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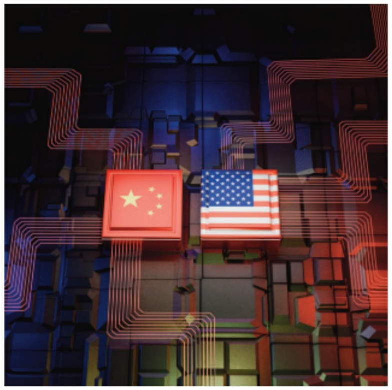
TOP of MIND

THE US-CHINA TECH RACE



While the US and China have reached a new trade deal, their fierce race to achieve tech superiority remains as intense as ever, with both pursuing policies to develop self-sufficient tech stacks. So, will such policies prove successful, and what investment opportunities do they provide? The Wahba Initiative for Strategic Competition's Mark Kennedy assesses the tech race's current state (the US leads in a key arena but China is catching up or leading in many others) and GS' Alec Phillips and Hui Shan dig into the why, what, and how of US and Chinese policy efforts to win the race. DGA-Albright Stonebridge Group's Paul Triolo and the Critical Minerals Institute's Jack Lifton then explain the intricacies and chokepoints of the two supply chains in focus here—semiconductors and rare earths—and GS' Daan Struyven digs into power's critical role in determining the winner. Lastly, we explore related investment opportunities, with GS equity analysts and strategists seeing compelling opportunities in rare earths and Asia tech.

"It is entirely possible that neither the US nor China emerge as the outright victor in the tech race. I can envision a world in which the US leads in developing the most advanced technologies, while China leads in global installations.

- Mark Kennedy

The desire to reduce our dependence on China [for rare earths] is valid. And there is a viable path to achieving that, even if it won't amount to self-sufficiency. It's just a matter of picking the right companies, technologies, and people.

- Jack Lifton

The US expanding or even maintaining its current lead [in advanced AI] is not a foregone conclusion... much will depend on the Chinese semiconductor industry's ability to overcome the hardware chokepoints.

- Paul Triolo"

WHAT'S INSIDE

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Macro news and views

We provide a brief snapshot on the most important economies for the global markets

US

Latest GS proprietary datapoints/major changes in views

- No major changes in views.

Datapoints/trends we're focused on

- US growth, which we expect to modestly reaccelerate to 2.3% in 2026 (on a Q4/Q4 basis) owing to a reduced tariff drag, tax cuts, and easier financial conditions.
- Fed policy; we expect the Fed to deliver a 25bp rate cut next week followed by two 25bp cuts in 2026 for a terminal rate range of 3-3.25%, but see downside risks to our forecasts given ongoing labor market weakness.
- US productivity outperformance vs. other DMs, which structural factors & AI adoption tailwinds should sustain.

Japan

Latest GS proprietary datapoints/major changes in views

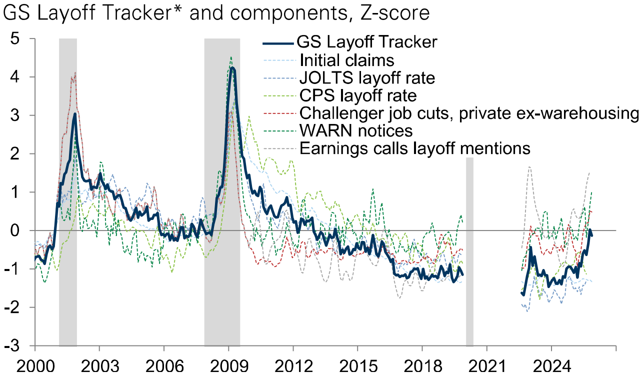
- No major changes in views.

Datapoints/trends we're focused on

- BoJ policy; while Jan 2026 remains our baseline forecast for the next hike, the likelihood of a rate hike this month has risen following a recent hawkish speech by Governor Ueda.
- Heightened Japan-China tensions, which we estimate could result in a 0.2pp hit to Japanese GDP growth from reduced Chinese tourism and lower Japanese exports to China.
- An expected rise in Japanese potential growth over the next several years, driven by labor productivity growth.

US layoffs: on the rise

GS Layoff Tracker* and components, Z-score

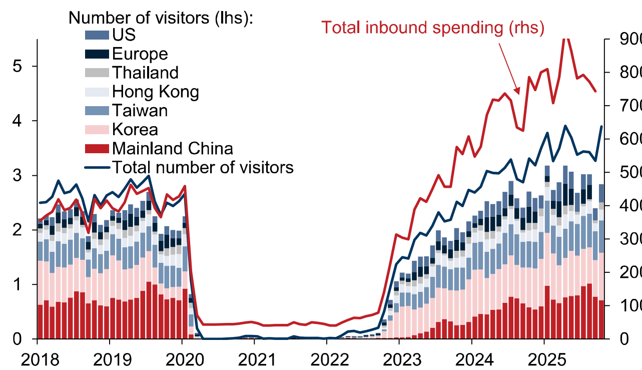


*First principal component of our tracking of WARN notices, initial claims, Challenger layoffs, and earnings calls layoff discussions.

Source: Dept. of Labor, Challenger, Gray & Christmas, Federal Reserve, GS GIR.

Japan: rising China tensions, falling Chinese tourism

Foreign visitors to Japan (lhs, mn per month) and their inbound spending (rhs, ¥bn per month)



Source: JNTO, BoJ, Goldman Sachs GIR.

Europe

Latest GS proprietary datapoints/major changes in views

- We lowered our 2026/27 Euro area GDP growth forecasts to 1.2%/1.3% yoy (from 1.3%/1.5%) to reflect increased export competition with China and lower potential growth.
- We raised our 2026 UK GDP growth forecast to 1.1% yoy (from 1.0%) as the Autumn Budget projections suggest a smaller fiscal drag on demand than we originally assumed.

Datapoints/trends we're focused on

- BoE rate cuts, the next one of which we expect this month.
- ECB policy; we expect the ECB to remain on hold, though the risks are tilted toward renewed rate cuts next year.

Emerging Markets (EM)

Latest GS proprietary datapoints/major changes in views

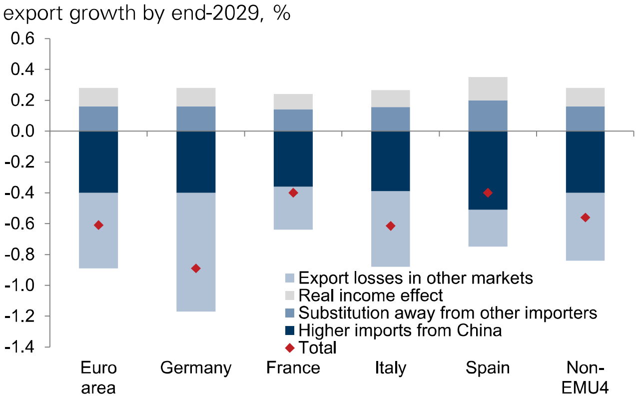
- We recently raised our CY2025/2026 India real GDP growth forecasts to 7.6%/6.6% yoy (from 7.3%/6.5%) following much stronger-than-expected 3Q2025 GDP data.

Datapoints/trends we're focused on

- China shock 2.0; China's renewed focus on export-led growth will likely benefit its economy and raise its current account surplus to 1% of global GDP by 2029, reducing its trading partners' manufacturing output and employment.
- EM growth; we expect growth in China, Brazil, and India to slow in 2026 but pick up in several mid-sized EMs, leaving overall EM growth broadly unchanged.

Europe: an export drag from China's second wave

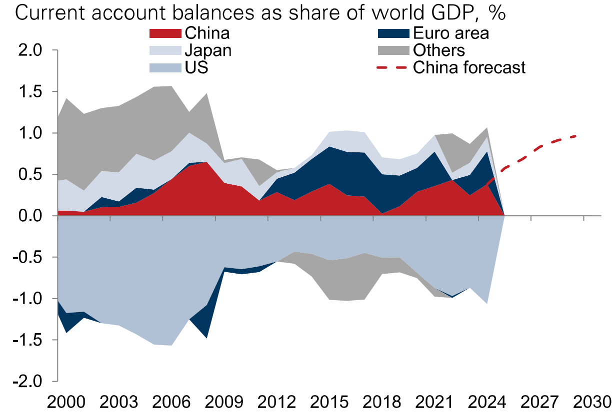
Estimated country-level real GDP impact of higher Chinese export growth by end-2029, %



Source: Haver Analytics, Goldman Sachs GIR.

China shock 2.0

Current account balances as share of world GDP, %



Source: IMF, Haver Analytics, Goldman Sachs GIR.

The US-China tech race

While the US and China reached a new trade deal following bilateral talks at the October APEC summit, their fierce race to achieve technological superiority—driven by a complex interplay of security, economic, and geopolitical interests—remains as intense as ever, with both countries pursuing policies to develop self-sufficient tech stacks. Whether such policies will prove successful, and the investment opportunities they provide, is Top of Mind.

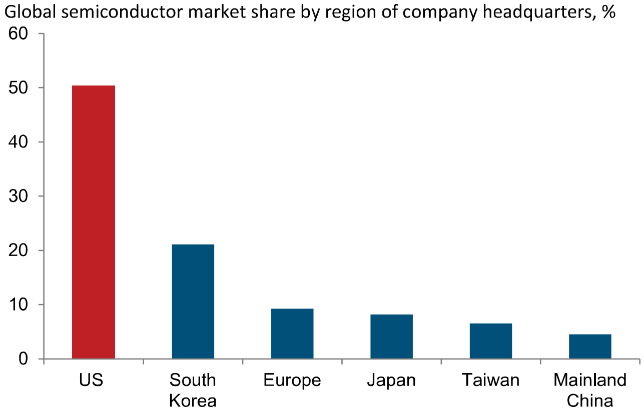
We first ask Mark Kennedy, Founding Director of the Wahba Initiative for Strategic Competition at NYU's Development Research Institute, to assess the current state of the tech race. He explains that while the US leads in many key areas of technological innovation (including semiconductors, AI frameworks, cloud infrastructure, and quantum computing), China is quickly closing the gap or even dominating in three other critical arenas of the race—practical applications like physical AI and robotics, installations of the digital plumbing that underpins technology owing to China's strong presence in the Global South, and technological self-sufficiency as China has worked to reduce its dependence on Western technologies.

GS Chief US Political Economist Alec Phillips and Chief China Economist Hui Shan then dig deeper into the why, what, and how of US and Chinese policy efforts to win the tech race. Phillips explains that US policymakers are combining the playbooks deployed during World War II/the Cold War and the US-Japan economic rivalry of the late 20th century by taking an increased role in some areas (like semiconductors and AI) while relying on financial incentives to boost domestic production and purchases in sensitive sectors (like rare earths). And Shan details Chinese policymakers' "holistic and highly coordinated" approach to supporting technology, which involves systematic planning, significant financial backing, and assisting in other areas from land acquisition to talent development.

We then explore the two supply chains most in focus amid this race: the global semiconductor supply chain—for which the US has a slight edge—and the rare earth supply chain—which China currently controls (see pgs. 10 and 11).

The US accounts for half of the global semiconductor market...

Global semiconductor market share by region of company headquarters, %

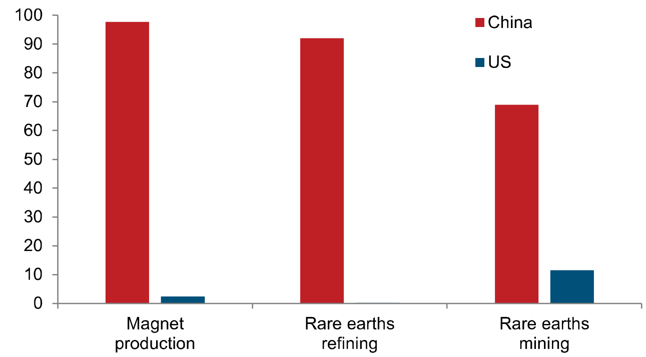


Source: World Semiconductor Trade Statistics (WSTS), Gartner, Omdia, Semiconductor Industry Association, compiled by Goldman Sachs GIR.

We first turn to Paul Triolo, Partner at DGA-Albright Stonebridge Group, for an explanation of the intricacies and key chokepoints of the semiconductor supply chain, which he says makes it difficult for any country to achieve self-sufficiency. But he argues that despite the US' current lead in chip innovation, "if any country can do it (i.e., achieve self-sufficiency), it's China, owing to its vast resources and pool of engineering talent", though he sees significant technical and financial challenges. But he also believes that recent US policy efforts to strengthen its domestic semiconductor capabilities don't go far enough, leaving open the possibility that China could close the gap with the US in developing the world's most powerful AI models, while also maintaining or even growing its lead in AI adoption given China's embrace of open-source models.

...while China dominates the rare earths space

China vs. US market shares in each category, %



Source: IEA, Woodmac, Goldman Sachs GIR.

We then speak to Jack Lifton, Co-chair of the Critical Minerals Institute, who breaks down China's grip on the supply chain for rare earths, and especially the heavy rare earths used in defense and other critical industries. While he believes China's chokehold can be broken, he argues that current US efforts to do so will not succeed because US policymakers are not investing in "the right companies, technologies, and people." But he also thinks the need for such efforts is overblown given that US rare earth demand is small and acceptable substitutes exist, at least in the military complex.

GS Co-head of Global Commodities Research Daan Struyven nonetheless makes the case that China's dominance in rare earths, together with its abundant power supplies—in sharp contrast to the US' power constraints—give China an edge in the AI and broader tech race. Triolo and Kennedy agree that China's power advantage presents a challenge for the US, which they say sets the stage for the energy-abundant Middle East to play a pivotal role in the US-China tech race.

So, how should investors be positioned as US and Chinese policymakers deploy their playbooks for "winning" this race? GS equity analysts find that the stocks of leading semiconductor manufacturing and equipment companies have already largely priced in US-China tech developments. But they think continued efforts by both countries to develop their own tech stacks could remain a key driver of price action for Western rare earth mining and refining companies. And GS senior Asia Pacific strategists Tim Moe and Kinger Lau see significant opportunities for Asia tech companies—which have outperformed this year—amid these ongoing policy efforts.

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Interview with Mark Kennedy

Mark Kennedy is Founding Director of the Wahba Initiative for Strategic Competition at New York University's Development Research Institute. Below, he lays out the current state of the US-China tech race, arguing that the US leads in a key arena, but China is quickly catching up or even leading in many others.

The views stated herein are those of the interviewee and do not necessarily reflect those of Goldman Sachs or of NYU.

Ashley Rhodes: Technology seems to be at the center of the US-China strategic rivalry. Is that an accurate characterization, or has the role of technology been overplayed?

Mark Kennedy: The role of technology is not being overplayed. Technology isn't just at the center of the US-China rivalry—it's the central switchboard. Whoever controls how technology, data, and computing power are routed will impact every domain—from military might, to economic influence, to the flow of information. So, the significance of technology in the US-China rivalry is anything but overstated. The profound impact that this technological contest could have on global systems and the resulting geopolitical implications are, if anything, underappreciated.

Ashley Rhodes: Who is currently "winning" the tech race?

Mark Kennedy: It's important to understand that there are four key arenas in this race: technological innovation, practical application of the technology, installation of the digital plumbing or infrastructure underpinning the technology, and technological self-sufficiency. The US is currently leading in most advanced technologies, including semiconductors, AI frameworks, cloud infrastructure, and quantum computing, as well as in attracting global talent. However, China is ahead in areas such as quantum communications, hypersonics, and batteries.

China is also making rapid strides to catch up to and, in some cases, overtake the US in technological application. For example, China deploys robotics in manufacturing on a scale twelve times greater than the US when adjusted for differences in employee income. And while US regulations often limit applications like drone deliveries to your door, China is proactively testing and deploying advanced physical AI and robotics like uncrewed taxis and vertical takeoff vehicles, accelerating their practical adoption.

China is also dominating on the global installations front. It has established a strong presence in the Global South, surpassing the US and other Western nations in building essential digital networks there. And China has made significant strides toward achieving technological self-sufficiency through its dual circulation strategy aimed at reducing its reliance on the West while increasing Western dependence on China. Recent Chinese government measures, such as restricting domestic purchases of Western chips and offering incentives for using domestic alternatives, underscore this push for technological independence. At the same time, China's vast overproduction capacity in batteries and critical minerals has further increased Western dependence on China's supply chains. The US has been ambivalent at best as it relates to this aspect of the tech race and remains reliant on China in many ways. So, on net, while the US leads in the development of the technology itself, China is rapidly closing the gap—or even leading—in application, infrastructure installations, and tech self-sufficiency.

Ashley Rhodes: Have US export controls on advanced chips materially impeded China's technological progress?

Mark Kennedy: The impact has not been especially significant. China had already planned to reduce its reliance on American semiconductor technology, and the introduction of US export controls has merely accelerated that transition. China is finding ways to adapt by using less advanced chips and still maintains some access to certain US chip technologies. So, while these measures are slowing China's technological progress, they are not significantly impeding it and are unlikely to be the silver bullet that allows the US to maintain its tech lead indefinitely.

Ashley Rhodes: Conversely, will China's grip on rare earths impede the US' ability to maintain tech leadership?

Mark Kennedy: Rare earth elements are a critical input in the tech race, making China's export restrictions a real threat to America's long-term prospects for developing an independent tech ecosystem. While China has granted the US a one-year reprieve on these restrictions, the recent deal between the two countries is fragile and the US will remain vulnerable unless it can rapidly expand its access to rare earths. The US has been aware of this vulnerability for a long time but has admired the problem more than it has taken deliberate steps to address it. America is just now waking up to the seriousness of this threat and beginning to take steps in the right direction, including US government efforts to invest in rare earth companies and take ownership stakes in key firms. But the US is still a long way from achieving self-sufficiency, and true resilience will depend on working closely with allies like Australia and Canada to establish secure, diversified supply chains. Regrettably, US relationships with its key allies have become increasingly fractured, which isn't helpful.

Ashley Rhodes: What else will it take for the US to win?

Mark Kennedy: Beyond diversifying supply chains for critical minerals and other essential technological inputs, the US must more broadly move beyond its historically laissez-faire approach toward technology and lean into winning the tech competition across all arenas. This means significantly increasing investment in research and development, reversing the recent trend of stagnant or declining university funding, and easing restrictions that hinder the entry of global talent.

The US must also expand its energy infrastructure to support the growing power demands of data and computing. While China has gone far in securing energy resources—particularly in renewables such as wind, solar, and nuclear—the US approach has been inconsistent. The current shift toward nuclear energy is promising, but achieving the necessary scale will take time.

And the US must strive to match China's push to dominate installations in the Global South or risk losing influence in these regions. To date, restrictive policies—such as the Biden Administration's AI Diffusion Rule and other restrictions—have limited the reach of US tech. Actions like cutting off Ukraine's satellite access have raised concerns that the US may wield technological access as a form of geopolitical leverage. And where the US withholds its tech, China readily steps in. While recent AI policy discussions have recognized the importance of deploying the domestic tech stack globally, the real challenge is getting multiple government agencies and private companies to act with the same unity and speed as China does.

Ashley Rhodes: The US does seem to be increasing public-private partnerships to make progress toward these goals. How important are such partnerships?

Mark Kennedy: Government involvement in the critical minerals sector will play a crucial role given that China's dominance allows it to lower prices and squeeze out competitors. So, US companies need to have some guarantee that prices will be at a level that will at least sustain their production. These guarantees will be essential to generating the sources of supply at the mineral level that will allow the US to apply its magic at the digital level. And government involvement will be critical to expanding the reach of US technology to other parts of the world, like the Global South.

However, the benefits of other types of government involvement are less clear. For example, it's unclear whether the government taking an ownership stake in Intel will prove helpful beyond the near-term boost in capital and confidence it provided. Such a move could actually be harmful if measures like "golden shares" prevent the company from making the tough decisions that will be required for it to remain globally competitive. Intel's role as the sole domestic foundry of scale is vital, especially as TSMC's investment in the US remains a shadow of the company's efforts to maintain its silicon shield in Taiwan. The trick is providing support without politicized interference. Past US ownership in established commercial enterprises has seldom delivered long-term benefits.

Ashley Rhodes: Conversely, what additional steps must China take to win the tech race?

Mark Kennedy: China is already doing many things right. Its most effective strategy has been sustained, targeted investment in key technologies that will determine the future. And China has long understood the importance of securing and leveraging essential resources like rare earths as well as areas like ports. As we've discussed, China has also been ahead in establishing new markets in key regions like the Global South.

But China recognizes that it needs to accelerate the advancement of its domestic semiconductor industry. To that end, the Chinese government has begun channelling investments into local chip manufacturing, prioritizing long-term development over short-term performance gains.

Another critical priority should be building trust. The Chinese model is characterized by centralized control; their systems are not easily interoperable or replaceable, leading to a degree of lock-in. And China's cybersecurity laws require companies to provide any requested data to government authorities. All this undermines international trust in Chinese tech. The tech competition is in many ways a battle for trust. The US is currently leading in this area given its history of transparency and reliability, while China has more work to do in ensuring that its technology is not only affordable and reliable but also trustworthy.

Ashley Rhodes: How important are other countries in determining who wins the tech race?

Mark Kennedy: The technological alignment of other countries will be pivotal in determining the outcome of the tech race. Again, China has been aggressively targeting the Global South, offering comprehensive digitalization packages—often as service contracts—which enable it to build, maintain, and exert substantial control over networks and the data they carry. This access to vast amounts of data, in turn, enables China to train AI models that provide insights into how to tailor products or services specifically for those markets, reinforcing its influence and making it increasingly difficult for competitors to match the value China offers.

By contrast, the US has not matched China's government-backed efforts in these markets. Once-prominent programs like USAID, whose grants supporting host country capabilities paired with financing support helped the US prevail in many international infrastructure competitions, have largely been diminished. This has left the US at risk of ceding technological influence while China positions itself to digitally connect up to 70–80% of the world's landmass, aligning it away from US interests. The US really needs to consider whether it should be doing a better job of matching China's thumb on the scale in determining through whose networks the world's data flow.

The Gulf countries will also play a pivotal role in the tech race given their abundant energy resources. Whoever succeeds in establishing influence within these countries will gain privileged access to vast energy resources they can use to power their technological ambitions and capabilities. That said, with both China and the US likely to be increasingly engaged in the Gulf for this reason, establishing security protocols to ensure that tech provided to the Gulf does not drift to China will be essential. Geopolitically, the US must embrace the Gulf, or China will fill the void.

Ashley Rhodes: Ultimately, how do you envision the US-China tech race playing out?

Mark Kennedy: It is entirely possible that neither the US nor China emerge as the outright victor in the tech race. I can envision a world in which the US leads in developing the most advanced technologies, while China leads in global installations, particularly outside of America and its closest allies. China could also prevail in applications as its vast quantity of electric engineering graduates and PhDs could take on a quality of its own. And China could win the "we're independent of you, but you're still dependent on us" race. So, a world could exist in which the US owns the blueprints—leading in software and code—but China owns the buildings—commanding the hardware and circuitry—which would have the potential to significantly reshape economies and geopolitics as we know it.

A US policy roadmap for the tech race

Alec Phillips explores the US policy roadmap for achieving technological self-sufficiency

US policymakers have drawn parallels between the tech rivalry with China and the urgent US industrial and scientific efforts during World War II as well as the US-Soviet tech competition during the Cold War. During both periods, intense scientific and technological rivalries led the US government to organize and fund research and development in several key areas of competition (e.g., nuclear fission and aerospace).

However, many of the technologies central to the US-China tech rivalry today are primarily commercial. While most have benefitted from publicly funded research and have military or strategic uses, the markets for these technologies are much broader and, in many cases, the technology has already been commercialized. Indeed, private sector funding for AI or semiconductors dwarfs government programs. This presents a challenge that goes beyond scaling up public (i.e., military) spending, with arguably greater parallels to the US-Japan economic rivalry in several sectors during the 1970s and 1980s.

US policy appears to be following approaches along both lines, with a larger government role in some areas while primarily relying on financial incentives for production or purchase of domestically-produced products in sensitive sectors.

Focusing investment in strategic sectors

While no formal definition of the sectors of greatest strategic importance exists, the Trump Administration appears to prioritize AI, quantum computing, nuclear technology, and biotechnology, along with related inputs like rare earths/critical minerals and semiconductors. Robotics and drones, shipbuilding, aerospace, and power technology also appear to be priorities, though not as central a focus.

Technologies targeted by several government initiatives

	Genesis Mission (Nov. 2025)	White House memo on R&D priorities (Sep. 2025)	Trump memo to OSTP Dir. (Mar. 2025)	DoD "Critical Technology Areas" (Nov. 2025)	Sec. 232 Invest-igation	China-focused Sec. 301 Invest-igation	Outbound invest-ment rules (Nov. 2024)	Subsidy program (CHIPS, IRA, OBBBA)	Loan or equity stake (2025)	Trade partner invest-ment goals
AI	●	●	●	●			●			●
Quantum	●	●	●	●			●			
Nuclear	●		●					●	●	●
Semis	●				●	●	●	●	●	●
Biotech	●	●		●						●
Critical Minerals	●				●			●	●	●
Space	●	●								
Shipbuilding						●		●		●
Aerospace					●			●		●
Steel					●				●	
Robotics					●					
Energy trans. /storage								●		●

Source: White House, Department of Defense, USTR, Goldman Sachs GIR.

The Trump Administration has several tools to invest in strategic sectors:

- **CHIPS Act grants:** While around $43bn of the $50bn in direct funding in the CHIPS Act (2022) has been allocated, the Commerce Department continues to deploy funding from the Act, including for financing equity stakes in key firms.
- **Advanced manufacturing incentives:** The One Big Beautiful Bill Act (OBBBA) renewed and expanded the Advanced Manufacturing Investment Credit (48D) from 25% to 35%, which subsidizes domestic investment in semiconductor manufacturing capacity and related tech. While 48D was originally enacted in the CHIPS Act, funding is open-ended and separate from the $50bn grant authority noted earlier. The OBBBA also preserved the Inflation Reduction Act's (IRA) Advanced Manufacturing Production Credit (45X), which subsidizes domestic production of batteries as well as wind and solar components, but the new legislation reduces the credit for costs attributable to products from Chinese companies. The OBBBA also included broader manufacturing incentives, including immediate expensing of manufacturing structures and equipment.
- **Government financial stakes:** The Trump Administration has announced stakes in firms in the critical minerals, nuclear energy, semiconductor, and steel sectors totaling $10bn (Intel accounts for nearly $9bn of this). While some of these financial commitments involve equity, others consist primarily of loans. OBBBA expanded the scale and reach of these programs via a $1.5bn appropriation allowing up to $200bn in lending through the Dept. of Defense Office of Strategic Capital, which will likely lead to lower-cost, longer-term loans than these firms would otherwise receive. OBBBA also gives $2bn to the Defense Innovation Unit, which focuses on scaling commercial tech for military use, and $10bn to the Industrial Base Fund, for investments in critical minerals supply chains and to bolster the US critical minerals stockpile.
- **Trade partner investment pledges:** The Trump Administration announced agreements with the European Union ($600bn), Japan ($550bn), South Korea ($350bn), and Switzerland ($200bn) to invest in the US. The structure of these pledges is not entirely clear but the most defined of them, the Japanese investment pledge, suggests that these pledges might function primarily as low-cost loans with a small equity component, targeting a combination of strategic sectors (e.g., semiconductors, energy storage, and data centers) and traditional investments (e.g., natural gas and electric utility infrastructure, fertilizer production, etc.).
- **Lighter domestic regulation:** The Trump Administration has pledged to ease regulation in general, targeting permitting new projects and energy generation, with Trump signing an executive order in July to accelerate permitting of data center infrastructure. Congress is debating permitting reform, with proponents making another push for enactment in the next few months. If enacted, this could facilitate a buildout of the power grid, where undercapacity threatens to become an obstacle to AI infrastructure investment.

Creating a demand signal for certain industries

While demand is clear in some segments like AI and semiconductors, it is less reliable in others. In those areas, US policy provides assurances/guarantees for certain technologies produced in the US or pursuant to public-private agreements:

- **Offtake agreements, floor prices, and other market interventions:** Recent agreements that the Trump Administration has reached with companies in targeted sectors include offtake agreements and floor prices to limit vulnerability to market and non-market forces (see pg. 17). This is particularly relevant in areas like rare earths, where the periodic lifting of restrictions could lead to substantial price volatility and make domestic production uneconomic, facilitating continued Chinese dominance in the sector.
- **Government procurement and demand subsidies:** Defense spending has been an important contributor to US

innovation and will likely play a role in some sectors. OBBBA provides ~$30bn for domestic shipbuilding, for example. And the IRA continues to subsidize renewable energy investment and production and electric vehicle purchases, though the OBBBA both tightened and phased these down to place more emphasis on domestically-produced technology.

Reducing demand for Chinese technology

In addition to boosting investment in and demand for US tech, the US has in place or is contemplating several policies that aim to reduce demand for competing Chinese products:

- **Tariffs on Chinese products:** The Trump Administration reduced the 30% tariff imposed on imports from China earlier this year to 20% as part of the October deal, which also paused US export controls in return for China's easing of rare earth export restrictions. The remaining tariff consists of 10% on all imports plus an additional 10% "reciprocal" tariff that exempts several categories, discussed below. These tariffs apply on top of the ~10% weighted average tariff applied on Chinese imports during Trump's first term. We expect tariffs on China to remain at the current level for the foreseeable future, with risks toward lower tariffs if the Administration does not fully replace them should the Supreme Court block them in its upcoming ruling.
- **The threat of tariffs on key sectors:** The Trump Administration launched national security investigations under Sec. 232 into imports of semiconductors, pharmaceuticals, critical minerals, drones, polysilicon, wind turbines, robotics and industrial machinery, as well as medical consumables and devices. While we have assumed that the Administration will follow through with threatened sectoral tariffs, we no longer assume the imposition of any pharmaceutical tariffs in light of the political challenge this could create and the Administration's signaling that most major firms in the space would be exempt. Similarly, tariffs on semiconductors/electronics could be controversial ahead of the midterm elections and would raise the cost of consumer electronics. That said, the Administration will likely continue to use tariffs to protect sensitive sectors in the US, particularly from competition from lower-cost Chinese firms.
- **Regulation of Chinese components in US systems:** During the final days of the Biden Administration, the Office of Information and Communications Technology and Services (OICTS) and the Bureau of Industry and Security (BIS) at the Commerce Department issued rules limiting the use of tech from China or other "foreign adversaries" in connected and self-driving vehicles. Some lawmakers have urged the Trump Administration to take similar actions in other areas, including AI and cloud infrastructure, robotics, energy generation and storage, network hardware, and chip manufacturing equipment, among other sectors. Separately, the Commerce Department has issued guidance that the use of advanced Chinese chips would likely violate US export control policies.
- **BIOSECURE Act:** In October, the Senate passed an amendment to the National Defense Authorization Act (NDAA) that would bar federal agencies from contracting with "companies of concern", which could limit US firms dealing with the federal government from using inputs from Chinese entities. While this provision looks unlikely to be included in the final Act, it reflects US policymakers' clear intent to limit reliance on the Chinese health supply chain.

Limiting diffusion of certain US technology

US policy has also focused on limiting the supply of technology to China, particularly in the areas of AI and semiconductors:

- **Export controls:** The US continues to impose export controls on sensitive technologies, particularly advanced semiconductors and chip manufacturing technology. The US "entity list" has grown this year, and the Commerce Dept. expanded the definition of an affiliated entity under a September 2025 rule that would have had a big impact on the ability of Chinese companies to procure US technology. However, implementation of this rule was delayed as part of the October deal and it appears unlikely that the US will impose further export controls on China for the next year.
- **Outbound investment rules:** Restrictions on US investment in Chinese entities that operate in AI, chips, and quantum technologies, which the Biden Administration finalized in late 2024, are now in effect. Congress is also finalizing its NDAA legislation for 2025 and is considering codifying similar but potentially broader rules, though outbound restrictions look unlikely to be included in the final legislation. While investment in Chinese biotech, aerospace, and other key sectors are not covered under current rules, the White House has signaled an intent to consider these transactions.
- **GAIN Act and the Diffusion Rule:** The Biden Administration finalized rules at the start of 2025 that would have required US chip companies to retain a sufficient portion of AI-relevant chips for domestic users and strictly limited exports to several countries, including China. The Trump Administration rescinded that rule in May, but the Senate passed an amendment to the NDAA in October that would resurrect some aspects of it, giving US customers priority before allowing export. The final legislation looks unlikely to include these restrictions, but the outcome is uncertain.

A tailored policy roadmap

US policy approaches to the tech race will vary by sector. The AI sector, for example, has little need for financial incentives, but could benefit from regulatory easing and public-private coordination, particularly related to the mobilization of federal research programs and diffusion across the economy (note the Administration's recent "Genesis Mission" to coordinate research and make federal scientific datasets broadly available).

By contrast, small amounts of funding can have a much bigger impact in other sectors, where financial incentives are likely to play a larger role. The total annual market for rare earths, for example, is smaller than several of the individual manufacturing incentives in the IRA, CHIPS Act, or OBBBA. Quantum computing investment is similarly small scale, and federal financial resources seem likely to play a larger role there.

In the near term, US efforts in the tech race with China will likely focus more on domestic incentives rather than on restricting growth of China tech. Following the recent trade deal, it seems unlikely that the White House will take steps that could destabilize the relationship in coming months, but frictions in the relationship are bound to return eventually.

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The why, what, & how of China tech policy

Hui Shan assesses the why, what, and how of China's policy support for technology

The Chinese government has long emphasized the importance of science and technology, with this focus intensifying dramatically in recent years as the US-China tech race has heated up. Indeed, China has implemented several policies to advance technological innovation, including establishing a new Central Science and Technology Commission in the "Party and State Institution Reform" in 2023 to coordinate the construction of the national innovation system, as well as restructuring the Ministry of Science and Technology to optimize the management of the science and technology innovation system. With the US-China tech rivalry showing no signs of slowing, China's drive for technological self-sufficiency will likely remain central to China's policy agenda.

The why

Driving this increased emphasis on science and technology has likely been the Chinese leadership's view that the US and China are locked in long-term strategic competition, making technological self-reliance vital for China's development and national security. Notably, while the 13th Five-Year Plan (FYP) in 2015 contained no mention of the "international situation" (国际形势), the 2018-19 US-China trade war prompted its inclusion in the 14th FYP along with the phrase "a great change unseen in a century" (百年未有之大变局). By 2025, in the wake of the Covid pandemic, Russia's invasion of Ukraine and subsequent Western sanctions on Russia, stricter US semiconductor export controls, and sharply higher US tariffs on China, the phrase "international situation" was cited three times in the 15th FYP proposal, with the language "high winds, rough seas, even raging storms" (风高浪急甚至惊涛骇浪) used to describe the seriousness of the geopolitical challenges that China faces. Against this backdrop, China is determined to strengthen its industrial base, maintain its manufacturing competitiveness, and enhance its domestic innovation capability.

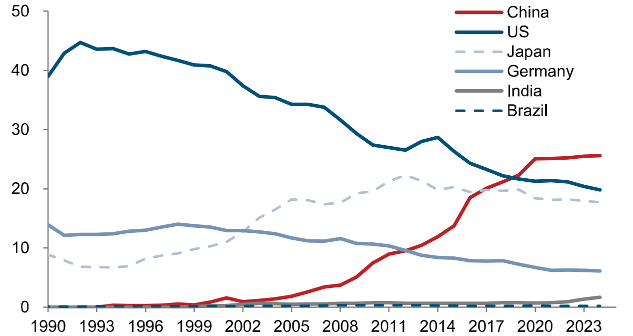
The what

The Chinese government's approach to technological progress demonstrates both continuity and evolution. In 2015, policymakers introduced the "Made in China 2025" plan, which included primary development priorities of information technology, robotics, green energy and electric vehicles (EVs), aerospace equipment, ocean engineering and high-tech ships, railway equipment, power equipment, new materials, pharmaceuticals and medical devices, and agricultural machinery. Since then, China has made remarkable progress in these sectors, securing a dominant position in the global markets for EVs, renewable energy, and shipbuilding.

Looking ahead, the 15th FYP proposal outlines three key areas for future development. The first centers on "chokehold technologies," including integrated circuits, industrial machine tools, high-end instruments, basic software, advanced materials, and biomanufacturing. In these sectors, policymakers will likely spare no effort or expense to achieve breakthroughs and attain self-reliance given their importance to China's national security and resilience against external pressure.

China has the top number of patent applications in the world

Share in global patent applications, %



Source: World Bank, compiled by Goldman Sachs GIR.

The second area focuses on "emerging industries," including new energy technologies, advanced materials, aerospace, and the low-altitude economy (i.e., drones and urban air mobility). These sectors will likely receive substantial investment as the government aims to make them important drivers of China's economic growth.

The third area targets "future industries," including quantum technology, biomanufacturing, hydrogen energy and nuclear fusion, brain-computer interfaces, embodied intelligence (integrated AI and robotics), and sixth-generation (6G) mobile communications. While these sectors are largely in the early stages of development, policymakers view them as potential game changers that could redefine global technological leadership in the coming decades. The government's ongoing support ensures that China remains at the forefront of research and innovation in these cutting-edge fields, even if widespread commercialization may still be years away.

The how

China's government support for science and technology—and their adoption in industrial sectors—is holistic and highly coordinated. First, it involves systematic planning, including through the FYPs as well as detailed catalogs published by the National Development and Reform Commission (NDRC) identifying industries to encourage, restrict, or eliminate. For example, the latest catalog (released in 2024) encourages certain specialty chemicals, while targeting some small-scale, oil- and gas-based, and polluting chemical productions for restriction or elimination.

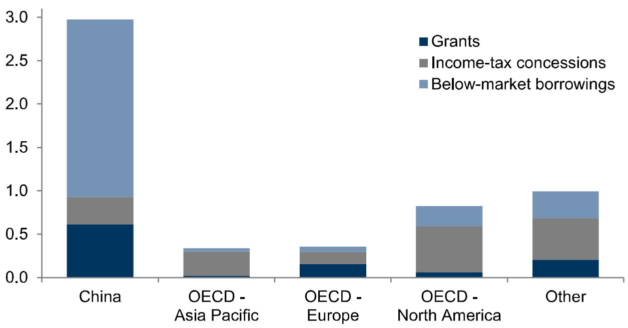
Second, this support includes significant financial backing from various levels of government, including through government-guided funds for tech investments. As of 2024, China had established over 2,000 of these funds, with a targeted total of RMB12.8tn[1]. And at the March 2025 Two Sessions, the NDRC announced a RMB1tn government-guided fund for early-stage tech investments in areas like AI, quantum technology, and hydrogen storage. Beyond direct investments, grants, and subsidies, the Ministry of Finance offers tax benefits to tech companies and the PBOC runs a relending program dedicated to technology and innovation. Consequently, Chinese industrial

[1] According to data compiled by the Qingke Research Center.

sectors receive far more financial subsidies than their global counterparts[2].

China splashes out on industrial subsidies

Industrial subsidies for 14 key industrial sectors, averages over 2005-22, % of annual firm revenue



Source: OECD, compiled by Goldman Sachs GIR.

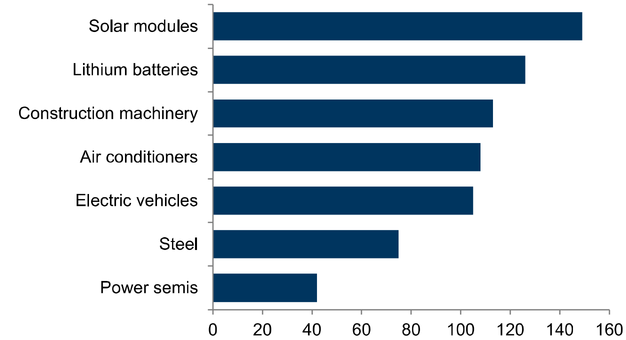
Third, China's government support extends far beyond traditional tax, credit, and financing assistance. In strategic priority areas, the government often offers cheap land, expedited permits and approvals, and abundant energy supplies while facilitating connections between upstream and downstream industries to foster a complete supply chain. It also helps source and develop needed talent, and direct government procurement toward domestic innovations. For example, local governments often sell land to raise revenues, with industrial land priced at only a tenth of residential land. This allows the government to collect implicit taxes from households and then use those funds to subsidize industrial production. And in 2025, the Ministry of Education added 25 undergraduate majors in higher education, including AI, decarbonization, and digital governance. Such a coordinated and systematic approach is key to China's success in achieving significant advancements in technology and high-tech manufacturing over relatively short periods of time.

China's system for supporting tech innovation and emerging industries allows it to mobilize resources from all directions and rapidly scale up production following breakthroughs. However, this system also tends to generate wasteful investment and overcapacity as Chinese local governments respond to the same signals from the central government. In recent years, top leadership has become increasingly concerned about these drawbacks, with President Xi recently stating that not all local governments should develop AI, build data centers, and make EVs. Official outlets now emphasize the importance of building a "unified national market" (全国统一大市场) and growing "new-quality productive forces in alignment with local conditions" (因地制宜发展新质生产力). And, since July, the government has launched "anti-involution" initiatives across many industries to curb investment and prevent excessive price cutting.

However, China's repetitive investment and industrial overcapacity issues are deeply rooted in its political system and cannot be easily solved. Local officials, eager to demonstrate political loyalty and competence, often focus policy efforts on sectors prioritized by the central government. Unless the incentive structure changes—enabling local officials to pursue independent development strategies and achieve promotion without pursuing central directives—accelerated investment in industries explicitly mentioned in the 15th FYP proposal will likely continue. As a result, overcapacity will likely remain a feature of China's economy, even as it shifts from steel and cement in the past to solar panels and EVs today, and potentially to semiconductors and AI in the future.

China's capacity exceeds global demand for several key products

China's capacity as a share of global demand in 2024, %



Source: Goldman Sachs GIR.

Leveraging strengths in the US-China tech competition

China has increasingly relied on two key advantages in its tech competition with the US: its dominance in global supply chains and strong economic ties with the Global South. A notable example of supply chain leverage is China's recent tightening of export controls on critical minerals—including those announced on October 9 covering rare earth minerals, related products like alloys and magnets, as well as refining and processing technology and equipment. Given the importance of rare earths in high-tech manufacturing and China's dominance in refining and processing, such restrictions could significantly disrupt global manufacturing supply chains, prompting the US to ease some of its semiconductor export controls in exchange for China suspending its proposed rare earth export controls, demonstrating the effectiveness of this leverage.

China is also working to establish its technology standards abroad through trade and investment in the Global South. For example, Huawei operates in over 170 countries, encouraging these countries to adopt Chinese telecom technology standards. As more countries follow suit, the resulting network effect increases the attractiveness of China's standards for others. And in 2024, officials called for deeper participation in international standards organizations—including the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the International Telecommunication Union (ITU)—and emphasized strengthening standard connectivity with Belt and Road Initiative participants. With China now a larger trading partner than the US for over 140 countries, the Chinese government seeks to use these ties to expand markets where Chinese technology prevails.

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[2] According to OECD calculations.

Semiconductors, at a glance

What are semiconductors, and who makes them?

Semiconductors are also known as **microchips or chips**. A microchip is a set of electronic circuits layered on a thin wafer of semiconductor material, typically silicon. Transistors located on the chip act as miniature electrical switches that can turn a current on or off. The more transistors that are located on a chip, the more the chip can do. The size of a microchip and the number of transistors on it varies; a microchip the size of a human fingernail can contain billions of transistors.

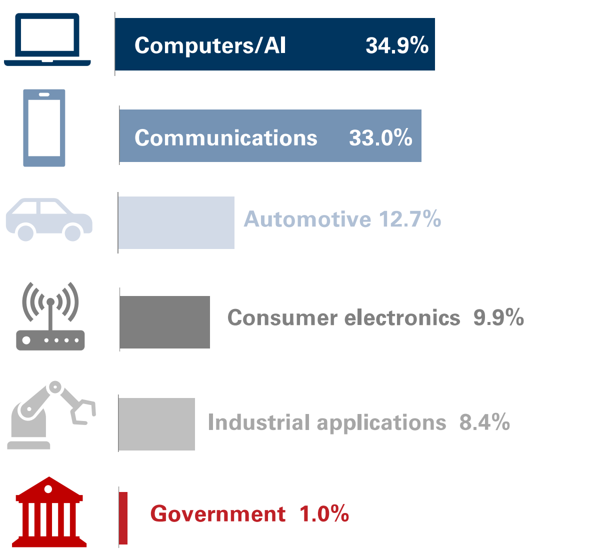
There are three main types of microchip companies: **Integrated Device Manufacturers (IDMs)** (Intel, Samsung), who design and manufacture chips in-house, **Fabless companies** (Nvidia, AMD), who design chips in-house but outsource manufacturing, and **Foundries** (TSMC, GlobalFoundries), who manufacture chips for fabless companies as well as for IDMs who don't have sufficient in-house capacity.

What do semiconductors do?

Semiconductors are the building blocks of technology, and are central inputs in many devices, including cars, computers, smartphones, and medical devices. There are three main types of chips: logic chips, memory chips, and Discrete, Analog, and Other (DAO) chips. Logic chips are the 'brains' of electronics. They process information in order to complete tasks. Central processing units (CPUs) are built for general functionality, graphics processing units (GPUs) are optimized for visual displays, and neural processing units (NPUs) are designed for machine learning applications. Memory chips store information. DRAM chips save data when a device is turned on, while NAND chips save data after a device is turned off. DAO chips transmit, receive, and transform information dealing with continuous parameters, like temperature.

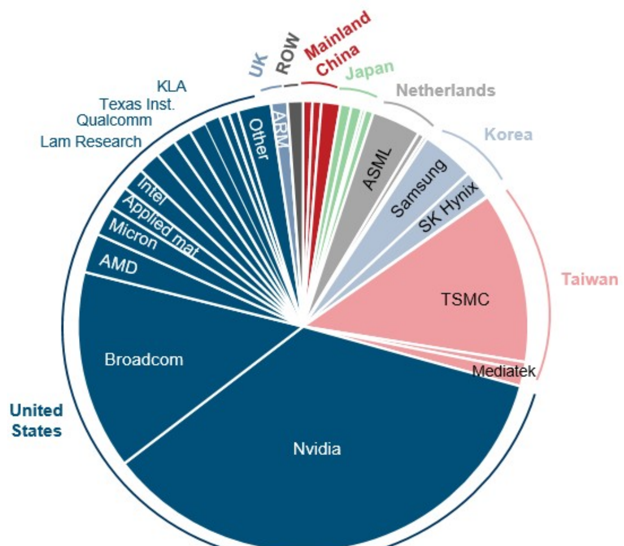
How are semiconductors used?

Global demand share by end use, 2024



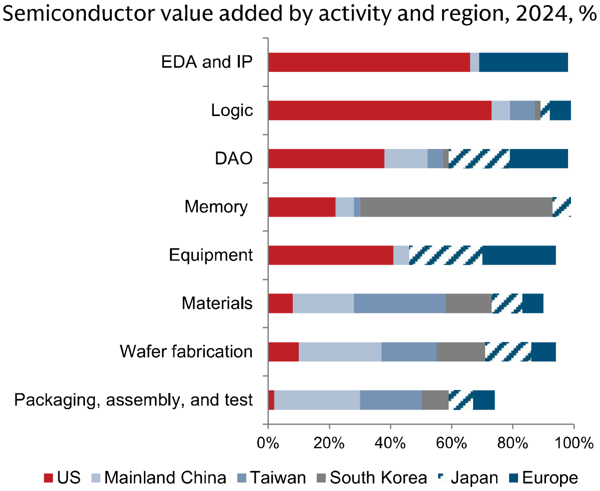
Who are key competitors in the chip industry?

Global semiconductor companies by market cap



What in the supply chain does each region specialize in?

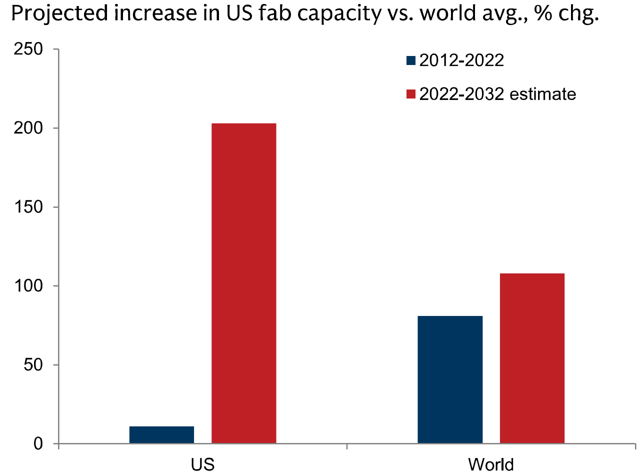
Semiconductor value added by activity and region, 2024, %



Note: DAO is discrete, analog, other; EDA is electronic design automation.

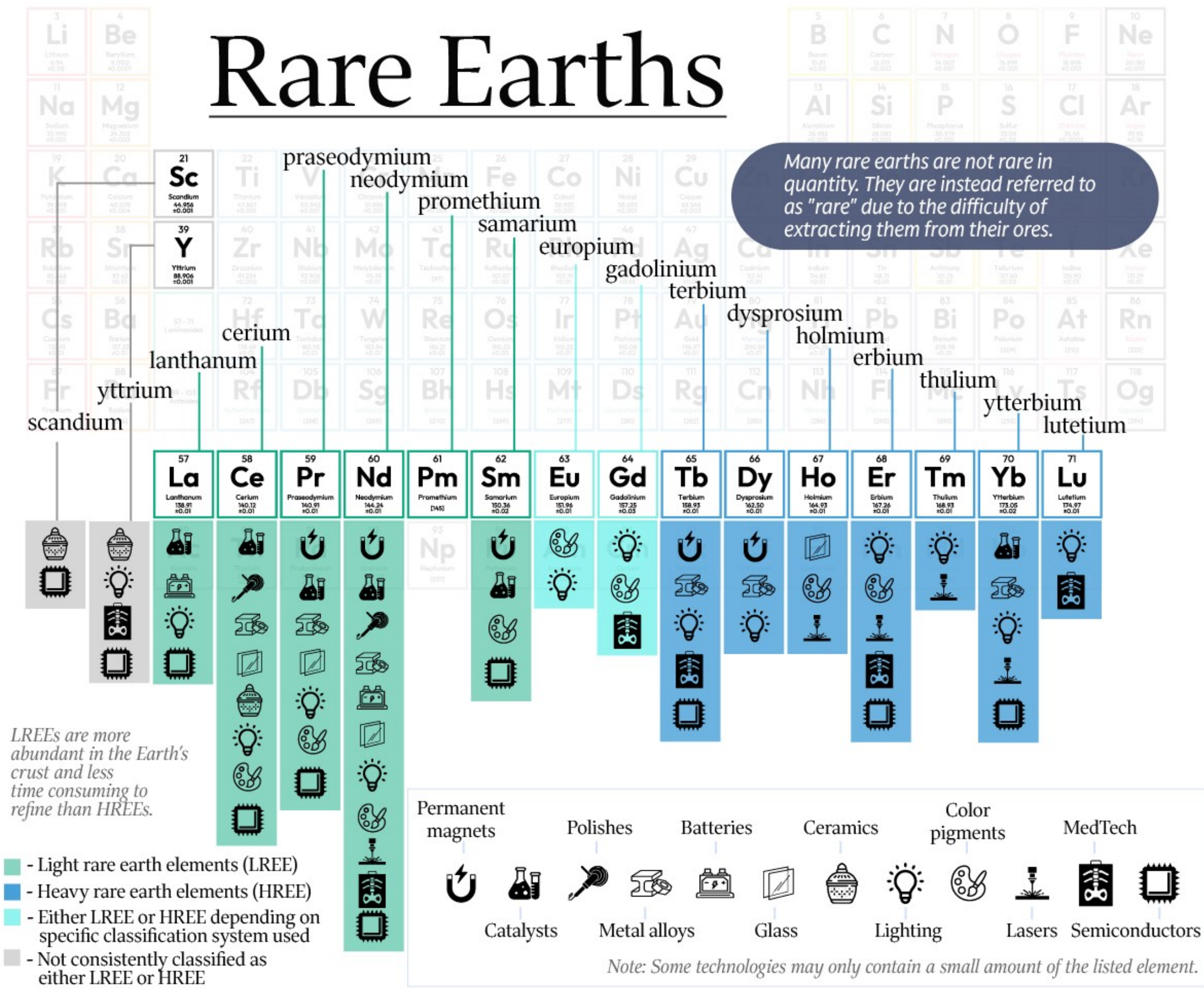
Where is chip-making investment concentrated and how could it evolve?

Projected increase in US fab capacity vs. world avg., % chg.

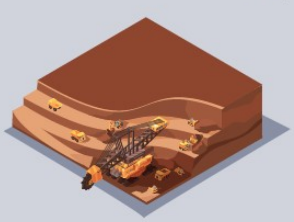


Source: Semiconductor Industry Association, BCG, government websites, various news sources, companiesmarketcap.com, Goldman Sachs GIR.

Rare earths, at a glance



The rare earth supply chain, at a glance



Mining

Rare earth elements are mined from the ground. These elements are found in various ore deposits. The mining method depends on the type of deposit. Methods include open-pit mining, underground mining, and in-situ leaching.

China has the largest share of global rare earth reserves (49%). This includes both light and heavy rare earths, with known HREE reserves extremely scarce outside of China and Myanmar. China also dominates global rare earth mining (69%). Other countries with significant rare earth reserves/mining are:

- Brazil (23% and 0%)*
- India (8% and 1%)
- Australia (6% and 3%)
- US (2% and 12%)

Processing and Refining

Following mining, the extracted ore undergoes several stages of processing. These include crushing and grinding (the raw ore is crushed and ground into small particles), beneficiation (which separates the rare earths minerals from other waste minerals), and extraction and separation (chemical treatments are used to extract the individual rare earths from concentrate).

China also dominates global rare earths refining (92%), particularly in heavy rare earths, with Chinese refineries producing the vast majority of the world's supply of dysprosium and terbium metals. Lynas, an Australian company with operations in Malaysia, is one of the only other major players at this stage of the supply chain, accounting for 4% of global refined production. The US accounts for only 1%.

Manufacturing of products

The separated oxides are converted into rare earth metals and, in turn, alloys. These alloys are used to create powerful magnets known as permanent magnets, which are a key component of various technologies.

China is the world's largest supplier of permanent magnets, which are critical in many technologies. China accounts for 98% of magnet manufacturing.

** Figures in parentheticals represent the share of reserves and mining, respectively.*

Source: IEA, Rareearths.com, Federal Register, various news sources, Goldman Sachs GIR.

Interview with Paul Triolo

Paul Triolo is Partner at DGA-Albright Stonebridge Group. Below, he argues that it will be hard for any country to achieve self-sufficiency in semiconductors, but if any can, it's China.

The views stated herein are those of the interviewee and do not necessarily reflect those of Goldman Sachs.

Allison Nathan: Where are the critical chokepoints across the global semiconductor supply chain?

Paul Triolo: Let me first clarify that there is not one semiconductor supply chain but rather multiple interlocking ones. And it's not a one-way supply chain—a semiconductor product can crisscross the globe several dozen times before being inserted into a final product. So, the term "supply chain" is not representative of the reality of the global semiconductor industry. A more accurate characterization would be "the most complicated set of technologies on Earth."

Within that are three key chokepoints. The first is advanced lithography, the tool that prints the intricate patterns of semiconductor circuits onto silicon wafers at feature sizes far smaller than the width of a single hair. Feature sizes have shrunk rapidly over the past several decades, which has been the driving force behind Moore's Law. The Dutch company ASML is currently the only firm capable of manufacturing the Extreme Ultraviolet (EUV) lithography machines critical to produce advanced chips—those with feature sizes below 5 nanometers (nm)—as it has successfully integrated the cutting-edge light sources, precision optics, and complex computational software for wafer alignment necessary for these machines.

The second chokepoint is etching, the process that exposes the underlying circuit after lithography. Sophisticated etching equipment is needed for chips produced with EUV lithography, and only a handful of toolmakers—like the US' Lam Research and Applied Materials and Japan's TEL—produce it. The third chokepoint is advanced chip manufacturing. Taiwan's TSMC dominates this space, producing over 90% of the world's most advanced chips, because its business model of focusing solely on manufacturing products designed by its clients rather than competing with them, strong relationships with toolmakers, and ability to deliver quality and quantity at scale have made it the trusted partner for integrated device manufacturers like Intel and Samsung and fabless companies like Nvidia.

Allison Nathan: Is it possible for any country to achieve self-sufficiency in semiconductors given these hurdles?

Paul Triolo: If any country can do it, it's China, owing to its vast resources and pool of engineering talent. And it would be wrong to think that just because China isn't self-sufficient today it won't be in the future. Despite the common argument that China always intended to be self-sufficient in this space, the reality is that as long as Chinese companies had access to the most advanced tools, they had little incentive to develop or use local alternatives. China now has the incentive because the US and its allies have largely cut it off from access to EUV lithography and other tooling, including advanced etch, deposition, and metrology. But such technology is difficult to replicate because it requires integrating several complex systems at scale, including advanced optics, specialized light sources, intricate software, and materials like photoresists, all of which must work seamlessly together with other manufacturing tools. And this is only half the battle. As an industry insider once told me, building a prototype is easy, but servicing hundreds of sets of this equipment 24/7 is incredibly challenging owing to the complex nature of the machinery and the need for a very capable workforce to support deployments of these complex tools for customers worldwide that are expecting maximum uptime and few, if any, defects. So, competing with ASML in this space is very difficult. And even if new entrants could develop the know-how, leading-edge semiconductor manufacturers would be reluctant to take a risk on an unproven technology given the enormous costs involved.

Allison Nathan: So, are you saying that US policies have been effective in slowing China's efforts to compete in the semiconductor space and, ultimately, the AI race?

Paul Triolo: Whether US policies have been effective depends on the goal. The US and its Western partners have prevented Chinese companies from purchasing EUV equipment, and the US has banned the sale of advanced GPUs to China through export controls, though this has now been partially reversed. So, US policies have succeeded in restricting China's access to advanced lithography and chips. But these restrictions have spurred China to improve its own capabilities. China is exploring alternative technologies to generate UV light for lithography systems, and Chinese firms are working to improve their GPU design and development capabilities. And US policies have been wholly ineffective in impeding China's ability to develop advanced AI models. All leading open-source and open-weight generative AI models today are the work of Chinese firms like Alibaba, Baidu, Tencent, Moonshot, Zhipu AI, and DeepSeek, in stark contrast to a year ago when Western firms like Meta and Mistral topped the leaderboards. While the US continues to develop the world's leading AI models, the open-source and open-weight nature of Chinese models has allowed them to increasingly dominate real-world adoption due to their lower cost and accessibility. While the issue of model diffusion does not get a lot of airtime, it's vital because winning the AI race will depend not only on model capabilities but also on usage.

Allison Nathan: How have Chinese companies achieved so much without access to advanced lithography and chips?

Paul Triolo: China's progress owes to successes at both the company and national levels. Chinese firms have become incredibly well-versed in how hardware and software interact with AI models and how to train these models using less compute. DeepSeek, for example, successfully used low-level hardware programming, which provides high performance but requires more advanced programming skills, to maximize the use of the limited hardware it had, including the A100 Nvidia GPU the company obtained before the US imposed export controls in October 2022 and the downgraded version of the H100 GPU Nvidia was permitted to sell. Simultaneously, the

Chinese government has supported the domestic AI industry and made it easier for domestic companies to gain access to compute by building data centers nationwide and ensuring reliable access to power by investing heavily in the grid and expanding renewable energy capacity. While major companies like Alibaba, Tencent, and Baidu have their own cloud-based infrastructure and so don't need state support, these government efforts are a lifeline for smaller companies across China. But again, Chinese companies lack access to the most advanced Western GPUs, so despite these favorable state policies, overcoming the compute problem remains difficult.

Allison Nathan: So, ultimately, can China close the gap with the US in developing the most powerful AI models?

Paul Triolo: The idea that the US can maintain its lead in advanced AI is premised on scaling—the belief that increasing computational resources will lead to better models. But the jury is still out on that, and a new technology could come along that obviates the need for training large models on millions of GPUs. Chinese firms, particularly Alibaba and DeepSeek, have also proven capable of developing advanced models with much less compute than US leaders. So, the US expanding or even maintaining its current lead is not a foregone conclusion.

Of course, much will depend on the Chinese semiconductor industry's ability to overcome the hardware chokepoints we've discussed. Making semiconductors is one of the most complex things humans do. The sheer knowledge required is immense and takes decades to acquire. And China started decades behind the US. But US controls have ironically turned all Chinese fabs restricted from accessing advanced US tools into critical tech incubators for China's domestic toolmakers, accelerating their move up the value chain and speeding China's ability to get to more advanced semiconductor production for AI.

China's lack of deep capital markets also poses a challenge. Unlike the US, where abundant patient capital has supported long-term investments in the semiconductor space and companies can readily access deep and liquid financial markets to fund large data center buildouts, China's capital markets are underdeveloped, leading companies to rely more on the government for financing. While that may change over time, the US currently enjoys a significant advantage in this regard.

Again, if any country can overcome these challenges, it's China. But with no historical precedent for an undertaking of this scale, predicting China's chances of success and the timing of key breakthroughs such as advanced lithography is difficult.

Allison Nathan: What challenges does the US face as it tries to strengthen its leadership in semiconductors and AI?

Paul Triolo: While the US is the global leader in chip design and tooling, manufacturing is largely dominated by Asian firms—particularly TSMC and, to a lesser extent, Samsung and some Japanese firms. So, the US is in a strange position—it pioneered the semiconductor industry, but manufacturing has largely gone to Asia as Intel lost its spot as the global leader in manufacturing by missing out on the mobile and AI revolutions and entering the foundry business very late. Intel remains a major CPU producer and is still a huge player in the space, but the market has moved away from its historic core business.

The US has had some success in reshoring advanced manufacturing, with TSMC building a facility in Arizona that now produces 4nm GPUs. But the Arizona facility will likely only reduce the US' reliance on Taiwan for advanced manufacturing by 10% by 2030—far short of the 20% goal of end-to-end share of global capacity laid out as the goal of the CHIPS Act. The major obstacle to significant reshoring is the cost and complexity. Building a fab costs ~$30-40bn, and the US lacks enough engineers and tradespeople as well as the institutional knowledge to pull this off owing to three decades of offshoring. So, just like Mainland China, the US faces sizable challenges.

Allison Nathan: Does China's dominance in rare earths and extensive buildout of power generation capacity provide it with significant advantages over the US in the AI race?

Paul Triolo: I don't view the rare earth issue as particularly salient in this context. While some rare earth elements are used in semiconductor manufacturing, and the industry utilizes rare earth permanent magnets, the numbers are tiny, and enough alternatives exist across the supply chain. So, while rare earths will likely be a constant irritation of ongoing US-China tensions, they won't affect the buildout of large-scale AI infrastructure. China's power advantage is the more critical issue for the US, because energy will be a key gating factor in the AI race. The US has a massive supply chain problem when it comes to supplying the hardware needed to generate enough power. It also lacks a unified grid, which makes it hard to move power around. The Middle East, with its significant access to cheap power, will have an important role to play here, with the US already starting to leverage partners in the region to offset China's power advantage and US weaknesses in this area.

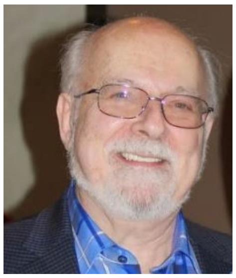
Allison Nathan: The US government has invested and taken stakes in companies to strengthen domestic semiconductor and AI capabilities. Will such efforts be enough to address all these challenges?

Paul Triolo: They are a step in the right direction but likely not enough. While the government's investment in Intel via the CHIPS Act has helped put it on the road to regaining its footing, Intel's long-term viability hinges on securing a large client base over which to amortize the high costs of chip manufacturing. The government has tried to help with that by encouraging Nvidia and Apple to shift production from TSMC to Intel, and may do more of that now that it has taken an equity stake. But to achieve meaningful progress, the Commerce Department must become an industrial policy juggernaut. The CHIPS Program Office, which the Biden Administration established to implement the semiconductor incentives of the CHIPS Act, was a good start. But the Trump Administration has downsized it and is instead trying to reshore semiconductor production via tariffs, which are unlikely to persuade firms to build US facilities given the costs and complexities. What's needed is a credible, long-term commitment to industrial policy. The governments of Taiwan, Japan, and South Korea have long pursued industrial policy, which is a key reason why these places are home to successful chip industries. So, US policymakers need to step up their game for America to prevail in this tech race.

Interview with Jack Lifton

Jack Lifton is Co-chair of the Critical Minerals Institute. Below, he breaks down the global rare earth supply chain and China's role as a chokepoint, but he argues that current US attempts to achieve rare earth self-sufficiency are misguided and the need for them is overblown.

The views stated herein are those of the interviewee and do not necessarily reflect those of Goldman Sachs.



Jenny Grimberg: What does the rare earth supply chain look like?

Jack Lifton: The rare earth supply chain is mostly a "mine to magnet" supply chain. The process begins with the extraction of rare earth elements, which are found, economically, in deposits of the minerals bastnaesite and monazite, and in ionic adsorption clays. Two primary rare earth mines—those mined only for rare earths—exist in the world: Mountain Pass in California, operated by MP Materials and containing one of the world's largest deposits of bastnaesite, and Mount Weld in Australia, operated by Lynas Rare Earths and containing monazite. But the largest rare earth mine in the world is located in Inner Mongolia, where rare earth elements are produced as companion minerals of iron ores.

After mining, the ore goes through an initial processing stage to concentrate the rare earth minerals followed by a separation stage, during which the rare earth elements are individually separated and purified into oxides. Selected separated oxides are then converted into rare earth metals, which are alloyed, or combined, with other elements to form the precursor alloys for magnets. Lastly, these alloys are processed into "permanent magnets" that produce their own persistent magnetic field.

Jenny Grimberg: As many investors are now attempting to get up to speed on the rare earth supply chain given the role of rare earths in critical technologies, what would you caution are the biggest misconceptions around it?

Jack Lifton: Many people seem to believe that all the money is made in the mine, but very little of it is. If money could be made in the mine, the large mining companies, like Australia's BHP and Rio Tinto, the UK's Anglo American, and the US' Newmont and Kennecott, would simply buy rare earth deposits and develop them. But these mining giants have largely stayed out of primary rare earth mining.

The money is instead in the magnet, with permanent magnets accounting for around 70% of global rare earth product revenues. It's also widely underappreciated that permanent magnets come in different forms. Electric vehicle drive motors and military equipment like aircraft, tanks, and weapons utilize specialty rare earth permanent magnets, which are designed to maintain their magnetic strength throughout high temperature cycles that could reasonably be encountered during warfare, especially nuclear warfare. Car accessory motors like power steering, by contrast, utilize ordinary rare earth permanent magnets, which don't perform well in high temperatures, but don't need to given their uses.

Jenny Grimberg: China is widely considered the critical chokepoint in the rare earth supply chain. Is that true?

Jack Lifton: Yes. Despite their moniker, many rare earths are not that rare. For example, neodymium, a light rare earth element used in permanent magnets, is more abundant in the Earth's crust than lead. And many countries, including the US, have significant rare earth reserves. But China has the largest reserves of heavy rare earth elements like dysprosium and terbium, which are critical for temperature cycling degradation resistant specialty neodymium-iron-boron magnets—the most powerful permanent magnets. Even more crucially, China has a dramatic advantage over the rest of the world in the extraction, separation, and refining of these elements because it has done this work nonstop for several decades and developed an immense internal infrastructure for it.

China long ago figured out how to extract dysprosium and terbium from the ionic adsorption clays they principally come from. Today, it uses this method in Myanmar, where the majority of the heavy rare earths that China uses are now produced, while processing remains in China. As Myanmar sites are degrading in quality, China is increasingly looking to other countries in Southeast Asia with similar deposits—Laos, Thailand, Vietnam, Indonesia, and particularly Malaysia—and offering large sums of money for the right to build a rare earth industry in these countries. The catch is that China would bring in its own technicians and equipment, ensuring that it maintains complete control of the global production of heavy rare earths.

Jenny Grimberg: Can't the US break China's chokehold on the heavy rare earth supply chain with the significant investments the US government is making in domestic rare earth companies?

Jack Lifton: No. While the US does have significant rare earth reserves, these are mainly light rare earth deposits; there are no known heavy rare earth deposits in the US. And just having deposits isn't enough. The material has to be of a high enough concentration in a location where currently available technology can recover it economically. I suspect that New York's Central Park has as many rare earths as Ramaco Resources and American Rare Earths recently discovered in Wyoming. But that doesn't make it worthwhile to mine Central Park. Again, this is an important reason why large mining companies haven't developed US deposits—it's just not economic to do so.

The US also lacks the rest of the supply chain. Rare earths are so similar chemically that ordinary chemical operations can't separate them; specialized separation facilities are necessary. Mountain Pass is home to a light rare earths separation facility, which dates back to the 1960s and mainly arose out of the need to separate europium to produce the red phosphor for color televisions. I was actually involved in this research. But even if there were accessible, economic deposits from which heavy rare earths could be extracted, the US has no commercial-scale facility for heavy rare earth separation today.

And while the US was a pioneer in the development of rare earth permanent magnets, with General Motors research and Japan's Sumitomo developing the world's first commercial rare earth permanent magnet in the late 1970s, the US currently has limited capacity to produce such magnets. All the equipment in use today has come from China. I recently attended the opening ceremonies of Canadian company Neo Performance Materials' new rare earth magnet manufacturing plant in Estonia and saw that the equipment is mostly Chinese. But China has since banned the export of technology for extracting, separating, and processing rare earths.

And as a chemical engineer who has worked in metallurgy of rare metals, I can tell you that successfully replicating such technologies is a much more daunting task than many people seem to think. On top of that, the institutional knowledge necessary to make rare earth permanent magnets, especially the specialty magnets, is all but gone. I know all the people left in America with experience making such magnets, and you could fit them into a handful of phone booths.

Overcoming all of these challenges is not just a question of money. Policymakers need to invest in the right companies, technologies, and people, which isn't happening today.

"The institutional knowledge necessary to make rare earth permanent magnets, especially the specialty magnets, is all but gone. I know all the people left in America with experience making such magnets, and you could fit them into a handful of phone booths."

Jenny Grimberg: So, are you saying current government efforts to achieve US self-sufficiency won't succeed?

Jack Lifton: Yes. Bear in mind that the annual capacity of the largest modern rare earth permanent magnet plant ever built in the Western world—the Estonia plant I recently visited—is 2,000 tons. So, current plans to build a 10,000-ton US magnet plant, funded by the government and private equity investors, seem ridiculous given everything we've discussed. The government's current plan to achieve US self-sufficiency is simply unattainable in the short run and will not succeed.

Jenny Grimberg: How, then, will the US be able to meet its rare earth needs if it can't rely on China?

Jack Lifton: Let me first clarify the other aspect of rare earths that is underappreciated: the actual amount of rare earth minerals that the US needs is small. The US consumes only around 3% of global rare earth mineral supplies, and specialty rare earth permanent magnets are a lesser subset of that. The 16mn total cars sold in the US last year required roughly 10,000 tons of ordinary magnets, but the 1.2mn electric vehicles sold in America last year required only around 3,000 tons of specialty magnets. And while the military's demand for specialty magnets is classified information, calculations I've performed jointly in the recent past with the Department of Defense suggest the military demand for specialty magnets is probably only around 1,000 tons/year. And a portion of that demand is for samarium-cobalt magnets, which were the first rare earth permanent magnets used in the automotive industry and don't typically use heavy rare earth elements. So, US needs for heavy rare earths is a trivial amount of world demand.

"The government's current plan to achieve US self-sufficiency is simply unattainable in the short run and will not succeed."

Jenny Grimberg: Even if the actual amount of rare earth minerals the US needs is small, aren't rare earths nonetheless crucial for defense and other technologies?

Jack Lifton: Absolutely not, at least in the case of defense. Almost any magnet application can be addressed by iron-based ferrite magnets, aluminum-nickel-cobalt (Alnico) magnets, or rare earth magnets of either the neodymium-iron-boron or samarium-cobalt variety. The choice ultimately depends on physical size requirements and whether the magnet needs to maintain its magnetic strength under different temperature regimes and be able to withstand the disruptive effects of an electromagnetic pulse. Samarium-cobalt magnets are resistant to electromagnetic pulse exposure, and neodymium-iron-boron magnets modified by dysprosium and terbium are resistant to demagnetization by high temperature exposure. When no such exposures are likely, non-rare earth permanent magnets can be used as substitutes. So, acceptable workarounds for rare earths exist for most applications in the military complex.

I should also point out that the Department of Defense has contracted with Vacuumschmelze, a former German company now owned by a US private equity firm, to build a magnet manufacturing plant in South Carolina with an announced capacity of 2,000 tons/year. If that's successful, it will more than cover the US military's rare earth magnet needs.

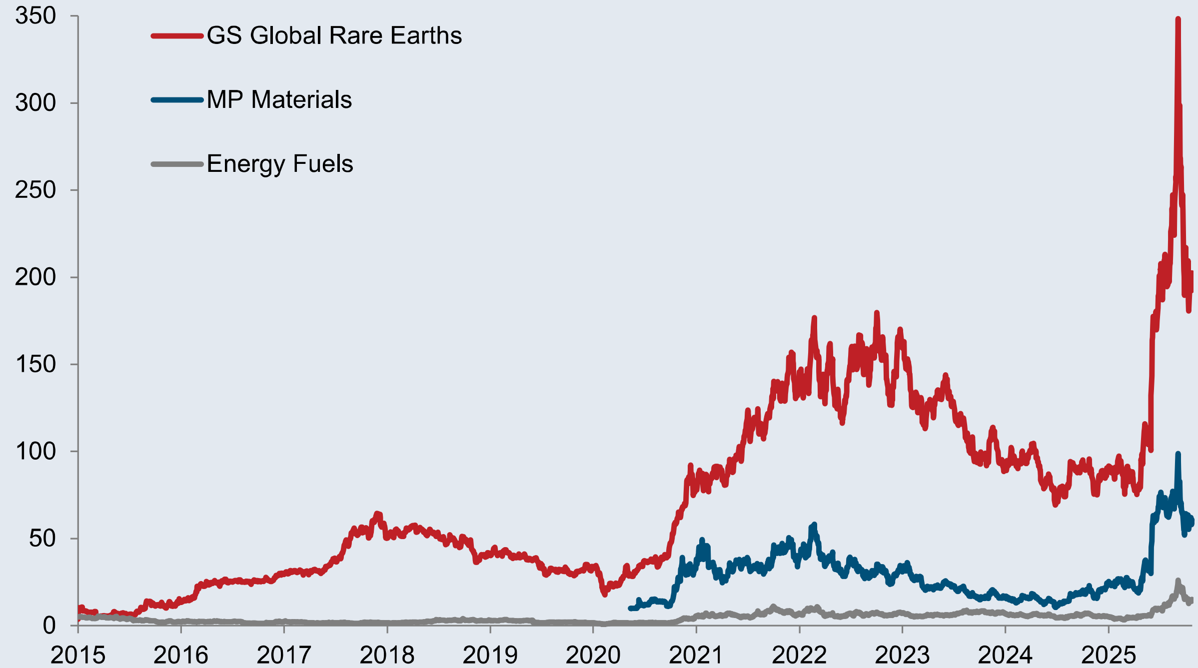
Jenny Grimberg: So, is the apparent urgency for the US to achieve self-sufficiency in rare earths overblown?

Jack Lifton: I believe so. That said, the desire to reduce our dependence on China in this regard is valid. And there is a viable path to achieving that, even if it won't amount to self-sufficiency. It's just a matter of picking the right companies, technologies, and people. The US could source light rare earths—neodymium, praseodymium, and samarium—from Mountain Pass, which, again, is teeming with them, and heavy rare earths from Malaysia, which will likely start producing them by 1Q2026. And it could use domestic capacity that currently exists or is expected to come online in the coming years for the separation work. Lastly, it could leverage overseas partners outside of China to produce the rare earth magnets themselves. Good options are available in Japan and Estonia, and these options would be far less costly than building overly large brand-new facilities in the US, which the US government unfortunately seems intent on financing.

Pricing rare earths

While rare earth stocks have retraced sharply following the US-China trade deal, they are still up significantly year to date amid the ongoing push to diversify rare earth supply chains...

Performance of GS Global Rare Earths basket* and largest components of the basket

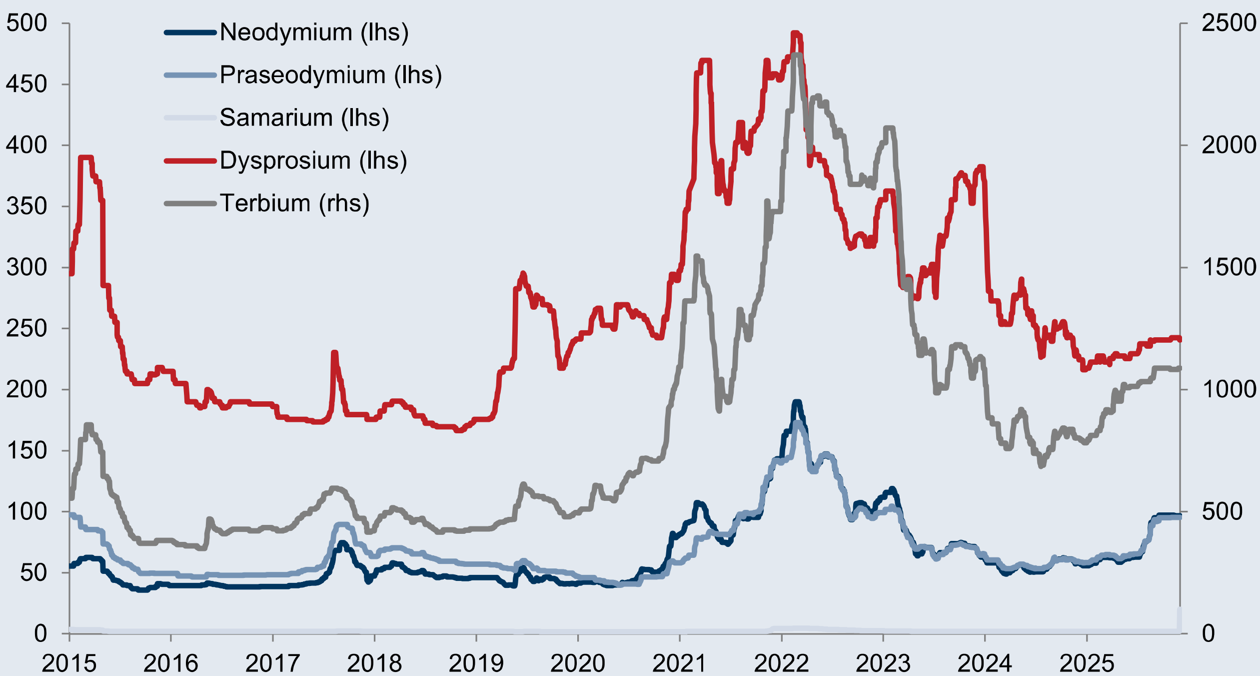


*Basket composed of the most exposed and liquid companies in the rare earths space. These are: MP Materials (US, 44% weight in basket), Energy Fuels (US, 32% weight in basket), Lynas Rare Earths (AU, 7.7% weight in basket), USA Rare Earths (US, 7.5% weight in basket), NioCorp Developments (US, 3.1% weight in basket), Iluka Resources (AU, 2.8% weight in basket), JL Mag Rare-Earth Co (HK, 2.4% weight in basket), Neo Performance Materials (CA, 0.4% weight in basket), and Arafura Rare Earths (AU, 0.2% weight in basket).

Source: Goldman Sachs FICC and Equities, Goldman Sachs GIR. Basket developed by the GS Global Banking & Markets division.

…and the spot prices of key rare earth oxides have risen over the past year, though they remain well below their peaks

China prices of select light and heavy rare earth oxides (before VAT is excluded), $/metric kg



Source: Asian Metal Inc., Bloomberg, Goldman Sachs GIR.

Special thanks to GS Australia metals & mining analyst Chris Bulgin for pricing data.

Tech race company impacts: rare earths

How are US and Chinese efforts to develop their own tech stacks impacting the companies in your coverage universe, and do you expect continued such efforts to be an important driver of price action ahead?

Australia Metals & Mining

Paul Young and Chris Bulgin, GS Equity Research

While China has temporarily lifted the export restrictions it imposed on seven rare earth (RE) elements (scandium, yttrium, samarium, gadolinium, terbium, dysprosium, and lutetium) in April 2025, the country's clear effort to control its tech stack has fostered the emergence of two distinct markets—the China spot market and a new term floor price market.

The emergence of a term floor price market is a strategic effort by Western governments to establish a guaranteed minimum price for RE elements and broader critical minerals to encourage domestic magnet production and reduce reliance on China. Government agencies and companies, including the Department of Defense (DoD) and MP Materials (MP) in the US and Carester and Solvay in France, have responded with significant funding and announced agreements. The DoD and MP Materials agreement includes an "offtake" commitment whereby the DoD has agreed to purchase MP Materials' output for a specified period as well as a $110/kg price floor for neodymium-praseodymium oxide (NdPrO), whose price is the most referenced in the RE space due to the oxide's key presence in end-use applications (e.g., rare earth permanent magnets).

For companies which possess refining capabilities, these developments are highly impactful. We anticipate that from around mid-2027, these companies will contract the majority of their sales at a floor price exceeding $100/kg (real$). This is separate from the China spot price for NdPrO, which we now forecast will rise to $85/kg (from $75/kg previously, both real$) as we expect deficits over the medium term to 2027 and perhaps beyond. The higher floor price, benchmarked by the DoD-MP deal, is crucial. It reflects the strategic importance of refining capacity, which is a significant bottleneck for new Western rare earth permanent magnet supply, and is designed to ensure an implied high return on capital.

Separately, the scarcity of heavy rare earths like terbium (Tb) and dysprosium (Dy) in Europe, driven by export restrictions as well as China's limited production (1,800tpa) and its reliance on Myanmar imports, has led TbDy prices to rise by ~3x according to channel checks with EU metal makers. Consequently, we have lifted our contracted price forecasts for dysprosium and terbium to approximately $600-700/kg and $2,000-2,500/kg, respectively.

The continued efforts by both the US and Chinese governments to secure their own tech stacks will undoubtedly remain an important driver of price action. Our upgraded price forecasts for NdPrO and heavy rare earths, along with the expectation of new Western magnet capacity by mid-2027, indicate that these strategic shifts are not currently fully priced in but are actively shaping future market dynamics and contract structures.

US rare earths

Brian Lee and Nick Cash, GS Equity Research

In addition to providing floor pricing for NdPrO and guaranteeing offtakes for MP Materials' magnet expansion, the DoD took an equity stake in MP and provided capital for the company to expand its separation capabilities and accelerate the downstream production of neodymium-iron-boron (NdFeB) magnets as part of their deal.

This will ultimately reduce the US' reliance on China-related rare earth permanent magnet supply chains. We estimate US magnet demand of roughly 25,000mt in 2025, of which defense needs represent roughly 3,000mt-4,000mt according to estimates cited by Vulcan Elements.

That said, the US will still likely rely on China for commercial NdFeB magnets unless additional recycling capabilities are built out (which would reduce the need for new mining/processing) or the US is able to obtain more NdPrO from sources outside of China. As a result, we believe any further efforts by the US and China to control/develop their own tech stacks could result in price swings for NdPr and NdFeB magnets.

Tech race company impacts: semis

How are US and Chinese efforts to develop their own tech stacks impacting the companies in your coverage universe, and do you expect continued such efforts to be an important driver of price action ahead?

US Semiconductors, Data Centers, and IT Services

Jim Schneider, GS Equity Research

The US has implemented several policies to strengthen its control over key technologies and limit the export of such technologies to China. This began in 2012 with the Obama Administration's addition of Chinese organizations to the US Entity List, which prevented these organizations from acquiring US technologies. Restrictions have broadened significantly in subsequent years. Since 2012, the number of US restrictions on exports to many countries, including China, has greatly expanded, especially post 2019. On January 15, 2025, the Biden Administration published the AI Diffusion Rule, which limited the export and use of key semiconductor technologies based on certain performance thresholds, with additional geographical restrictions based on a multi-tiered system of geographies ranging from those requiring no license to complete prohibitions. While the Trump Administration rescinded the rule on May 13 before it went into effect, the Administration also warned against the use of specific AI processor products from Huawei and the use of China-based LLMs as well as other AI technologies. Electronic Design Automation (EDA) software vendors Cadence and Synopsys also acknowledged the receipt of Commerce Department orders restricting the export and sale of certain software tools used in semiconductor design in June, though these restrictions were lifted in July.

While shifting US export controls represent the greatest fundamental risk to the companies in our coverage, these risks have been increasingly reflected in (somewhat) de-risked estimates and priced into stocks. For AI computing companies we believe the risk of further controls is largely priced in at this stage and see minimal further downside risk to estimates.

For AI-related networking and EDA software companies, our base case assumes continued strategic competition without further bans. We continue to see modest incremental risks to semiconductor capital equipment given incremental additions to the Entity List.

And when it comes to companies in "traditional" markets including PCs, smartphone, server, automotive, and industrial/Internet of Things, we see low probability of a complete ban across most traditional segments, consistent with past statements from the Administration.

Greater China Tech

Allen Chang and Xuan Zhang, GS Equity Research

China has implemented a range of policies in an effort to build a comprehensive domestic semiconductor ecosystem. The government has focused on addressing supply chain bottlenecks with government-backed investment, including the China Integrated Circuit Industry Investment Fund (Phases 1 and 2 totaled $47bn and Phase 3, which is currently ongoing, totals another $47bn). These investments have supported companies across the local semiconductor ecosystem, including Integrated Circuit (IC) design, equipment, IC manufacturing, advanced packaging, Electronic Design Automation (EDA), and materials. The government has also provided subsidies, including an up to 50% power subsidy for data centers using local AI chips and subsidies for capacity expansions that some local governments have offered. R&D expenses have also been made tax deductible, with the government implementing a "China R&D super deduction" that allows companies to claim an additional 100% of eligible R&D expenses as pre-tax deductions.

This comprehensive suite of government policies has helped Chinese semiconductor companies increase their product offerings, develop more high-end technology, and receive more orders from domestic customers that prefer to use China-produced products. The data center power subsidies have also contributed to the rising share prices of domestic AI chip suppliers. However, the long-term drivers of share prices remain order deliveries and product expansions. Indeed, expectations of continuous government support are already priced in, with investors now placing greater emphasis on sustainable growth, healthy competition, and continuous innovation rather than anticipating more government incentives.

We expect leading domestic Semiconductor Production Equipment (SPE) players and high-end semiconductor suppliers with significant technological moats to benefit as domestic supply and demand increase.

Asia Pacific Technology

Bruce Lu and Ryan Huang, GS Equity Research

TSMC is increasingly anchored to the US side of the semiconductor ecosystem. Specifically, TSMC has announced its intention to invest $165bn in advanced semiconductor manufacturing in the US. This includes plans for six advanced wafer manufacturing fabs in Arizona, two advanced packaging fabs, and a major R&D center to support strong multi-year demand from customers, particularly US Cloud Service Providers (CSPs) and AI GPU/Application Specific Integrated Circuit (ASIC) leaders, who are the primary growth drivers for TSMC's advanced node demand.

European Communications Technology, Semis, and Hardware

Alex Duval and Anant Jakhar, GS Equity Research

Chinese efforts to pursue self-sufficiency in semiconductor production necessarily require lithography tools to print circuits onto chips. ASML has a monopoly in Extreme Ultraviolet (EUV) lithography systems, which are critical for manufacturing the most advanced and powerful chips (those with the smallest node sizes). Since 2019, regulation has precluded ASML from sending EUV tools to China, and indeed no such tools have been exported to the geography.

As such, press reports have suggested that China may try to create its own EUV machines. But such efforts appear unlikely to succeed, at least for the next decade, given that ASML's roadmap for EUV came to fruition nearly two decades later than envisaged despite the company's significant scale, experience, and knowledge in this domain owing to the complexity of generating and leveraging EUV light. Moreover, any new producer of such machines would need to ramp their technology based on feedback from advanced customers. ASML also has an important ecosystem of suppliers—the result of decades of work—that is absent in China, further complicating the country's efforts to produce EUV. As a result, a serious competitor to ASML that could dent its global market share seems unlikely to emerge over the next decade, if ever.

By contrast, ASML has been allowed to sell Deep Ultraviolet (DUV) lithography systems—which are less advanced in their capabilities to produce chips with very small node sizes—to China. However, in 2024, the Dutch government imposed significant restrictions on such sales, especially on the more advanced DUV systems.

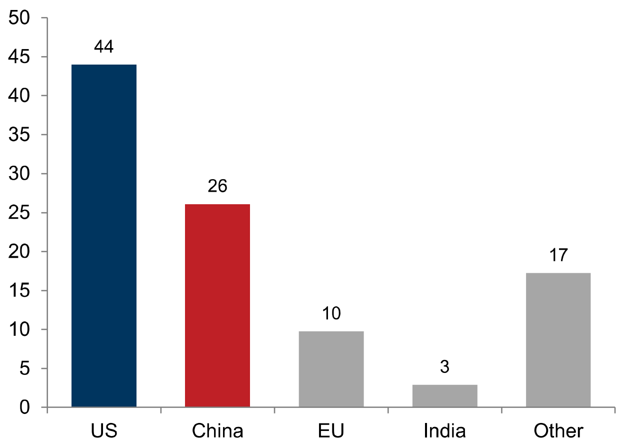
China's physical edge in the tech race

Daan Struyven argues that China's edge in the supply of rare earths and power critical to the tech race will be hard for the US to overcome

The global tech race is heating up, with fierce competition centered on semiconductors, rare earths access, energy supply, talent, and AI adoption. The US is now the frontrunner in the AI race, hosting 44% of global data center capacity vs. 26% for China, and home to leading-edge chips. However, China has a substantial edge in the supply of certain commodities and power critical to the tech race, which will be difficult for the US to overcome.

The US hosts 44% of global data center capacity

Installed data center capacity, as of June 2025, % of global



Source: IEA, Goldman Sachs GIR.

China's critical metals dominance

Chinese policymakers have engineered dominant positions in critical input markets for the buildout of chips, data centers, the associated power grid, and other leading-edge technologies. This dominance is most extreme for rare earth elements (REE), which was foreshadowed by former Chinese leader Deng Xiaoping's 1992 remarks, "the Middle East has oil; China has rare earths."

Dominance in REE, magnets, and critical metals markets reduces China's dependence on other countries in the AI and defense industries and is a powerful source of economic and geopolitical leverage. While the rare earths market is 33 times smaller than the copper market, rare earths, magnets, and other critical minerals are vital for the production of chips, batteries, AI, and defense equipment. So, supply disruptions of these critical elements could result in substantial economic losses.

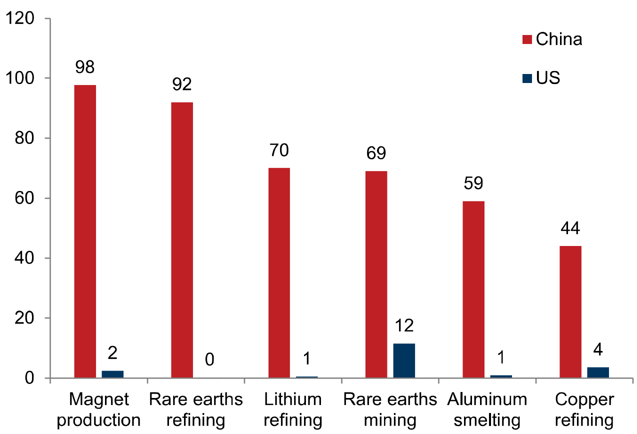
China is particularly dominant in magnet manufacturing (98% market share) and refining of rare earths (92% market share) but also has a 69% market share in mining rare earths. And while China has agreed to a one-year suspension of the US rare earth export controls announced on October 9, the April restrictions primarily concerning the geologically scarcer so-called heavy rare earths remain in place.

While countries outside of China, especially the US, are accelerating efforts to build independent REE and magnet supply chains, they face two major challenges. First, known reserves of some rare earths, such as the recently restricted heavy rare earths, are very scarce outside of Myanmar and China, and the process of building a mine typically takes 8-10 years. Second, refining rare earths is technically complex and requires deep expertise. Building and ramping up refineries usually takes around five years.

Looking beyond rare earths, while geology matters when it comes to reserves, decades of industrial policy have enabled China to dominate refining across critical minerals. China's refining market share dramatically exceeds US market share for many minerals, including lithium (critical for storing energy and modernizing the grid), copper (critical for distributing power locally), and aluminum (critical for transmitting power over long distances).

China dominates critical minerals refining and magnet production

China vs. US market shares, %



Source: IEA, Woodmac, Goldman Sachs GIR.

Diverging power capacity

China's ample power market spare capacity is set to grow further on a policy-driven supply boom since a 2021 power crunch, when high energy demand and coal shortages led to power rationing. At the same time, already tight US power markets are tightening further. As a result, power bottlenecks are likely to at least temporarily slow US progress in the AI race by 2030, especially in its regional power markets, where spare power capacity is most scarce.

Specifically, eight out of the thirteen US regional power markets are already at or below critical spare capacity levels based on our estimates of peak summer effective spare power generation capacity—our summary measure of power availability and reliability. This US power market tightness already triggered large spikes in both real-time power prices last summer and power generation capacity prices in the PJM market, which includes Virginia, the world's data center capital.

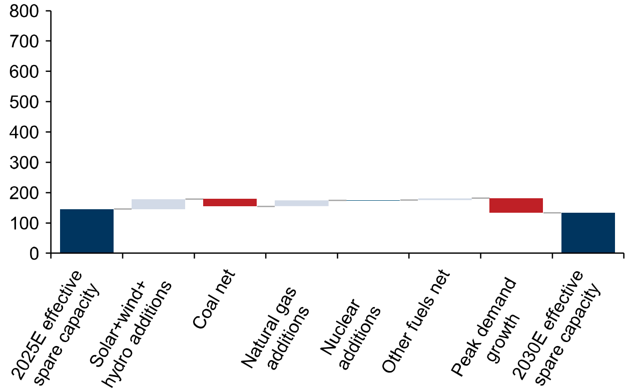
We expect US power spare capacity to decline further as renewable and natural gas power builds are insufficient to offset scheduled coal retirements and meet rapid power demand growth, which is now outpacing GDP growth.

China, in contrast, already has ample spare capacity, which we expect to grow further. By 2030, we project that China's effective power spare capacity will be equivalent to over three times the world's expected data center power demand (~400

GW vs. ~120 GW), positioning China to fuel rapid data center expansion.

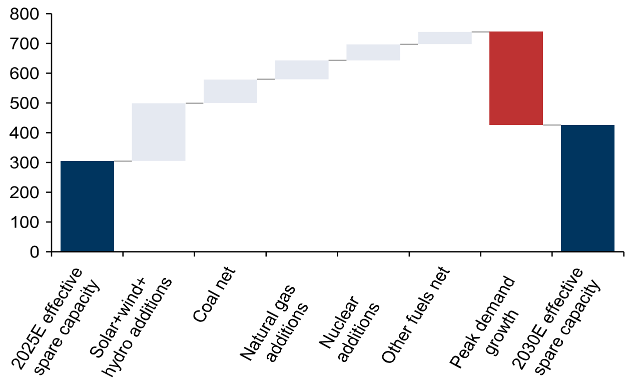
We project power spare capacity to decrease further in the US…

Estimated peak US summer effective power spare capacity from 2025 to 2030, GW



…but to rise in China

Estimated peak China summer effective power spare capacity from 2025 to 2030, GW

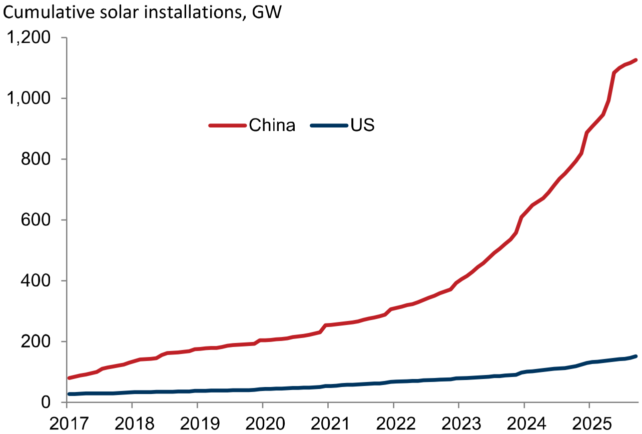


Source: IEA, Wind, EIA, Goldman Sachs GIR.

The most remarkable feature of China's ongoing power capacity boom over the past five years has been the rapid expansion of all power supply sources to ensure energy security. The scale and speed of China capacity additions especially stand out for solar energy—with installed capacity in China now roughly six times higher than in the US—and for nuclear energy. While building nuclear reactors has been a slow and expensive process in the US, learning-by-doing has reduced the real construction cost of nuclear reactors in China.

China has rapidly expanded power capacity for both solar…

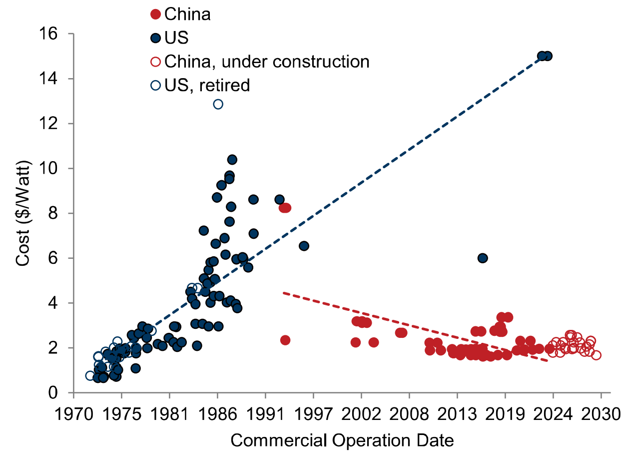
Cumulative solar installations, GW



Source: Ember, Nature, Goldman Sachs GIR.

…and nuclear energy

Construction costs of nuclear reactors



Note: Construction costs don't account for financing costs (such as interest during construction) and exclude operating and fuel costs, as these have remained low and relatively stable over time. All costs are rescaled to their equivalent 2020 value.
Source: Ember, Nature, Goldman Sachs GIR.

Broader implications: more China leverage, higher power and copper prices, and greater insurance value of commodities in portfolios

Beyond the risk that critical commodity and power bottlenecks slow US progress in the tech/AI race, we see four other major implications of China's dominance in these crucial areas:

1. China's tight control over rare earths and other critical minerals will likely **constrain the scope for other countries to impose significant trade barriers against China**. This will likely allow China to maintain some access to advanced chips as well as support rapid growth in China manufacturing exports and its current account surplus.
2. **US power markets are at risk of significantly higher prices and even outages**. This risk is particularly acute in local power markets where data centers are booming, with 72% of all US datacenters sitting in 1% of US counties.
3. As the need to invest in the power grid—a vulnerable link in the energy supply chain—becomes more acute amid the global AI race, rising geopolitical tensions, and the shift to hybrid warfare, **solid copper demand growth along with lagging mine supply should drive a rally in copper prices** from 2028 to $15,000 by 2035.
4. The growing concentration of the supply of critical metals and commodities in countries competing for AI, broader tech and geopolitical leadership **raises the risk of supply disruptions and underscores the insurance value of commodities in portfolios**.

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China's tech drive, Asia's opportunity

Tim Moe and Kinger Lau argue that China's drive to build its own tech stack creates significant opportunities for Asia tech

While Presidents Trump and Xi recently reached an agreement to reduce trade frictions between their two countries, the strategic competition between the US and China in multiple domains—most importantly, technology—continues. As part of this, China has doubled down on its strategic support to key sectors of the economy, with policy initiatives like those in the 15th Five-Year Plan proposal underscoring the Chinese government's commitment to building an indigenous tech stack, particularly in next-gen information technology (e.g., semiconductors), AI, and high-end manufacturing (e.g., robotics and drones) (see pgs. 8-9 for a detailed policy roadmap). These strategic priorities create significant opportunities for technology companies across China and Asia more broadly.

AI is the name of the game…

The technology sector has driven much of the gains in Asian equities this year. Tech hardware & semiconductors and the internet/media/entertainment sector—which includes large Chinese e-commerce companies—have each rallied over 50% year-to-date. The AI theme has powered most of these moves. Indeed, index constituents with tangible revenue connections to AI have accounted for over 90% of the gains in Taiwan equities and 50-60% of the gains in Mainland China, Japan, and Korea equities. As Mainland China continues to pursue technological self-sufficiency and the fundamental picture for the sector remains favorable, we believe the technology sector's leadership can persist and so stay overweight.

Our implementation focus remains on AI and the adjacent theme of power investment spurred by the electricity demands of AI data centers. Specifically, we see opportunities in all the major AI components: (1) hardware, (2) semiconductors, (3) Artificial Intelligence Generated Content (AIGC) applications, a broad category of software that uses AI to produce new content, and (4) physical AI such as robotics, assisted driving, and Artificial Intelligence of Things (AIoT), which combines AI technologies with the Internet of Things infrastructure. That said, AIGC applications and physical AI have lagged hardware and semiconductors, which suggests better entry points for the stocks levered to those components.

Within the power investment theme, we strategically favor nuclear, though its strong performance and the small number of listed direct plays may warrant some caution. Renewables may also benefit tactically from China's anti-involution policies as well as over the longer term as China continues making significant investments in solar, wind, and other green technologies to achieve technological and energy self-sufficiency.

…but broader tech also provides opportunities

China's focus on self-sufficiency in advanced technologies could also benefit the biotech sector. China's biotech industry is already at an inflection point as its innovative drug assets are gaining global recognition. Merck KGaA, for example, recently executed a worldwide commercialization agreement for Shanghai-based Abbisko Therapeutics' pimicotinib medication. And we think defense tech, quantum computing, and the emerging low-altitude (eVTOL, which refers to electric vertical takeoff and landing aircraft that operate in low altitudes) and space economies are also worth keeping a close eye on and could present interesting investment opportunities.

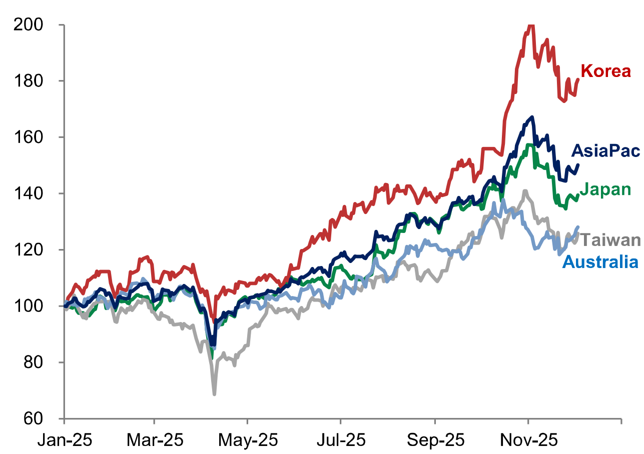
More broadly, our Chinese Prominent 10 (10 existing market leaders that appear well-placed to capitalize on their past successes and further elevate their dominance in the Chinese stock market) and Going Global (25 Buy-rated companies that look well positioned to compete globally) themes provide exposure to the government's continued focus on technological development and manufacturing competitiveness.

US' tech drive is beneficial for Asia too

The parallel US effort to reduce its technological reliance on Mainland China and develop its own tech stack also presents opportunities for Asia-Pacific companies. Taiwan's TSMC is now manufacturing close to 90% of Nvidia's chips (by value), including the Blackwell wafers it recently began producing at its Phoenix facility. Japan's Mitsubishi Electric is supplying power systems and components for next-gen US data centers while Hitachi and Toshiba are making significant investments in US energy infrastructure. And the US and Australia recently signed a critical minerals and rare earths agreement to invest at least $1bn in projects in each country, which should benefit select companies in the Australia mining sector. We see a number of companies in Australia, Japan, Korea, and Taiwan that could benefit from the theme of enhanced US technological self-sufficiency, part of the larger theme of US reindustrialization.

US reindustrialization-related Asian stocks have performed well year to date, and we think this theme has further room to run

Indexed performance of US reindustrialization beneficiaries (in USD)



Note: Cap-weighted backtesting performance with a 4% cap applied to the AsiaPac portfolio at the start of 2025.

Source: FactSet, Goldman Sachs GIR.

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Policies driving the US-China tech race

2018

March 2018 – The US claims that China has conducted unfair trade practices related to technology, intellectual property, and innovation. The US applies 25% tariffs on ~$50bn of Chinese goods, including semiconductors and electronics.

April 2018 – The US bans the sale of components to Chinese tech company ZTE.

August 2018 – The US extends tariffs to an additional $200bn worth of Chinese goods, including a wider range of electronic components and goods.

2019

June 2019 – China launches a science and technology innovation board to facilitate the financing of high-tech manufacturing companies.

May 2019 – The US bans the sale of components to Chinese tech company Huawei, though with some exemptions.

October 2019 – China launches its "Big Fund" Phase II, a government-led investment fund aimed at bolstering the country's semiconductor industry.

2020

January 2020 – As part of the Phase One trade deal, China commits to increase purchases of US goods and services, limit technology transfers, and improve IP enforcement.

May 2020 – The Chinese government grants semiconductor fab SMIC $2.25bn to build new chip capacity.

August 2020 – The Chinese government vows to increase the self-sufficiency rate of semiconductors to 70% in 2025 from 30% in 2019.

November 2020 – The US makes a $9.6mn contribution to MP Materials efforts to build separation capacity for light rare earths to its California extraction operations site—the US' only rare earth extraction operation.

2021

February 2021 – The US awards Lynas $30.4mn to develop domestic separation capabilities for light rare earths.

March 2021 – China releases its 14th Five-Year Plan which prioritizes technological self-sufficiency, with a focus on key industries including the semiconductor industry.

June 2021 – Biden expands Trump-era ban on US investment into Chinese firms with ties to defense or surveillance technology sectors.

February 2022 – The DoD grants $35mn to MP Materials to separate and process heavy rare earths, creating a full value chain operation, from extraction to manufacturing magnets at a single facility.

2022

August 2022 – The US passes the CHIPS Act, which blocks certain chip exports to China.

October 2022 – The US announces restrictions on exports of advanced computing chips and related equipment to China.

December 2022 – The US blacklists 36 Chinese companies, including advanced chip producers, restricting their use of US semiconductor manufacturing tech.

December 2022 – China announces a support package for its domestic semiconductor industry to counter heightened US chip restrictions.

2023

March 2023 – China launches cybersecurity review of imports from US memory-chip maker Micron and later bans sales of Micron chips.

July 2023 – China announces new restrictions on gallium and germanium exports.

October 2023 – The US tightens restrictions on the sale of chips that Nvidia designed for the Chinese market.

October 2023 – China imposes export restrictions on certain types of natural graphite.

December 2023 – China announces a ban on rare earth extraction and separation technologies.

2024

March 2024 – The DoD establishes a goal to develop a complete 'mine-to-magnet' supply chain for rare earth materials that can meet all US defense needs by 2027.

August 2024 – China announces new export controls on critical raw materials including antimony and superhard materials.

December 2024 – China bans exports of gallium, germanium, antimony, and superhard materials to the US.

2025

January 2025 – The Biden Administration establishes the AI Diffusion Rule which limits the export and use of US chip technologies based on a multi-tiered system.

April 2025 – China implements export controls on several rare earth elements and magnets used in the defense, energy, and auto sectors in response to US tariffs.

May 2025 – The Trump Administration rescinds the AI Diffusion Rule but warns against the use of Chinese tech.

July 2025 – The DoD announces a deal with MP Materials that includes an offtake commitment and a price floor.

August 2025 – The US reportedly strikes a deal allowing Nvidia to sell chips to China, but Nvidia must give the US government 15% of the revenue from these sales.

October 2025 – The US announces a 100% tariff on China and additional export controls in response to China's rare earth export controls, but later agrees to loosen restriction after Trump-Xi talks.

October 2025 – China expands rare earths export controls, which are later suspended as part of a broader US-China deal. China's 15th Five-Year Plan proposal includes a focus on developing "chokehold technologies" including chips.

Note: Exhibit does not constitute an exhaustive list of US and Chinese policy developments.
Source: Center for Strategic and International Studies, White House, USTR, Peterson Institute for International Economics, various news sources, Goldman Sachs GIR.

Summary of our key forecasts

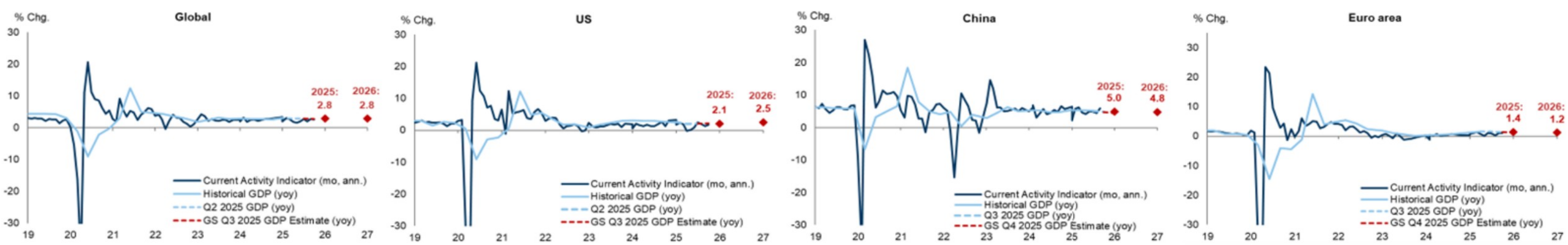
GS GIR: Macro at a glance

Watching

- **Globally,** we expect real GDP growth of 2.8% yoy in 2026 amid fading headwinds from US tariffs and rising real income growth. We expect global core inflation to decline to 2.2% by the end of 2026 as the tariff-driven boost fades and shelter and wage inflation fall further.
- **In the US,** we expect real GDP growth to rise to 2.3% on a Q4/Q4 basis in 2026 as the tariff drag fades, fiscal policy turns more expansionary, and the Fed continues to ease. We expect core PCE inflation to decline to 2.3% yoy by the end of 2026 as tariff pass-through fades, wage growth slows further, and rent inflation remains benign. We expect the unemployment rate to end 2026 at 4.3%.
- **We expect the Fed** to deliver one more 25bp rate cut this year in December followed by two 25bp cuts next year in March and June for a terminal rate range of 3-3.25%.
- **In the Euro area,** we expect real GDP growth of 1.2% yoy in 2026 reflecting receding trade-related growth headwinds, real income gains, and a fading fiscal policy drag but growing headwinds from more intense export competition with China. We expect core inflation to decline to 1.8% by end-2026 amid lower energy prices, a stronger Euro, and the potential for a negative inflation effect from Chinese trade rerouting.
- **We expect the ECB** to remain on hold for the foreseeable future given our and the ECB's forecast of better growth ahead and target-consistent inflation over the medium term.
- **In China,** we expect above-consensus real GDP growth of 4.8% yoy in 2026 given resilient export growth, continued government easing, and a decreasing drag from the ongoing property market downturn. On the inflation front, we believe China's overcapacity problem will take time and effort to solve and expect CPI/PPI inflation of 0.6%/-0.7% next year.
- **WATCH US LABOR MARKET, FISCAL DYNAMICS AND GEOPOLITICAL DEVELOPMENTS.** Uncertainty about the US labor market remains high, and the recent rise in some layoff indicators could mean that the weakness in the labor market is becoming too entrenched to be checked by a modest cyclical growth acceleration. Fiscal pressures—including in the US, UK, France, and Japan—also remain important to watch. And geopolitical developments pose risks worth watching, especially as a potential Russia-Ukraine peace deal remains highly uncertain and US-China relations remain fragile.

Goldman Sachs Global Investment Research.

Growth



Source: Haver Analytics, Goldman Sachs Global Investment Research.
Note: GS CAI is a measure of current growth. For more information on the methodology of the CAI please see "Technical Updates to Our Global CAIs," Global Economics Comment, Sep. 01, 2025.

Forecasts

Economics

GDP growth (%)	2025 GS (Q4/Q4)	2025 Cons. (Q4/Q4)	2025 GS (CY)	2025 Cons. (CY)	2026 GS (CY)	2026 Cons. (CY)
Global	2.6	--	2.8	2.5	2.8	2.4
US	2.1	1.7	2.1	2.0	2.5	2.0
China	4.5	4.4	5.0	4.9	4.8	4.4
Euro area	1.2	1.1	1.4	1.4	1.2	1.1

Policy rates (%)	2025 GS	2025 Mkt.	2026 GS	2026 Mkt.
US	3.63	3.66	3.13	2.99
Euro area	2.00	1.93	2.00	1.89
China	1.40	1.44	1.20	–
Japan	0.50	0.66	1.00	1.06

Markets

Interest rates 10Yr (%)	Last	E2025	E2026
US	4.06	4.20	4.20
Germany	2.75	3.00	3.25
Japan	1.89	1.70	1.90
UK	4.37	4.25	4.00

FX	Last	3m	12m
EUR/$	1.17	1.20	1.25
GBP/$	1.33	1.35	1.36
$/JPY	155	150	145
$/CNY	7.04	6.95	6.85

Commodities	Last	3m	12m
Crude Oil, Brent ($/bbl)	63	58	57
Nat Gas, NYMEX ($/mmBtu)	5.00	4.50	5.00
Nat Gas, TTF (EUR/MWh)	28.19	30	28
Copper ($/mt)	11,576	10,725	10,610
Gold ($/troy oz)	4,210	4,160	4,745

Credit (bp)		Last	2Q25	4Q25
USD	IG	79	88	85
	HY	269	303	300
EUR	IG	90	102	100
	HY	278	310	307

Equities

S&P 500	E2025 GS	E2025 Cons.	E2026 GS	E2026 Cons.
Price	6,800		7,600	
EPS	$262	$271	$280	$309
Growth	7%	10%	7%	14%

Returns (%)	12m	YTD	E2025 P/E
S&P 500	5.1	16.5	25.8x
MXAPJ	14.0	24.0	17.4x
Topix	5.9	19.7	17.7x
STOXX 600	3.3	13.5	16.3x

Consumer	2025 CPI (%, yoy)	2025 Unemp. Rate	2026 CPI (%, yoy)	2026 Unemp. Rate	Wage Tracker 2025 (%) Q1	Q2	Q3	Q4
US	2.7	4.5	2.5	4.3	3.9	3.9	4.0	--
Euro area	2.1	6.4	1.8	6.5	--	--	--	--
China	0.0	--	0.6	–	--	--	--	--

Source: Bloomberg, Goldman Sachs Global Investment Research. For important disclosures, see the Disclosure Appendix or go to www.gs.com/research/hedge.html.

Market pricing as of December 3, 2025

Glossary of GS proprietary indices

Current Activity Indicator (CAI)

GS CAIs measure the growth signal in a broad range of weekly and monthly indicators, offering an alternative to Gross Domestic Product (GDP). GDP is an imperfect guide to current activity: In most countries, it is only available quarterly and is released with a substantial delay, and its initial estimates are often heavily revised. GDP also ignores important measures of real activity, such as employment and the purchasing managers' indexes (PMIs). All of these problems reduce the effectiveness of GDP for investment and policy decisions. Our CAIs aim to address GDP's shortcomings and provide a timelier read on the pace of growth.

For more, see our CAI page and Global Economics Comment: Technical Updates to Our Global CAIs.

Dynamic Equilibrium Exchange Rates (DEER)

The GSDEER framework establishes an equilibrium (or "fair") value of the real exchange rate based on relative productivity and terms-of-trade differentials.

For more, see our GSDEER page, Global Economics Paper No. 227: Finding Fair Value in EM FX, 26 January 2016, and Global Markets Analyst: A Look at Valuation Across G10 FX, 29 June 2017.

Financial Conditions Index (FCI)

GS FCIs gauge the "looseness" or "tightness" of financial conditions across the world's major economies, incorporating variables that directly affect spending on domestically produced goods and services. FCIs can provide valuable information about the economic growth outlook and the direct and indirect effects of monetary policy on real economic activity.

FCIs for the G10 economies are calculated as a weighted average of a policy rate, a long-term risk-free bond yield, a corporate credit spread, an equity price variable, and a trade-weighted exchange rate; the Euro area FCI also includes a sovereign credit spread. The weights mirror the effects of the financial variables on real GDP growth in our models over a one-year horizon. FCIs for emerging markets are calculated as a weighted average of a short-term interest rate, a long-term swap rate, a CDS spread, an equity price variable, a trade-weighted exchange rate, and—in economies with large foreign-currency-denominated debt stocks—a debt-weighted exchange rate index.

For more, see our FCI page, Global Economics Analyst: Our New G10 Financial Conditions Indices, 20 April 2017, and Global Economics Analyst: Tracking EM Financial Conditions – Our New FCIs, 6 October 2017.

Goldman Sachs Analyst Index (GSAI)

The US GSAI is based on a monthly survey of GS equity analysts to obtain their assessments of business conditions in the industries they follow. The results provide timely "bottom-up" information about US economic activity to supplement and cross-check our analysis of "top-down" data. Based on analysts' responses, we create a diffusion index for economic activity comparable to the ISM's indexes for activity in the manufacturing and nonmanufacturing sectors.

Macro-Data Assessment Platform (MAP)

GS MAP scores facilitate rapid interpretation of new data releases for economic indicators worldwide. MAP summarizes the importance of a specific data release (i.e., its historical correlation with GDP) and the degree of surprise relative to the consensus forecast. The sign on the degree of surprise characterizes underperformance with a negative number and outperformance with a positive number. Each of these two components is ranked on a scale from 0 to 5, with the MAP score being the product of the two, i.e., from -25 to +25. For example, a MAP score of +20 (5;+4) would indicate that the data has a very high correlation to GDP (5) and that it came out well above consensus expectations (+4), for a total MAP value of +20.

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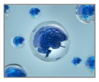

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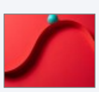

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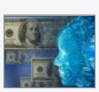

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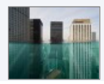

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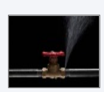

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Reg AC

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We, Allen Chang, Paul Young, Alexander Duval, Brian Lee, CFA, Bruce Lu, and James Schneider, Ph.D., hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

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