes to develop automated lithiumion manufacturing.

In the first quarter of 2023, China overtook Japan to become the world's leading exporter of automobiles, spurred by rising global demand for EVs; Japanese battery manufacturers have less than 10% of the global market share in the lithium-ion battery market and trail even their South Korean competitors, which entered the competition at a much later stage. Nonetheless, industrial policies in both Tokyo and Washington could change those figures. There are only a select few large battery makers in Japan, namely Panasonic, Mitsubishi, and Toshiba. Japanese companies such as Asahi Kasei, Toray Industries, and Sumitomo Metal Mining are market leaders in the manufacturing of separators and positive electrode materials, respectively.²¹ However, without intervention in the market they could, much like their battery manufacturers, they could also begin to trail their Chinese peers.

In mid-2022, Tokyo's Economy, Trade, and Industry Ministry unveiled its industrial strategy setting a target of increasing the manufacturing capacity of Japanese manufacturers to 600 GWh (globally) by 2030, equivalent to 14.4 million units of standard EV batteries and domestic production capacity of EV and energy storage batteries at 150-gigawatt hours (GWh) by 2030.²²

The Japanese government is targeting 20% of global market share by 2030. That target would require coordination and support from Washington, New Delhi, and Brussels. Japan had a 25% market share in 2018 which has since declined to less than 10%, with

¹⁸ The rise of China's new energy vehicle lithium-ion battery industry: The coevolution of battery technological innovation systems and policies, Science Direct: <https://www.sciencedirect.com/science/article/pii/S2210422422001204>

¹⁹ China is upping its bets on Southeast Asia's EV market as South Korea drives to narrow the gap, PingWest: <https://en.pingwest.com/a/11751>

²⁰ China's Electric Vehicle Battery King, Time:

<https://time.com/6217992/china-electricvehicle-catl/>

²¹ Japan's battery startups take the world beyond lithium ion, Nikkei Asia: <https://asia.nikkei.com/Business/Technology/Japan-s-battery-startups-take-the-world-beyondlithium-ion>

²² Japan to expand storage battery production to meet demand, Japan News: <https://japannews.yomiuri.co.jp/business/economy/20220914-57966/>

both Chinese and Korean battery makers taking big slices of the battery market pie. In the period in which Japanese battery makers lost market share, Chinese market share went from 49% to 67% and Korean battery makers went from the single digits to over 25%. Panasonic is the only Japanese company in the top 10 battery manufacturers so far in 2023.²³ To revive its dwindling share in the battery market, Japan will not only require strong domestic industrial policy, but policies limiting Chinese batteries in Japan, preferential treatment in large auto markets of the world, and strategic joint ventures that enable the other three developments. Over the last few years, Panasonic has embarked on such a strategic partnership drive through a joint venture with Toyota PPEs to develop a 20 GWh capacity gigafactory.²⁴

Korea

Korean battery manufacturers have a significant lead over their Japanese peers. With a third of the market with Korean companies such as LG Chemicals, SK, and Samsung, Korean battery manufacturers are strong contenders to diversify battery supply chains. Of note, while Seoul has expressed its discontent with the IRA, which it initially perceived as undercutting existing trade agreements, the existing and planned investments in the US through the generous support offered under IRA provisions give Korean companies a significant lead in the American market. Seoul was an early adopter of targeted industrial policies for the battery industry. According to the government's plan, three companies – LGES, Samsung SDI, and SK On – will be supported to manufacture next-gen batteries, as well as invest in research and development and in allied industries such as separators. In response to the US IRA, the Korean government has offered generous support to Korean businesses to capitalize on the benefits of the IRA. The Export-Import Bank of Korea and state-owned Korea Trade Insurance are to provide around US\$5.3 billion in loans to support Korean battery manufacturers in the US over five years, starting in 2023.²⁵



Most American companies involved in the battery material value chain are in their nascent stages and do not have the capital-raising ability to take on large corporations.

Akin to the US approach to supporting select industries, the Korean government under Yoon has offered support to the battery industry and set an ambitious yet achievable target of 40% of the global market share by 2030.²⁶

Like the US transformation of the Rust Belt into the “EV Belt,” the Korean government is transforming a town known for its steel industry into its EV capital. The city of Pohang is undergoing a radical transformation with EV industries moving in. The city, known as the “miracle of Yeongil Bay” for transformational developments (including in steel²⁷), is once again leading the industrial policy implementation.²⁸

The Yoon government plans to expand the size and scale of investment tax credits from 8% to 15% for large companies and from 16% to 25% for small and medium sized enterprises, and the scope of the credits to include mineral processing. These measures, scheduled to expire in 2024, have been extended until 2025.

The prospects are strong for vertical integration of the battery value chain in Korea. POSCO is actively setting up lithium processing facilities, LG Chemicals is the leading battery manufacturer in Korea (ranked 2nd worldwide), and Hyundai is a leading

²³ Global Power Battery Installation Ranking in Q1 2023 – CATL First, BYD Second, Car News China: <https://carnewschina.com/2023/05/03/global-power-battery-installationranking-in-q1-2023-catl-first/#:~:text=Panasonic%20was%20the%20only%20Japanese,in%20the%20North%20American%20market.>

²⁴ Toyota to invest up to \$5.6B in battery production in Japan and US, Green Car Congress:

<https://www.greencarcongress.com/2022/09/20220901-toyota.html>

²⁵ South Korea to provide battery industry more support, Argus Media: <https://www.argusmedia.com/en/news/2437593-south-korea-to-provide-battery-industry-moresupport>

²⁶ S.Korea to inject \$15 bn in rechargeable battery sector by 2030, The Korea Economic Daily: <https://www.kedglobal.com/batteries/newsView/ked202304200022>

²⁷ History of POHANG IRON AND STEEL COMPANY LTD., Reference for Business: <https://www.referenceforbusiness.com/history/2/83/POHANG-IRON-AND-STEEL-COMPANYLTD.html>

²⁸ Billions Pumped Into Korea Battery City With China In its Sights, Bloomberg: <https://www.bloomberg.com/news/articles/2023-03-15/battery-makers-plow-31-billion-intoremaking-korean-steel-hub>

manufacturer of automobiles. This trio is positioned to achieve economies of scale in large markets.

An Emerging Trilateral

US automakers are stepping up collaboration with Japanese and Korean battery investors in North America. While China boasts cost advantages in anode materials production as a product of abundant graphite mineral resources, Japanese manufacturers are in a leading position technologically. South Korean battery maker SK On is limiting its exposure to the Chinese market by supporting an American start-up Urbix to develop anode materials in the US.²⁹

LG Energy Solution is planning on increasing its capital expenditure by 50% in 2023 from US\$5 billion in 2022 as it targets an annual production capacity of 300 GWh by the end of 2023.³⁰

The IRA: An Incentive-Laden Gauntlet

A lion’s share of the IRA subsidies goes towards battery manufacturing and mineral processing facilities (see Figure 5).

In 2022, energy installations globally almost double from a year earlier to 75 GWh. China and the US both accounted for much of this increase.

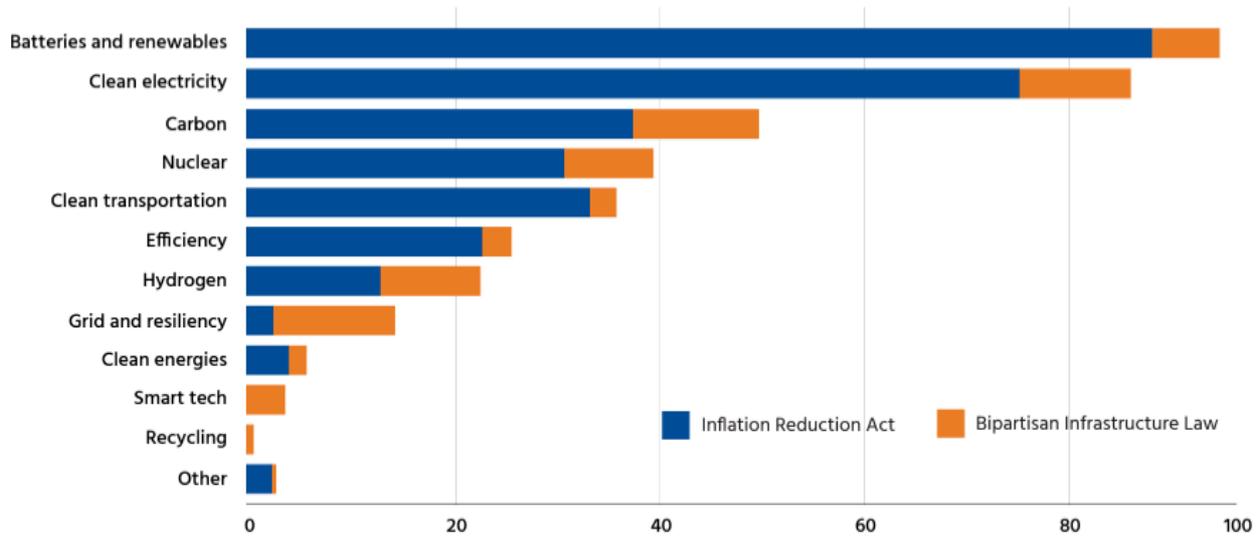


Figure 5. Funding for energy and batteries under IRA (in US\$ billions). Source: McKinsey³¹

The Arizona-based company, with the support of the Korean behemoth, plans to expand production in its Arizona facilities to 28,500 metric tons a year by 2025 (sufficient anode material for 300,000 to 400,000 EVs). Urbix is a small but growing American company that says its processes are environmentally friendlier than natural graphite processing undertaken in China.

Gigafactories are much easier to make operational, compared to mines. And thanks to the IRA, there is a gold rush to set up gigafactories in the US. Raising capital for gigafactories in this environment has become an easier task than raising for mining. The investment in the battery industry is about three to

To complement this process, SK has auto clients such as Ford, Hyundai, and Volkswagen. Leveraging this strong clientele, it is setting up a gigafactory in Georgia set to be operational in 2025.

Status	Capacity
Operational	73 GWh
Partially Operational	49 GWh
Under Construction	472 GWh
Planning	305 GWh

Figure 6. Battery manufacturing in the US. Source: Data collected by authors.

²⁹ SK On-Urbix to develop EV battery materials, The Korea Herald: <https://www.koreaherald.com/view.php?ud=20230119000569>

³⁰ LG Energy Solution Posts 2022 Earnings with Record-High Annual Revenue and Operating Profit, Battery Inside:

<https://inside.lgensol.com/en/2023/01/lg-energysolution-posts-2022-earnings-with-record-high-annual-revenue-and-operating-profit/>

³¹ The Inflation Reduction Act: Here’s what’s in it, McKinsey: <https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-inflation-reduction-act-hereswhats-in-it>

four times the pace of the upstream mining sector.³² As Benjamin Moores of Benchmark Minerals put it, batteries are moving from startup to scale-up, but the mines are not being built quickly enough to fuel this growth”.³³

While the IRA’s benefits provide a much-needed incentive for manufacturers, scaling at a level to compete with Chinese conglomerates is feasible only for large-scale Korean and Japanese companies. For example, while research suggests that the US capacity to produce LFP cells could increase by two-thirds by 2030, it is not reliant on American enterprise but on Korean and even Chinese Gotion’s investment decisions. LG Energy Solutions has announced it will invest US\$5.5 billion to build a battery plant in Arizona, including a US\$2.3 billion factory producing 16 GWh of LFP batteries for energy storage systems.³⁴

Nonetheless, there are a select few companies around the world that have used the benefits offered under the IRA. Pomega, a Turkish energy storage company broke ground on its first LFP plant in the US in 2023.³⁵

Similarly, Norwegian startup Freyr is planning on building an LFP plant in the state of Georgia with a capacity of 34 GWh at a cost of US\$1.7 billion (see Figure 7).³⁶

Furthermore, the subsidies are not limited to battery assembly but are targeted at the more complex challenge of sourcing cathodes and anodes. As highlighted earlier, reducing overreliance on China and Chinese companies for cathode and anode production is an almost insuperable challenge as China has several comparative advantages in the production of cathodes and anodes.

The Department of Energy’s Loan Program Office made the first loans to the critical minerals sector under the IRA and in July 2022, lent US\$102 million to Syrah Technologies for its graphite anode production facility in Louisiana. ³⁷ Syrah has an agreement with LGES to manufacture batteries in the US that go into batteries of American automobile companies such as Tesla and General Motors.

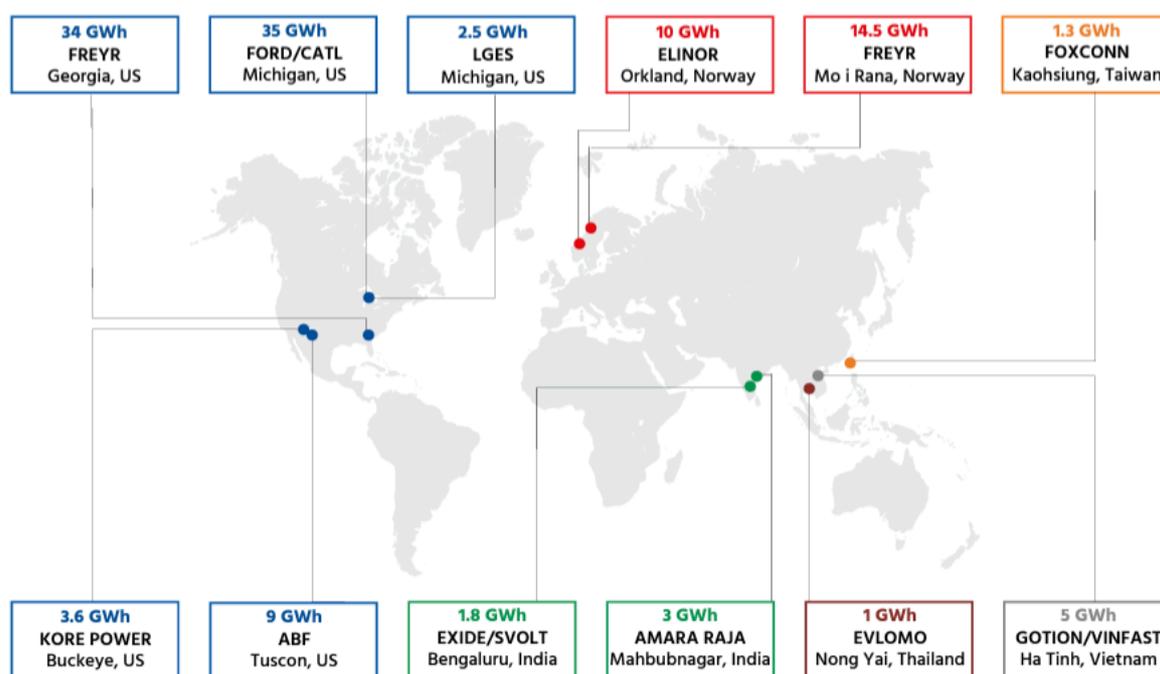


Figure 7. Planned LFP battery production outside of China. Source: Benchmark Mineral Intelligence.

³² The Inflation Reduction Act: Here’s what’s in it, Lithium Investing News: [https:// investingnews.com/europe-lithium-ion-supply-chain/](https://investingnews.com/europe-lithium-ion-supply-chain/)

³³ Simon Moores, Benchmark Minerals Intelligence, MCJ Collective: [https://www. mcjcollective.com/my-climate-journey-podcast/simon-moores](https://www.mcjcollective.com/my-climate-journey-podcast/simon-moores)

³⁴ LG ENERGY SOLUTION TO INVEST \$5.5 BILLION TO BUILD BATTERY MANUFACTURING COMPLEX IN QUEEN CREEK, Arizona Commerce Authority: <https://www.azcommerce.com/news-events/news/2023/3/lg-energy-solution-to-invest-55-billion-to-buildbattery-manufacturing-complex-in-queen-creek/>

³⁵ ESS gigafactory firm Pomega selling into a market with ‘a lot of scepticism about US cell production’, Energy Storage: [https://www.energy-](https://www.energy-storage.news/ess-gigafactoryfirm-pomega-selling-into-a-market-with-a-lot-of-scepticism-about-us-cellproduction/)

[storage.news/ess-gigafactoryfirm-pomega-selling-into-a-market-with-a-lot-of-scepticism-about-us-cellproduction/](https://www.energy-storage.news/ess-gigafactoryfirm-pomega-selling-into-a-market-with-a-lot-of-scepticism-about-us-cellproduction/)

³⁶ FREYR Battery Announces Plans for U.S. Gigafactory in Georgia, Business Wire: <https://www.businesswire.com/news/home/2022111005115/en/FREYR-Battery-AnnouncesPlans-for-US-Gigafactory-in-Georgia>

³⁷ DOE Grants \$102 Million ATVM Loan to Syrah Technologies, Bloomberg: <https://news.bloomberglaw.com/energy/doe-grants-102-million-atvm-loanto-syrah-technologies#:~:text=The%20Loan%20Programs%20Office%20closed,Department%20of%20Energy%20on%20Wednesday.>



While the IRA's benefits provide a much-needed incentive for manufacturers, scaling at a level to compete with Chinese conglomerates is feasible only for large-scale companies.

Challenges and Risk Assessment

There are several challenges to friend-shoring battery supply chains. Amongst the four sectors covered under the Biden administration's supply chain review, batteries are the most challenging sector to reduce reliance on China and Chinese conglomerates.

Too Many Carrots and Very Few Risks

The United States has been particularly outspoken about the concerns associated with China's prominence in supply chains, but its initial steps in addressing this problem showed how entrenched China is in this sector. Through the IRA, BIL, and other industrial policies, the Biden administration has given out incentives in the form of tax credits to a range of mineral processors and battery manufacturers. This has included incentives to Chinese companies that later ran into local opposition. A CATL project proposed in Virginia was moved to Michigan after Virginia Gov. Glenn Youngkin's vocal opposition.³⁸ Another backlash over the DOE's loan to Microvast, a Texas-based company with subsidiaries in China, led to the scrapping of grants to Microvast.

Nonetheless, the largest planned LFP battery facility is the Ford-CATL joint project in Michigan. Tesla uses CATL's LFP cells and Ford is partnering with both CATL in Michigan and Gotion in another undisclosed location in the US for battery production. The Michigan plant will have 35 GWh of annual capacity, enough for 400,000 vehicles a year. These

partnerships are not limited to US shores. Tesla, Ford, and other American automakers are forging global partnerships with Chinese battery makers such as Gotion and CATL to secure supplies of minerals and batteries in Indonesia and other mineral-rich nations. Furthermore, America and its partners are not only playing catch up to China's dominance in the industry or supply chain but its progress in adapting the latest technology in the sector. For example, while US, Korean, and Japanese automakers were getting started on manufacturing NCM batteries, the market had moved on to LFP cells that are much cheaper and more efficient. Before US battery makers could transition, China had already gained a monopoly in LFP battery cell manufacturing. This opens the debate on allowing Chinese companies a role in the transition to renewable energy. On balance, the US government's decision on providing subsidies to Gotion or CATL will have to factor in the perceived national security risk and the risk of trailing further behind in the highly competitive global marketplace. Particularly, since the US is highly reliant on LFP cells for energy storage systems, Chinese companies could find a back door to the IRA through joint partnerships. A case in point is the announcement by Gotion on building the US' largest LFP plant in Georgia. Coinciding with the LFP production schedule, the company has also planned for a cathode processing facility in Big Rapids, Michigan to create a closed-loop supply chain, indirectly extending Chinese dominance in the sector.

If the US government does not clamp down on such deals, either on the back end or at the end-user stage of auto manufacturers, American taxpayers will be supporting the preservation and possibly the growth of Chinese battery manufacturers on US shores. In their report on US attempts at reducing reliance on China in the EV supply chain, The New York Times suggests that it is impossible to have an ex-China supply chain, quoting one expert as saying no country can successfully manufacture electric vehicles "without having some type of cooperation with China, either directly or indirectly".³⁹ While it is a challenging endeavor, our analysis is not so ominous.

³⁸ Virginia governor scraps Ford's bid for EV battery plant with Chinese partner, The Detroit News: <https://www.detroitnews.com/story/business/autos/ford/2023/01/17/>

[virginia-governor-nixes-ford-catl-battery-plant-plan-over-china-ties/69815982007/](https://www.nytimes.com/2023/01/17/us/politics/virginia-governor-nixes-ford-catl-battery-plant-plan-over-china-ties/69815982007/)

³⁹ Ibid.

Betting on the Wrong Horse

Batteries for EVs have come a long way – from the heavy lead-acid batteries in the 1990s to the nickel-metal hydride batteries (like the ones that propel the modern Toyota Prius) to the more recent NCMs and LFPs. Lithium-ion batteries outperform nickel-cadmium batteries on every metric, The Promethean narrative focused on the next great battery breakthrough restricts the private sector from going “all in” on any particular battery chemistry and relied on a handful of battery chemistries with the right balance between reliability, performance, and economy. Moreover, over the last few years, the goalposts have been moving at regular intervals on the criteria for performance and economy. The rapid advancements in R&D in the battery sector make transitions expensive, and inefficient for smaller battery companies such as the ones in the US. The Chinese while supporting its auto industry transition to EVs using NCMs and other battery chemistries, invested in LFP, and that chemistry has now taken the battery market by storm. Similarly, over the last few years, CATL has invested in experiments with sodium-ion technology as a viable alternative to the lithium-ion batteries that dominate the EV market. While most of these inventions have occurred at a laboratory in North America, the private sector in China has been able to market-test them with increased freedom because of government support.

With sodium-ion technology and hydrogen-powered vehicles gaining market interest, without forward-looking industrial policy, US support to its indigenous and partner nation manufacturers will continue to fall short of China’s advancements in the industry. CATL has already successfully tested sodium-ion technology and Chinese companies such as HiNa Battery are actively expanding production.⁴⁰ While the energy density of sodium-ion batteries is lower than lithium-ion and does not run the risk of fire, the adoption is still in its nascent stages. Nonetheless, China houses a total of 28 plants with a capacity of 3.1 GWh of sodium-ion battery capacity.⁴¹

⁴⁰ China Unveils World’s Largest Sodium-ion Battery Plant as a Lithium Price Hedge, YICAI Global: <https://www.yicai.com/news/china-unveils-world-largest-sodiumion-battery-plant-as-a-lithium-price-hedge>

⁴¹ Sodium ion battery producers target the energy storage market, Benchmark Source: <https://source.benchmarkminerals.com/article/sodium-ion-battery-producers-targetthe-energy-storage-market>

Conclusion

To address repeated market failures, the US government should not only maintain close surveillance over its industrial policies but also implement policies that address challenges in allied industries and in partner nations.

- **Bring end-use sector under the national security umbrella** – American legislators have drafted a new bill that will include the auto sector in sectors of national security concern alongside pharmaceuticals, critical minerals, batteries, and semiconductors. In early May, US Representatives Rosa DeLauro of Connecticut, Brian Fitzpatrick of Pennsylvania, and Bill Pascrell of New Jersey reintroduced the bipartisan National Critical Capabilities Defense Act, legislation that would “establish a review process over the potential offshoring of critical United States’ supply chains to foreign adversaries like China and Russia”.⁴² Of note, the reintroduced bill included the automobile sector as a sector of national security concern. In the world’s largest auto show convened in Shanghai in April 2023, global auto majors showcased their latest EVs which hold a large market share in China and even brought their boards to the auto show as a token of appreciation and commitment.⁴³ Given the sheer size of China’s market, and its impact on batteries and mineral supply chains, it is vital for American policymakers to add the automotive sector as a sector of national security concern. Upon adding that designation, policymakers must find ways to reduce American manufacturers’ reliance on China to prevent a possible weaponization of interdependence.
- **Support Korea and Japan** – As reports have highlighted, Europe’s supply chain diversification or “de-risking” plans are less ambitious than Washington’s IRA and BIL. For example, its only major battery producer, Northvolt sources its lithium from Chinese

⁴² DeLauro, Fitzpatrick, Pascrell Reintroduce Bipartisan National Critical Capabilities Defense Act, Rosa DeLauro: <https://delaurow.house.gov/media-center/press-releases/delauro-fitzpatrick-pascrell-reintroduce-bipartisan-national-critical>

⁴³ Volkswagen unveils electric luxury sedan at China auto show, Nikkei Asia: <https://asia.nikkei.com/Business/Automobiles/Volkswagen-unveils-electric-luxury-sedan-atChina-auto-show>



Companies such as Ford and Tesla have global partnerships with China that undercut, in an indirect way, the industrial policies of the US and multilateral initiatives.

companies⁴⁴ and has not actively sought alternative shores as the US government has insisted with its partners in East Asia.⁴⁵ The US government should support South Korea and Japan in their domestic industrial policies and battery manufacturing plans not only through IRA but multilateral mechanisms such as mineral security partnerships, Quad, and other platforms. Japanese and Korean companies have been at the forefront of the battery revolution. Japanese automaker Toyota has led efforts in testing hydrogen cells for non-commercial vehicles. The Korean Ministry for Industry and Trade has allocated a significant portion of the government support towards R&D efforts. The US should capitalize on the efforts of allied nations and take note of the latest developments to address the gap with China.⁴⁶

- **Increase R&D expenditure and incentivize diversified investments** – While the US Department of Energy has rightly prioritized the processing of minerals and battery manufacturing and recycling facilities for its loan portfolio, diversifying that portfolio to include hydrogen, green hydrogen, and new battery chemistries such as sodium-ion technology will assist the US in catching up to China’s battery makers. Green hydrogen

can be a viable alternative to lithium-ion batteries for vehicles that require long-distance travel or have a higher payload capacity. The private sector has initiated the adoption of green hydrogen for commercial fleets. For example, Amazon is betting on green hydrogen for its “middle mile” operations to meet the demand that lithium-ion batteries cannot fulfill. The e-commerce giant has signed a deal with Plug Power for 10,950 metric tons annually of green hydrogen to use in forklifts and heavy-duty trucks. Going forward, green hydrogen can fulfill needs where electric batteries cannot such as bus, trucks, rail and marine. It is vital for the US to increase R&D in these alternatives and increase their share in the portfolio of loans.

- **Strengthen CFIUS (sticks) and extend regulatory arm to foreign shores** – Over the last two years, the US government has placed several trade restrictions and export controls to curb the influx of Chinese goods in critical sectors, ranging from semiconductors to solar panels. Companies such as Ford and Tesla have global partnerships with Chinese battery makers and mineral processing companies in countries such as Indonesia and Australia, in an indirect way undercutting the industrial policies of the US and multilateral initiatives. Scrutinizing all global mergers and acquisitions and offtake agreements with companies of nations listed under “nations of concern” will assist in maximizing the benefits of targeted industrial policies.⁴⁷
- **Support oil companies to strengthen critical mineral value chains** – The US government should rethink the role of oil companies in its clean energy transition. Several oil and gas companies are vying to rebrand via various battery chemistries, and hydrogen. Exxon Mobil is actively capitalizing on the momentum in the renewable energy sector. America has several such energy companies

⁴⁴ A Chinese company will supply lithium to Northvolt’s northern Sweden plant, Arctic Today: <https://www.arctictoday.com/a-chinese-company-will-supply-lithium-tonorthvolts-northern-sweden-plant/>

⁴⁵ Global and China Lithium-ion Battery Anode Material Industry Report 2021-2026 - ResearchAndMarkets.com, Business Wire: <https://www.businesswire.com/news/home/20220131005500/en/Global-and-China-Lithium-ion-Battery-Anode-MaterialIndustry-Report-2021-2026---ResearchAndMarkets.com>

⁴⁶ Toyota hydrogen power kit for semis gets green light in California, Toyota Auto Blog: <https://www.autoblog.com/2023/04/26/toyota-hydrogen-semi-zero-emissionspowertrain-california/>

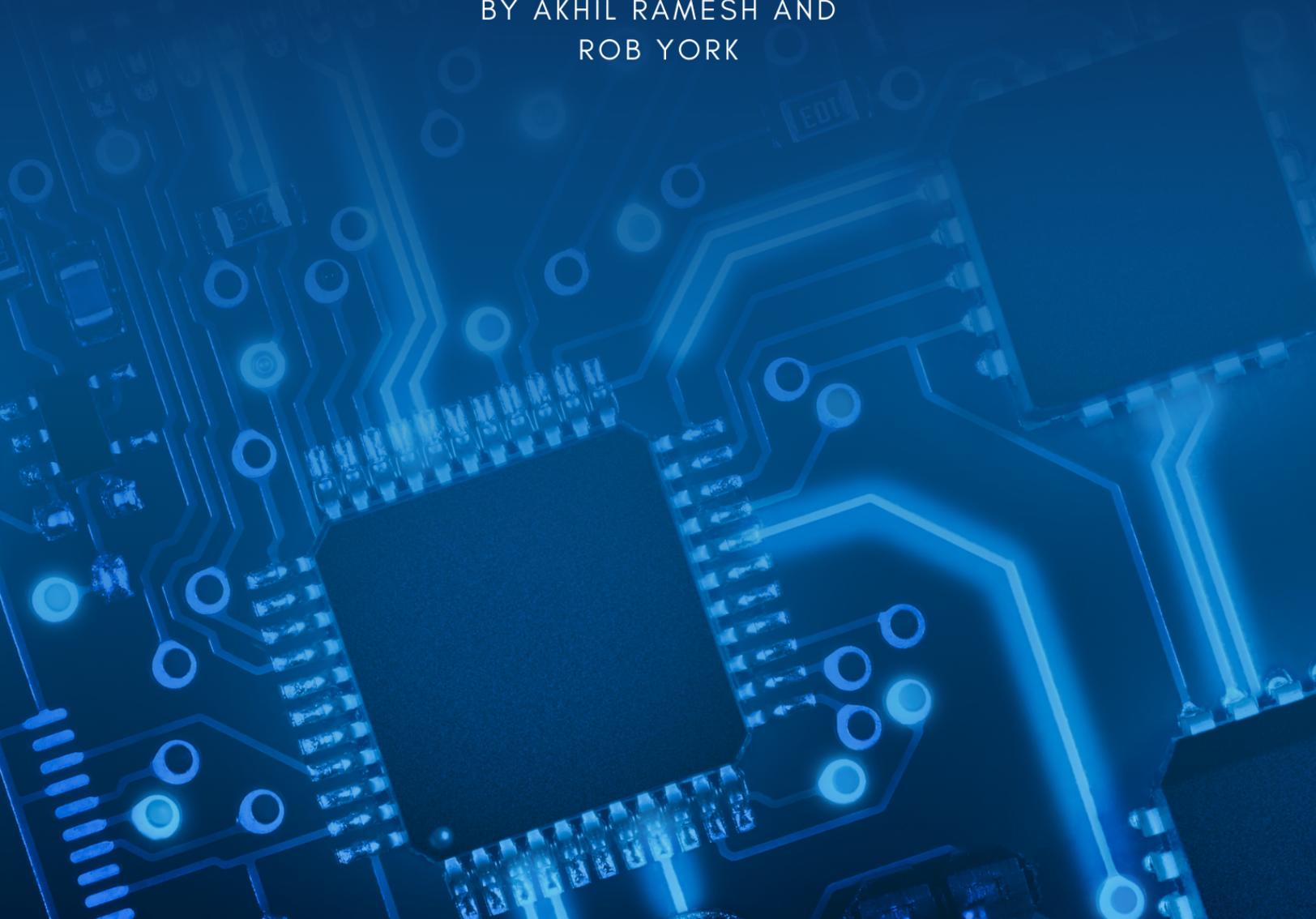
⁴⁷ Ford, VW & China seek deal with Indonesia for EV battery materials: <https://www.teslarati.com/indonesia-ev-battery-minerals-volkswagen-ford-china/>

re-calibrating their operational focus to cater to the rapidly growing renewable energy sector. With generous government support through subsidies under the IRA and other legislations, in 2023, it is a gold rush to invest in sectors identified as critical to national security by the US government, particularly critical mineral processing. Downstream divisions at traditional oil companies can provide the needle coke needed for synthetic graphite and address an overreliance challenge in the vital node in the battery supply chain.

4

De-risking semiconductor supply chains

BY AKHIL RAMESH AND
ROB YORK



Executive Summary

Akhil Ramesh and Rob York

In semiconductors, unlike in other critical supply chains, the US and its partners currently have the edge in innovation and, increasingly, production, over China. The global semiconductor supply chain, however, has unique vulnerabilities given that the world's largest pure-play foundry is in Taiwan, a key flashpoint in global geopolitics. Beijing has successfully used industrial policy to shore up its global dominance in critical minerals, electric vehicle batteries, and other critical technologies. To achieve greater supply chain security, certain countries such as Japan, Malaysia, and Korea, can prevent potential chokepoints, but semiconductor supremacy will largely be determined based on whether the US achieves self-sufficiency in fabrication and can friend-shore both raw materials and assembly, test and packaging, or whether China achieves breakthroughs in design technology.



The global semiconductor supply chain has unique vulnerabilities given that the world's largest pureplay foundry is in Taiwan, a key flashpoint in global geopolitics.

Introduction

Semiconductors, also known as “integrated circuits” or “microchips”, are usually made from wafers of silicon. They conduct electricity less well than purer conductors such as copper or aluminum, and their conductivity and other properties can be modified to meet the specific needs of technological applications. Semiconductors have become ubiquitous. Those circuits are at the heart of 21st century geopolitical and geo-economic contest – and increasingly a standoff that policymakers and industry cannot avoid. Nations at the forefront of critical innovation in spheres such as artificial intelligence, the internet of things and advanced computing in general are taking measures to secure the supply chain.

No other sector matters to the interconnected globalized world of the 21st century as semiconductors. The US, Japan, Korea, China and select European nations all play vital roles in the widely dispersed value chain of semiconductor manufacturing. Nonetheless, emerging markets such as Vietnam, Malaysia, India, and Mexico are increasingly entering the value chain, though at its lower end.

Interestingly, unlike pharmaceuticals, critical minerals, or batteries – supply chains covered earlier in this series – semiconductors are a sector where the US and allies enjoy a significant edge in innovation and production over China.¹ Nonetheless, the US and its allies have engaged in techno-nationalism through targeted industrial policies and trade protectionist measures. In the case of semiconductors, the US is not catching up but working to maintain its edge over China and limiting China’s advances in its control of critical technologies. Unlike the other three industries, there aren’t one or two nations to friend-shore the entire supply chain. The value chain is widely dispersed across the Indo-Pacific and parts of Europe. Nonetheless, different partner nations can step in to play the role of a friendly shore.

There are three broad myths to be debunked before we analyze the friend-shoring prospects for semiconductor supply chains.

One, the semiconductor supply chain is concentrated in one part of the world. While East Asia plays a vital role in the overall value chain, its role is limited to one or two segments of the value chain. The overall semiconductor value chain is widely spread across the Indo-Pacific and parts of Europe.

Two, the recent calls for diversification of supply chains are a result of global shortages arising from Covid disruptions, man-made and natural disasters, plus lockdowns in China. While the black swan event of Covid and the resulting global disruptions and lockdowns in China have impacted the value chain, these are not the only forces behind the urgency to diversify supply chains. Chip shortages are not a new phenomenon in the industry but are cyclical in nature. The semiconductor industry has faced shortages caused by natural disasters, variations in supply of raw materials, and other geographic and political events. However, these shortages have been short-lived; usually less than six months in length. The scale of such disruptions during the pandemic was a deviation from the norm. Most fabs operate at 80% utilization and modify this number based on fluctuations in demand.² As a Standard & Poor’s recent report on disruptions in semiconductor supply chains noted, events across the world such as a fire in a fabrication plant in one location, staffing shortages at a shipping facility elsewhere, an ice storm, and a ship getting stuck in Suez Canal, all impacted the chip supply chains.³

Auto manufacturers drastically cut their chip orders in early 2020 in anticipation of a major downturn in sales. However, as a result of Covid lockdowns and work-from-home settings, demand for equipment such as laptops and routers that enable video conferencing, e-learning, and recreational products (such as PlayStations and VR headsets) shot up. The increase in demand for consumer electronics led semiconductor production lines to pivot from producing lower end chips for automobiles to producing more higher-end chips for consumer electronics. A year later, with the easing of lockdowns in major auto markets, demand rose, and automakers found that foundries were already filled with orders from other sectors and much of the inventory had been sold into consumer electronics. While fabs increased utilization levels to up to 95%, the shortage persisted for the auto industry.

¹ <https://www.eastasiaforum.org/2021/08/06/the-united-states-is-determined-todominatethe-semiconductor-tech-war/>

² <https://www.semiconductors.org/chipmakers-are-ramping-up-production-toaddress-semiconductor-shortage-heres-why-that-takes-time/>

³ <https://www.spglobal.com/engineering/en/research-analysis/understanding-thecurrent-global-semiconductor-shortage.html>

Three, across liberal democracies, there has been a broad discussion about the need to diversify the supply chain due to geopolitical concerns rather than protectionism. Many security experts, politicians, and officials in the Indo-Pacific are wary of a so-called “Taiwan contingency” in the next five years,⁴ in which China mounts an invasion to retake the “renegade province” of Taiwan.⁵ Other voices disagree with this assessment, of course, and this paper takes no stance on that possibility.⁶ However, the possibility of severe damage to semiconductor manufacturing facilities cannot be discounted as a scenario in extremis.⁷

As our previous papers on friend-shoring pharmaceuticals, critical minerals, and batteries highlighted, China’s deployment of industrial policies has borne fruit in creating indigenous industries leading in all three sectors. If Beijing were to emulate such success in semiconductors, it would not be just another strategic sector where Chinese companies lead, but one with consequences beyond profits or shareholder value for Western companies. The sector has far-reaching implications for national security.

If China were to gain dominance in the sector as it has with other advanced technologies, some security experts fear that it will have the world’s most advanced military capabilities, strengthening conventional warfare capabilities and, as a direct result, setting the rules of the road in the industry.

Mapping Semiconductor Supply Chains

Semiconductor supply chains have three major segments.

As figure 1 illustrates, the supply chain is widely dispersed, with companies across the Indo-Pacific and Europe dominating various segments and sub-segments of the supply chain.

Demand for chips varies by sector and the types of semiconductors going into these different appliances are not identical. However, all major segments of the chip value chain find themselves caught in the trade tussle between the US and China.



Figure 1. Semiconductor supply chain (*Assembly, testing, and packaging). Source: Author’s complication.

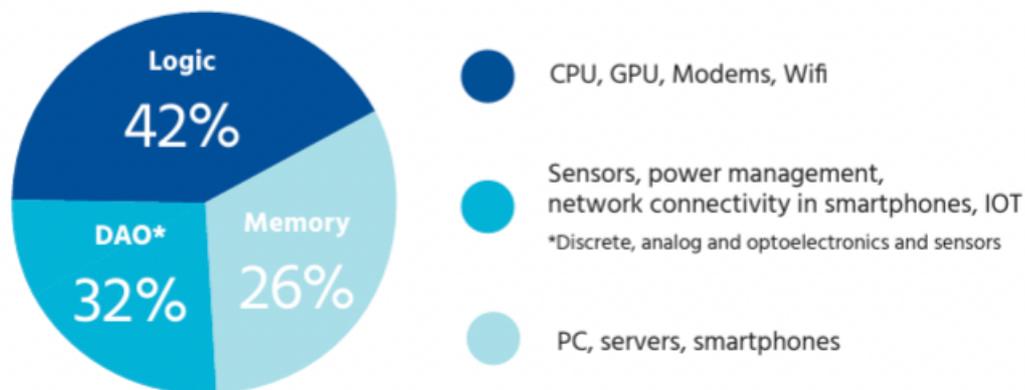


Figure 1.1. Types of chips. Source: Semiconductor Industry Association and Boston Consulting Group.

⁴ <https://www.rfa.org/english/news/southchinesea/us-china-war-01302023035216.html>

⁵ <https://www.economist.com/briefing/2023/03/09/america-and-china-are-preparing-for-a-war-over-taiwan>

⁶ <https://www.aljazeera.com/economy/2022/4/3/after-ukraine-war-taiwan-chipsupremacy-raises-economic-stakes>

⁷ <https://www.theguardian.com/world/2023/apr/21/taiwan-foreign-minister-warns-ofconflict-with-china-in-2027>

Demand

The US and China are neck-and-neck as the largest sources of demand at both current and projected levels (see figure 2). Washington’s slew of export control measures and Beijing’s indigenization efforts affect companies with large market shares in both geographies. As of 2021, mobile phones and information and communication technology (ICT)

one of the largest consumers of semiconductors. The company is among the world’s largest spenders on research and development including on artificial intelligence (AI) and advanced computing. This puts American and Western semiconductor companies who want to engage the Chinese market in a precarious position. It also pushes Huawei and other Chinese companies toward accelerating indigenization initiatives.

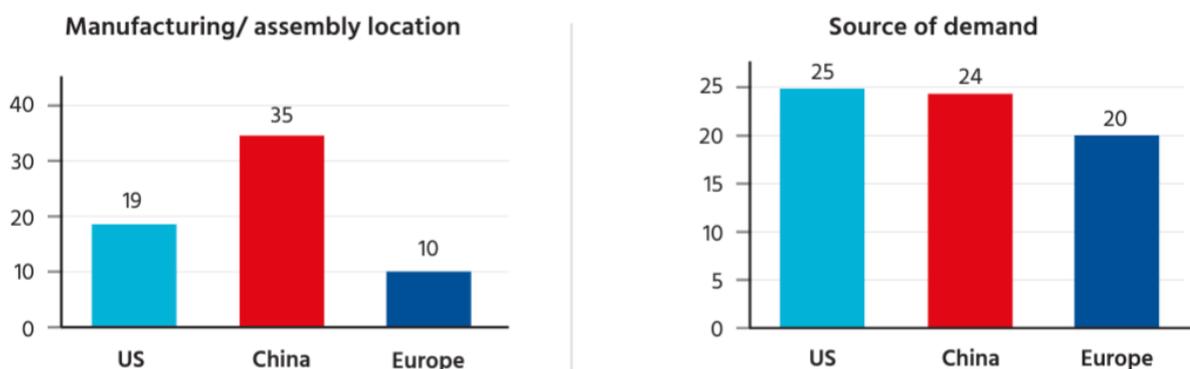
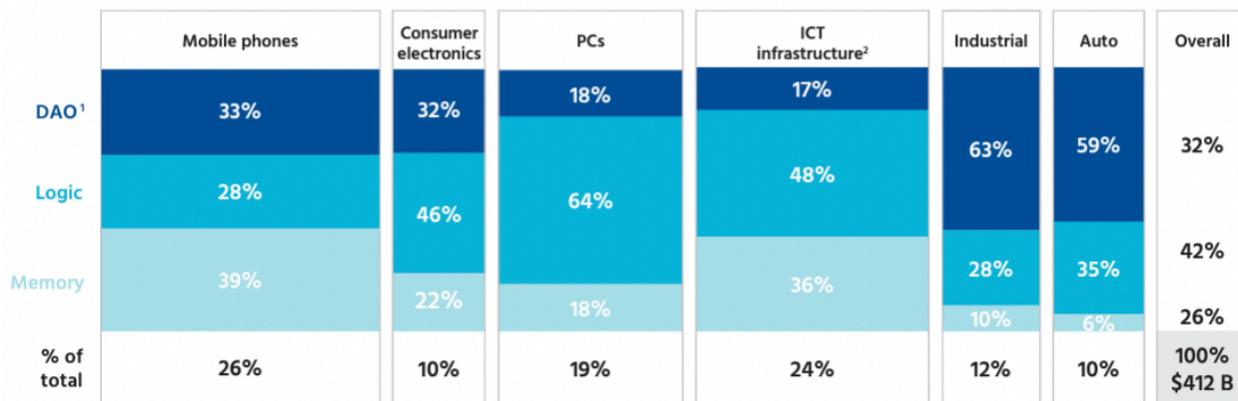


Figure 2. Global Semiconductor sales by geographical area, 2019(%). Source: Semiconductor Industry Association and Boston Consulting Group.



1. Discrete, analog and optoelectronics and sensors
2. Informations and communications technology infrastructure, including data centers and communication networks

Figure 3. End use demand of semiconductors (sectors). Source: Semiconductor Industry Association and Boston Consulting Group.

sectors have the largest demand for semiconductors (see figure 3). Furthermore, as end-users in China such as automobile makers, digital infrastructure, and other advanced technologies grow exponentially, the US’ targeted containment of these companies is aimed at choking off their supply of chips. A case in point is China’s Huawei Technologies.

China has engaged in countermeasures to US chip curbs by implementing export restriction policies on raw materials (the segment of the value chain where it holds a comparative advantage over its competition – see figure 4) required for chip production.

Shenzhen-headquartered Huawei is among the conglomerates most impacted by the US-China trade war. As a leading conglomerate in the ICT sector, it is



Huawei is among the world's largest spenders on R&D including on AI and advanced computing. This puts foreign chip companies who want to engage the Chinese market in a precarious position.

Supply

Design and Fabrication

The design segment adds the most value to the entire supply chain. The top 10 companies in this sector are American. Of note, three US-based firms make up over 70% of the electronic design automation (EDA) market.⁸ This segment is highly geographically concentrated in the US and to solidify its position, the US government has targeted export controls on

design software. In 2021, the US Department of Commerce included EDA software in a set of export controls to restrict China from accessing this software.⁹ China's EDA tools account for just over 2% of the global market.¹⁰

US export control measures appear to have so far limited the progress made by Chinese EDA firms. Companies such as China's especially competitive Empyrean have leveraged their subsidies to offer below-market prices and lure talent from companies in producers such as South Korea.¹¹ US export control measures may have a counterproductive effect with Chinese companies working toward indigenization with an unprecedented urgency. While Chinese companies such as Primarius, X-Epic, Semitronix, and others remain in nascent stages of developing indigenous capacity, Huawei says it has built over 78 design tools to catch up with American software.

On the other end of the value chain, some fabrication facilities have been reshored to American states such as Arizona and Texas and friend-shored to Japan and Germany. Intel is setting up fabrication units in Japan and Germany to increase geographical diversification. In the fabrication segment, Taiwan and China together account for more than 40% of market share.¹² Semiconductor manufacturing

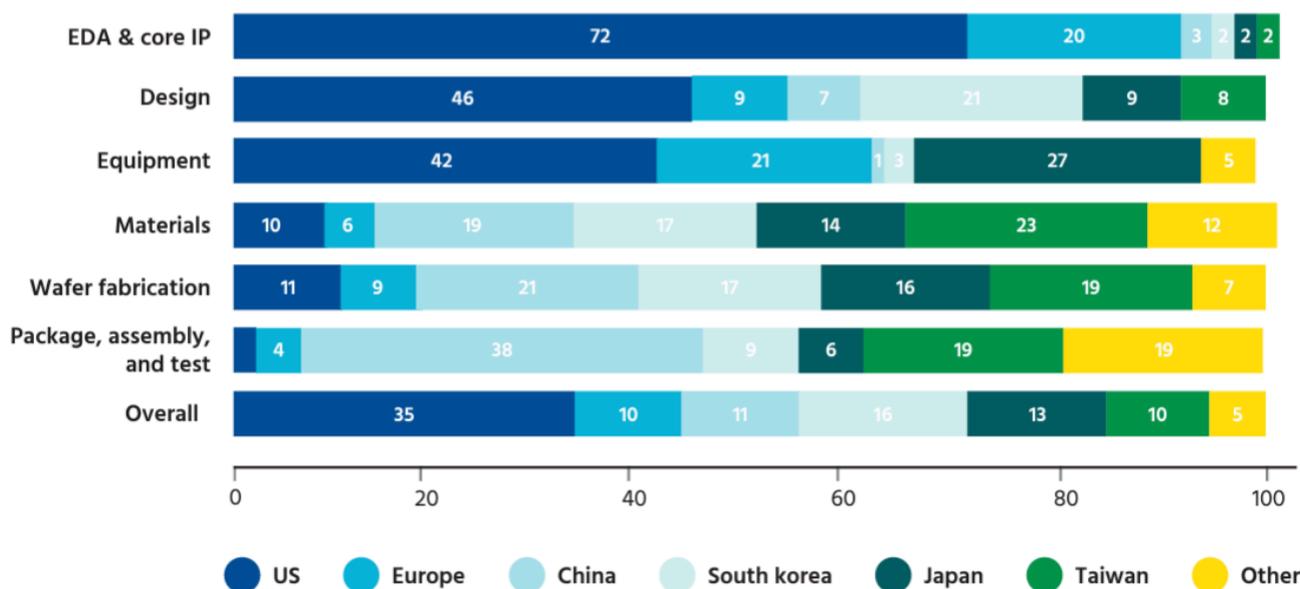


Figure 4. Comparative advantages of the US and partners in semiconductor supply chains vs. China. Source: National Semiconductor Economic Roadmap by Arizona Commerce Authority and Boston Consulting Group.

⁸ <https://www.dqindia.com/big-four-cadence-synopsys-ansys-and-siemens-edaaccount-for-over-90-of-eda-industry-revenues/>

⁹ <https://www.csis.org/analysis/mapping-semiconductor-supply-chain-critical-roleindo-pacific-region>

¹⁰ <https://forums.hardwarezone.com.sg/threads/huawei-huawei-confirmsbreakthrough-chinas-chip-industry-will-be-reborn-under-u-s-sanctions.6888547/> page-4

¹¹ <https://www.csis.org/analysis/mapping-semiconductor-supply-chain-critical-roleindo-pacific-region>

¹² <https://www.csis.org/analysis/mapping-semiconductor-supply-chain-critical-roleindo-pacific-region>

equipment (SME) is another chokepoint in the supply chain for China. The US, Netherlands and Japan lead the way in SMEs and the US under Biden has imposed export licensing requirements for SME exports to China, curtailing China’s advances in semiconductor manufacturing. Furthermore, the administration has convinced the Netherlands and Japan to follow suit. While the Netherlands Standing Committee on Foreign Trade and Development Cooperation issued restrictions on companies such as ASML to export photolithography scanners to China,¹³ Tokyo has gone a step further and imposed the most stringent export restrictions on SMEs to China, restricting 23 types of semiconductor technologies, including advanced microchip manufacturing equipment.

Core Intellectual Property

Companies in the US and UK control about 90% of the market. Intel, Cadence, and ARM are leaders in core intellectual property (IP). These companies are vital nodes in the value chain.

For example, ARM, originally a UK-based company, was bought by Masayoshi Son’s Softbank Group in 2016. Notably, this joint venture provides 27% of global licensing revenues for the parent company. ARM’s software is omnipresent in the technological world with 95% of smartphones, 63% of Internet of Things (IoT) devices and 24% of cars using it.¹⁴

In a similar turn of events, in 2017, a Chinese state-owned fund acquired UK-based Imagination Technologies, which develops core IP for mobile phone GPUs.¹⁵ While China could increase government subsidies to boost fabrication units and assembly, testing, and packing (ATP) sites as well as tighten its hold over raw materials, design, and core IP will remain a major chokepoint for China.

Raw Materials and ATP

China has the largest share of most raw materials required for semiconductor manufacturing. The US produces no arsenic, carbon, fluorine, gallium, tellurium, or tungsten. Of note, China has around 95% of the world’s primary lowgrade gallium, 83% of the global production share for tungsten, and 82% for magnesium.¹⁶ As China’s recent export controls such as licensing requirements for the export of gallium and germanium demonstrate, the US and its partners face formidable counter-chokepoints and need supply chain diversification. In the case of germanium and gallium, it was largely Japan’s and the Netherlands’ SME makers that were directly impacted.¹⁷

Wafer size (in)	 United States	 Japan	 Taiwan	 South Korea	 China	Total
2	10	5	19	2	49	85
3	20	4	3	0	9	36
4	63	36	19	8	57	183
5	5	15	3	2	14	39
6	84	74	30	9	64	261
8 (200mm)	61	53	26	12	36	188
12 (300mm)	33	29	44	32	41	179
Total	276	216	144	65	270	971

Figure 5. Wafer fabs by country. Source: Center for Strategic and International Studies

¹³https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2023Z04037&did=2023D09406

¹⁴ <https://asia.nikkei.com/Spotlight/Caixin/In-Depth-How-SoftBank-wrested-backcontrol-of-Arm-China>

¹⁵<https://www.theguardian.com/business/2017/sep/25/imagination-technologiesshares-canyon-bridge-takeover>

¹⁶<https://crsreports.congress.gov/product/pdf/R/R45810>

¹⁷ <https://www.aljazeera.com/news/2023/7/12/costlier-cars-why-chinas-galliumgermanium-export-curbs-matter>

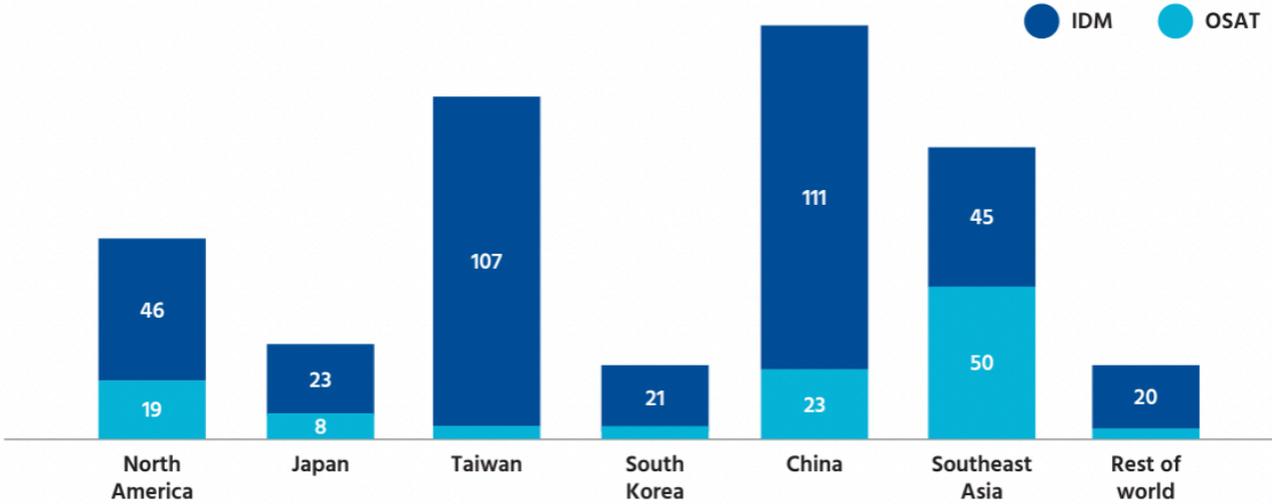


Figure 6. Number of ATP facilities. Source: Center for Strategic and International Studies.

Fabrication and ATP

China and Taiwan Dominance

China and Taiwan together account for more than half of the world’s fabrication facilities (see figure 6) by location. While these segments are relatively lower in value-add compared to design, they are concentrated in China and Taiwan, making the segment the West’s most vulnerable chokepoint.

Diversification measures have focused on reviving American capacity in fabrication and increasing partnerships with emerging markets such as Malaysia, Vietnam, and India in ATP activities while

strengthening South Korea’s existing position in the segment.

Developing Domestic Semiconductor Capacity

CHIPS and Science Act

In 2022, the CHIPS and Science Act was enacted to spur investments in semiconductor manufacturing, increase investments in research and development (R&D), science and technology, and workforce development for industries designated as national security interest such as IoT, AI, and quantum computing.¹⁸

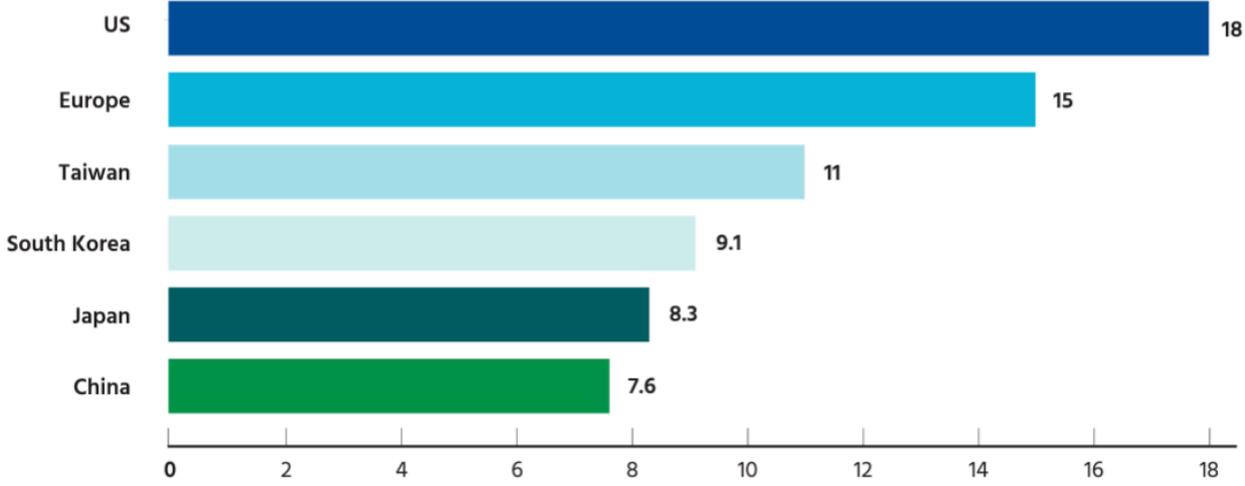


Figure 7. R&D expenditure by country as a % of sales, 2021. Source: Semiconductor Industry Association.

¹⁸ <https://www.whitehouse.gov/briefing-room/statements-releases/2022/08/09/factsheet-chips-and-science-act-will-lower-costs-create-jobs-strengthen-supply-chainsand-counter-china/>

China's Ecosystem

For China, advances in technology are about national pride as much as the success of its self-reliance. In 2020, China imported more than US\$350 billion worth of semiconductors (more than crude oil). In 2021, China became the largest importer of semiconductors in the world. Unlike with crude oil, for which it has established partnerships with Middle Eastern nations and has not had challenges accessing crude, the US and its partners have repeatedly either worked toward limiting its advances in the field itself or restricted the exports of advanced semiconductors and machines required for production. Chinese President Xi Jinping's 2025 target to reduce China's dependence on foreign technology and promote Chinese technological manufacturers in the global marketplace is directly tied to its success in the indigenization of high value-add segments of the semiconductor manufacturing process. Government handholding of semiconductor companies has proven a success in cases of Korea and Taiwan.

Tiger Technology

Semiconductors is one industry that has throughout its history thrived on the generous support of industrial policies. Nations with large market shares in the semiconductor value chain – both at the higher end of the value chain and the lower – have supported their private sector with subsidies. Starting in 2020, industrial policies in the US and its partner nations have been emphasized not only to revive manufacturing or catch up to their competition but also to prevent nations perceived as national security threats from gaining access to advanced chips. This is at odds with the export-led model of industrial policy in Taiwan and nations such as South Korea and Japan. For example, since the 1970s, the South Korean government has consistently adopted an export-led indigenization initiative. This has elevated companies such as Samsung and SK Hynix to become industry leaders in advanced chips.

In 2023, Washington's export controls and arm-twisting of tech corporations to fall in line with its strategic goals reflect fears that industrial policy in China could bear fruit as they had in Taiwan and

Korea. Adding credence to this concern, all East Asian economies made their entry into the sector (eventually becoming leaders) via lower value-add segments in the value chain. China has a strong packaging ecosystem that presents a chokepoint for American supply chains.

In the US, states such as Arizona, Texas, Ohio, and New York seek to revive semiconductor fabrication and advanced testing and packaging on US shores.¹⁹ GlobalFoundries, Intel, Samsung Foundry, TSMC, and Texas Instruments are all building new facilities in the US.²⁰ Arizona has been at the forefront of this manufacturing renaissance. Similar to the advantages many East Asian economies enjoy with vertical integration, based on Pacific Forum's conversations with local economic development and investment promotion agencies, it is evident that sectors such as solar panels, semiconductors (fabrication and ATP), batteries, and even autonomous vehicles manufacturing are riding a resurgence in the US thanks to federal subsidies such as the CHIPS Act and a business-friendly environment in the state.²¹ Coupled with near-shoring opportunities in Mexico, policymakers hope that states such as Arizona and Texas would strengthen US national security. However, analysts remain skeptical of reshoring entire value chains that are not cost-competitive in the US.

In early 2023, South Korea's parliament approved the K-Chips Act, increasing tax benefits to 15% from the previous 8% for large companies and to 25% from the previous 16% for smaller and medium-sized enterprises to spur manufacturing and investments in the sector.

Ecosystem: Penang to Arizona

Intel and its founder Gordon Moore are touted as pioneers in the semiconductor industry. Moore's Law, named after the late founder, is used by analysts to study the innovation trajectory of the industry. Not only has Intel consistently introduced commercially viable semiconductors over the last five decades, but it has also set itself apart from its competition by developing ecosystems both in the US and in foreign countries such as Malaysia. Intel's customers include the US Department of Defense.²²

¹⁹ <https://www.tomshardware.com/news/new-us-fabs-everything-we-know>

²⁰ <https://www.tomshardware.com/news/new-us-fabs-everything-we-know>

²¹ <https://www.opus-group.com/News/The%20Booming%20State%20of%20Industrial%20Development%3A%20Arizona>

²² https://www.theregister.com/2021/08/24/intel_qualcomm_ramp_c/

However, Intel's industry lead slipped when Taiwan Semiconductor Manufacturing Company Limited (TSMC) championed the foundry model, which Intel initially eschewed.

Intel was the first company to create ecosystems surrounding semiconductor manufacturing, both domestically in the US and abroad in places such as Penang, Malaysia. Three years after its founding, Intel set up its first offshore facility in Malaysia. It supported ancillary industries, even setting up a special training facility within the Penang plant called Intel University to train professionals in design and technologies. Fast forward to 2023, it is replicating the project by expanding its footprint in the country. It is opening a new plant in Penang for its advanced 3D chip packaging unit and one in Kulim for testing and assembly in the Southeast Asian nation with plans of quadrupling its packaging services capacity, as part of Intel's planned US\$7 billion expansion worldwide.²³

As an extension, part of Intel CEO Pat Gelsinger's goals of reducing the share of semiconductors produced in Asia to 50 percent from the current 80 – while having the US produce 30 percent and Europe 20 – Intel is expanding in Arizona and Ohio while simultaneously expanding its footprint in Southeast Asia.²⁴

Diversification, however, brings new challenges.

Challenges

Diversifying and friend-shoring semiconductor supply chains has caused unease among partners and allies. These diversification measures have made commercial business decisions and national security extricable. As friend-shoring measures rise, nations with higher environmental standards have initiated discussions on the environmental impact of such moves. There are three major barriers to accelerating supply chain diversification measures.

Environment, Societal, and Governance Standards (ESG)

The semiconductor industry contributes to more than 30% of global greenhouse gas emissions annually. It

is highly energy- and water-intensive. A reliable energy supply is vital for the manufacturing of semiconductors, which comes at the cost of the environment since most sources of energy used by facilities are not renewable. A large chip fab can use up to 10 million gallons (nearly 38 million liters) of water a day, equivalent to the water consumption of roughly 300,000 households a day.²⁵ High environmental standards and preexisting water scarcity in proposed locations exacerbate policy challenges. Big chip manufacturers such as Intel have therefore instituted strong water recycling programs.

The issue of per and polyfluoroalkyl (PFAS) chemicals, also known as the "forever chemicals", used as an additive in photoresists of semiconductors can develop into a larger industry challenge. The EU is considering regulations for the use of such substances. Japanese ink producer DIC has used fluorine as a substitute, but only in a prototype.



While most US companies have pulled out of China, partners and allies are not on the same page. The CHIP4 Alliance, while strong on paper, its results have not materialized yet.

In Arizona, TSMC has faced increased scrutiny over its water usage and its import of foreign labor. A big selling point for advocates of industrial policy was the increased use of local labor as a product of subsidies tied to union jobs. The Taiwanese behemoth has faced flak for bringing in talent from Taiwan for the fab under construction. While not all workers or unions are united on these concerns, select unions that represent construction workers have expressed concerns over foreign labor taking their role and the alleged lack of safety standards.

²³ https://asia.nikkei.com/Business/Tech/Semiconductors/Intel-to-quadruple-cutting-edge-chip-packaging-capacity-by-2025?utm_campaign=GL_asia_daily&utm_medium=email&utm_source=NA_newsletter&utm_content=article_link&d

²⁴ <https://observer.com/2022/10/intel-ceo-pat-gelsinger-predicts-chip-industrygeopolitical-tension/>

²⁵ <https://spectrum.ieee.org/fabs-cut-back-water-use>

Sunk-Cost Trap

While Washington and chip companies advocating for subsidies have used national security as a rationale for reshoring and friend-shoring, neither have advocated for abandoning the Chinese market altogether. The world's largest importer of semiconductors is too important for the bottom line of semiconductor manufacturers to trade it for subsidies in developed markets such as the US.²⁶ While most US companies have pulled out of China, partners and allies are not on the same page. Both Taiwan and South Korea maintain their positions on the mainland and Korean companies such as SK Hynix have in fact acquired the assets of departing US firms, such as Intel's facilities in Northeast China.

Washington has made exceptions (see below) to its export controls for Taipei and Seoul to prevent a backlash against American industrial policies from escalating. South Korean companies such as Samsung and SK Hynix rely on US and Japanese companies for semiconductor manufacturing equipment (SME) and on the Chinese market for more than 40% of their sales.²⁷ This dependence on two adversarial nations for both the front end and back end, coupled with political pressures, make it extremely challenging for semiconductor companies to navigate the turbulent conditions in their largest and second-largest markets. If history is any benchmark, Chinese companies leverage the support of foreign companies before eventually pushing them out of the Chinese market through preferential subsidies.

For its part, Washington must crack down on its own industry, or else it will come off as not practicing what it preaches. In the case of SME, over the last few years, and particularly, months before export restrictions come into force, China has imported a substantial amount of SME. In recent years, SME sales to China have come to around 30 percent of all US sales, 29 percent of all Japanese sales and 20 percent of South Korea's sales.²⁸ It is currently the largest market for SME in the Indo-Pacific region. It purchased over US\$28 billion worth of equipment in

2021. The "small yard, high fence" approach – wherein strategic assets are protected while the economic partnership remains, often cited by the US National Security Advisor Jake Sullivan as the administration's guiding principle, may come at a cost.²⁹ Moreover, as an extension of this practice, the Biden administration has played blow-hot, blow-cold bypassing export control measures on one day and watering it down by providing exceptions to partners on another. In early June 2023, the Biden administration announced that it will allow South Korean and Taiwanese companies to continue and expand their operations in China without any reprisals, such as being denied the opportunity to benefit under the CHIPS Act.³⁰ If Washington is going to set rules on investing in China and expect other countries to follow them, it must remain consistent.

Unhappy Partners

Washington's unilateral export curbs did not sit well with Korea and Japan. While Washington has found success with political measures such as peacebuilding and reconciliation between historical rivals Japan and Korea on trade and economic linkages, the two have expressed concerns over Washington's mercantilist turn.³¹ In the case of semiconductors, Seoul has been wary of Washington's protectionism given that China is Korea's largest market for exports. The CHIP4 Alliance is strong on paper with the US, Japan, Korea, and Taiwan contributing unique value-add across the different segments of the value chain, but its results have not materialized yet. At the same time, there are reports by organizations representing US semiconductor manufacturers that Huawei is leading a secret network of fabs across China to evade US sanctions.³²

Friend-Shoring Counts on the Success of Industrial Policies

Supply chain diversification heavily relies on industrial policies. While this paper has elucidated the success of select East Asian states, there is no

²⁶<https://www.nytimes.com/2023/07/08/business/economy/us-china-chips-janetyellen.html>

²⁷<https://asia.nikkei.com/Business/Tech/Semiconductors/Samsung-and-SK-Hynix-face-China-dilemma-from-U.S.-export-controls>

²⁸ <https://www.csis.org/analysis/mapping-semiconductor-supply-chain-critical-roleindo-pacific-region>

²⁹ <https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/10/13/remarks-by-national-security-advisor-jake-sullivan-on-the-biden-harris-administrations-national-security-strategy/>

³⁰ <https://www.wsj.com/articles/u-s-to-allow-south-korean-taiwan-chip-makers-to-keep-operations-in-china-5d7d72cc>

³¹ https://www.wsj.com/articles/loophole-allows-u-s-tech-exports-to-banned-chinese-firms-b4800164?mod=article_inline

³² <https://www.bloomberg.com/news/articles/2023-08-23/huawei-building-secret-chipplants-in-china-to-bypass-us-sanctions-group-warns#xj4y7vzkg>

shortage of failures of industrial policies. Major corporations are betting on the government's support for diversification. One major reason for the relative success of industrial policies in East Asia was policy consistency across different administrations. Among democracies in the Indo-Pacific or even Europe, that consistency is not a given. A change in government could reverse once-supportive policies. For example, while the CHIPS Act was a bipartisan effort, the IRA came into existence as partisan legislation³³ whose promises may be re-evaluated should power change hands after an election.

Tit-For-Tat Export Controls

The tit-for-tat export control measures deployed by both the US and China affected nations and companies at every segment in the value chain. Mergers and acquisitions in the sector are becoming increasingly challenging with regulators from both superpowers monitoring every transaction for national security implications.

China for its part has put in place policies restricting the export of minerals affecting Japanese and Dutch companies that rely on it for the manufacture of SMEs.

Conclusion

As the Chinese government nudges its domestic industry toward indigenization, Chinese companies such as Huawei, Tencent, Xiaomi, and other large conglomerates will work to address their comparative weaknesses in segments such as design and IP. The Chinese government has significantly increased its R&D expenditures over the last few years. Strategic mergers and acquisitions have become increasingly fraught, especially in the sale of advanced technologies such as photolithography or design and IP.

In this tit-for-tat environment, two factors will determine whether the US holds onto its leadership position: whether the US is successful with its industrial policies at home and on friendly shores, and whether Beijing succeeds in indigenizing the technology supply chain.



As the Chinese government nudges its domestic industry toward indigenization, large conglomerates such as Huawei, Tencent, and Xiaomi will work to address their comparative weaknesses.

³³ [https://www.epw.senate.gov/public/index.cfm/2023/8/capitolreleases-one-year-report-on-inflation-reduction-act-s-](https://www.epw.senate.gov/public/index.cfm/2023/8/capitolreleases-one-year-report-on-inflation-reduction-act-s)

[failedpromises#:~:text=BACKGROUND%3A,circumvented%20the%20regul%20order%20process.](#)

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