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Semiconductors dominance: U.S.-China competition and implications for the global supply chain

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Assessing Geopolitical Risks on Global Supply Chains: The Case of Semiconductors

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- Geopolitical challenges, such as US-China trade war, Brexit, tariffs, trade disputes, natural disasters, and Covid-19 pandemic, have compounded disruptions to global supply chains (Wolf & Kalish, 2021).
- The global semiconductor supply-chain, a technology-intensive industry, is vulnerable to disruptions due to its high concentration of manufacturing and interdependencies between countries (Yue Zhang, 2023).
- The geopolitical race for semiconductor dominance is reshaping global logistics and jeopardizing the technology and innovation capacity of states, particularly the US and China, which rely heavily on advanced chips for defense industry and future technologies (Hufbauer & Hogan, 2022).

Implications of Geopolitical Tensions on Semiconductors

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- There is a lack of comprehensive understanding of how geopolitical tensions affect policy-making and interventions in the global semiconductor supply-chain, as well as international business strategies (Yue Zhang, 2023).
- We **explore the impact of the US-China trade war on the global semiconductor supply-chain** and investigate short-term and long-term implications on technology innovation and development (Hufbauer & Hogan, 2022).
- we integrate quantitative analysis and qualitative description of the impact of global geopolitical dynamics on industrial strategies and policy actions aligned with national strategic objectives, such as the USA's Chips Act and China's technological autarchy (Yue Zhang, 2023).

Literature Review on the Relevance of Semiconductors and the Complexity of its Global Value Chain Gripped in the USA-China Trade War

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- Definition of semiconductors as materials allowing for electrical conduction. Common usage of the term to refer to computer chips or Integrated Circuits (IC) made of silicon slices with transistors (Holmes-Siedle, 1978; Kreher, 1997; Grundmann, 2006; Orton, 2008).
- Main types of chips: logic/system chips for processing information and memory chips for storage.
- Importance of chip size in determining sophistication. It is measured in nanometers (nm) (Grimes & Du, 2022).
- Increasing demand for advanced chips in technologies like AI, autonomous driving, and 5G (Li, 2021).
- Global value of the semiconductor industry expected to reach $1 trillion by 2030 (Purkayastha, 2022).

Literature Review on the Relevance of Semiconductors and the Complexity of its Global Value Chain Gripped in the USA-China Trade War

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- Concentration of core intellectual property in the USA, South Korea, Taiwan, and Europe (Teer & Bertolini, 2022). Key equipment in EU (ASML's photolithography).
- Production, assembly, and testing largely taking place in Asia and China (Teer & Bertolini, 2022).
- Disruption of global supply chains due to geopolitical tensions, trade restrictions, and the Covid-19 pandemic (Grimes & Du, 2022).
- Need for resilient and diversified supply chains, domestic production capacity, and innovation (Grimes & Du, 2022).
- Challenges and costs of building new chip fabrication plants (fabs). Companies will not consider it unless they are sufficiently motivated by subsidies or tax breaks. Potential fierce inter-state competition (Jensen, 2022)

USA-China Tech Rivalry: Policy Implementation

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Focus on China

- China has established presence in chipmaking at every step due to decades of investment (Hu & Xinlu, 2006; Lazonick & Li, 2012; Li, 2016, 2021).
- China's semiconductor supply chain shows resilience despite weaknesses under USA pressure (Li, 2021).
- Technological bottlenecks and reliance on foreign companies limit China's domestic production capacity (Grimes & Du, 2022; Li, 2021).
- China's *14th Five Year Plan* (FYP) and the *Law on Science and Technology Progress of the PRC (2022)* aim to develop and strengthen those areas identified as priorities in the 14th FYP, such as: AI, Quantum Technology, IC, neural networks, genomics and biotechnology, and health sciences (State Council of the PRC, 2021; The Standing Commitee of the NPC, 2021).

USA-China Tech Rivalry: Policy Implementation

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Focus on US

- Restricting China's access to advanced semiconductor technology is a key strategy in the emerging hi-tech cold war (Li, 2021).
- US export controls/restrictions were set to prevent technology spillovers to China
- The CHIPS Act of 2022 appropriated $50 billion for semiconductor manufacturing and R&D activities.
- The CHIPS program includes the establishment of a National Semiconductor Technology Center (**NSTC**), a public-private consortium that serves as a focal point for research and engineering in the semiconductor ecosystem (U.S. Dept. of Commerce, 2022b).
- The NSTC conducts research, prototyping, and seed new industries built on advanced chip capabilities (U.S. Dept. of Commerce, 2022b).

USA-China Tech Rivalry: Policy Implementation

Focus on US

- The CHIPS program also includes the National Advanced Packaging Manufacturing Program (NAPMP) led by National Institute of Standards and Technology (NIST) (U.S. Dept. of Commerce, 2022a).
- NIST is responsible for establishing up to 3 Manufacturing USA institutes to advance research and commercialization of semiconductor manufacturing technologies (U.S. Dept. of Commerce, 2022a).
- NIST's R&D program aims to advance measurement science, standards, material characterization, instrumentation, testing, and manufacturing capabilities in the semiconductor industry (U.S. Dept. of Commerce, 2022a).
- These initiatives reflect the U.S. government's aggressive policy to strengthen its semiconductor manufacturing and R&D capabilities as part of its national security strategy in the tech rivalry with China.

Quantitative analysis of trade flows between the USA and China - *Preliminary results*

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- Empirical analysis of recent trade flows between China and the US in semiconductor value chain reveals that:

I. China imports from the US a huge net value of Electronic integrated circuits and Machines and apparatus for the manufacture of semiconductor (even if imports of Electronic integrated circuits is recently decreasing). The USA appears to be much more competitive than China in those sectors.

II. While China is exporting semiconductor-related products to the USA (e.g., Silicon dioxide and Semiconductor devices), their net value is not particularly relevant.

III. Even though the USA is not the only supplier of China, it has an enormous relevance in providing to China semiconductor-related products, especially in supplying Machines and apparatus for the manufacture of semiconductor, in which the USA covers, on average per month, 16.4% of the total Chinese import of the sector. This entails a technological dependency of China from the USA.

IV. All in all, China exhibits a substantial weakness in semiconductor value chain compare to the US (reflected by a high trade deficit): this may encourage the US to adopt aggressive trade policies in the value chain to maintain technological supremacy and take advantage in the global marketplace.

- Network analysis to capture the centrality of the USA and China, relative to other countries, in semiconductor-related sectors (in progress)

On the EU front

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- Recent shortage due to the Covid-19 pandemic highlighted Europe's dependence on semiconductors imports. Supporting the chip industry in the EU is of paramount importance to **ensure supply security** and **economic competitiveness** (EP, 2023).
- Chip development is integral to **accelerating the twin digital** and **green transitions** and associated transformation of the EU's economy, industry and society as well as to the EU's geopolitical agenda.
- The Commission Communication 2030 Digital Compass: the European way for the Digital Decade set as an objective to increase the EU's share in global production capacity of semiconductors to 20% by 2030 (COM(2021) 118). The subsequent Commission's proposal for the 2030 Policy Programme *Path to the Digital Decade* reaffirmed this ambition (COM(2021) 574 final).

On the EU front

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- April 2023 agreement on the **Chips Act** - a range of measures meant to bring the EU's share of the global semiconductor value chain to 20% by 2030 (it currently stands at 9%).
- It is the first of a series of **industrial plans** that the commission has pushed to let governments increasingly intervene in the supply chain.
- The package should pave the way for more government subsidies for **advanced chip facilities**, an EU microchips research and development (R&D) budget and tools to monitor potential supply shortages.
- Goal: to attract investments from some of the world's biggest microchips makers…but Europe is already behind major competitors.
- The Act will allow EU countries to **subsidize** novel chip equipment and design facilities.

Final Consideration 1

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- Whereas history suggests that tech transfer had previously taken place from developed to not-developed country, in current times appears to be a great game between great powers.
- The events of the past year have created opportunities as well as heightened dangers:
  - ✓Russia's attempts to use energy as a weapon have underlined the threat to the USA and other countries of excessive dependence on potentially hostile foreign powers for critical manufactured products and materials
  - ✓It should thus give added impetus both at home and abroad to ongoing efforts to restructure some critical supply chains away from China (U.S.-China ESRC, 2022)

Final Consideration 1

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- The data analysis shows consistency with the literature and the official policy documents reviewed. The US export controls which were designed to freeze-in-place China's leading edge chip development are a powerful brake on Beijing's ambitions to become self-sufficient in foundational technologies.
- USA wants to prevent the Chinese rise in semiconductors from being as preponderant as that which has occurred in other technology sectors. Another goal is to achieve a balance of the semiconductor production structure for Atlantic and Western value chains

Final Consideration 2

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- However, it should not be obscured the fact that China is building significant capacity in semiconductor markets that rely on mature process nodes (Rhodium, 2023).
- An attempt by the US and partners to outpace China in building out manufacturing capacity for trailing edge/mature process nodes would require considerable time and resources, as well as political tolerance of higher prices.
- China, as an incubator state, might consider to develop and diversify its value chain against the backdrop of favouring regional trade-investment agreements (RTAs).
- Moreover, it remains to monitor and assess how much impetus the US's Chips Act will be able to provide to the US techno-industrial structure to maintain and forge new technological supremacy.

Final Consideration 2

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- The upcoming decade presents an invaluable yet intricate opportunity for Europe to develop its own semiconductor ecosystem and increase its global market share. This strategic objective does not intend to achieve self-sufficiency. It is not a feasible target and interdependencies in the supply chain will remain strong.
- Instead, an EU semiconductor ecosystem that is at the same time open to gain valuable R&D inputs and multi-way transfer of high technology from international collaborations as well as shock-resilient to mitigate geopolitical tensions, global crisis, and markets volatility. This requires navigating a complex geopolitical situation and maneuvering through large entities.
- The US export controls mark an emerging policy of “technological containment” that will force Europe to confront the implications of defining China as a “strategic competitor” and a “systemic rival”.

References

- Baldwin, R., & Evenett, S. (2020). *COVID-19 and Trade Policy: Why Turning Inward Won't Work*. https://cepr.org/publications/books-and-reports/covid-19-and-trade-policy-why-turning-inward-wont-work.
- Bown, C. P., & Kolb, M. (2018, April 19). Trump's Trade War Timeline: An Up-to-Date Guide. *Trade and Investment Policy Watch*. https://www.piie.com/blogs/trade-and-investment-policy-watch/trumps-trade-war-timeline-date-guide.
- Chand, M., & Tung, R. L. (2019). Skilled immigration to fill talent gaps: A comparison of the immigration policies of the United States, Canada, and Australia. *Journal of International Business Policy*, *2*(4), 333–355. https://doi.org/10.1057/s42214-019-00039-4.
- Chen, G.-H., & Hsiao, M.-E. (2022, November 18). Semiconductor industry: A shield to Taiwan or the source of insecurity? *Taiwan Insight*. https://taiwaninsight.org/2022/11/18/semiconductor-industry-a-shield-to-taiwan-or-the-source-of-insecurity/.
- Cheng, T.-F., & Li, L. (2022, July 27). The resilience myth: Fatal flaws in the push to secure chip supply chains. *Nikkei Asia*. https://asia.nikkei.com/Spotlight/The-Big-Story/The-resilience-myth-Fatal-flaws-in-the-push-to-secure-chip-supply-chains.
- Grimes, S., & Du, D. (2022). China's emerging role in the global semiconductor value chain. *Telecommunications Policy*, *46*(2), 101959. https://doi.org/10.1016/j.telpol.2020.101959.
- Grundmann, M. (2006). *The Physics of Semiconductors*. Springer Berlin Heidelberg. https://doi.org/10.1007/3-540-34661-9.
- Holmes-Siedle, A. (1978). Semiconductor devices. *Nature*, *272*(5648), Article 5648. https://doi.org/10.1038/272108b0.
- Hu, Q., & Xinlu, L. (2006). *909 chaoda guimo jicheng dianlu gongcheng jishi (Road to Chips: Records from Ultra Large Scale Integrated Circuit Project 909)*. Beijing: Electronics Industry Press.
- Hufbauer, G. C., & Hogan, M. (2022, December 11). *Washington won't chip away at China's military with semiconductor sanctions*. East Asia Forum. https://www.eastasiaforum.org/2022/12/11/washington-wont-chip-away-at-chinas-military-with-semiconductor-sanctions/.
- Jensen, N. M. (2022, February 17). Policy to spur US chipmaking would squeeze state, local government. *Lubbock Avalanche-Journal*. https://www.lubbockonline.com/story/opinion/columns/2022/07/17/nathan-jensen-policy-to-spur-us-chipmaking-could-be-misstep/65372990007/.
- Kimura, F., Urata, S., Thangavelu, S., & Narjoko, D. (2022, November 2). *Dynamism of East Asia and RCEP: The Framework for Regional Integration*. Economic Research Institute for ASEAN and East Asia - ERIA. http://www.eria.org/publications/dynamism-of-east-asia-and-rcep-the-framework-for-regional-integration/.
- Kreher, K. (1997). Fundamentals of Semiconductors – Physics and Materials Properties. *Zeitschrift Für Physikalische Chemie*, *198*(1–2), 275–275. https://doi.org/10.1524/zpch.1997.198.Part_1_2.275.

References

- Lazonick, W., & Li, Y. (2012). China's Path to Indigenous Innovation
- Li, Y. (2016). State, Market, and Business Enterprise: Development of the Chinese Integrated Circuit Foundries. In Y. Zhou, W. Lazonick, & Y. Sun (Eds.), China as an Innovation Nation (p. 0). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198753568.003.0007.
- Li, Y. (2021). The Semiconductor Industry: A Strategic Look at China's Supply Chain. In F. Spigarelli & J. R. McIntyre (Eds.), The New Chinese Dream: Industrial Transition in the Post-Pandemic Era (pp. 121–136). Springer International Publishing. https://doi.org/10.1007/978-3-030-69812-6_8.
- Orton, J. (2008). Perspectives. In J. W. Orton (Ed.), The Story of Semiconductors (p. 0). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199559107.003.0001.
- Purkayastha, P. (2022, October 29). US chip ban de facto declaration of war on China? Asia Times. https://asiatimes.com/2022/10/us-chip-ban-de-facto-declaration-of-war-on-china/
- State Council of the PRC. (2021). 中华人民共和国国民经济和社会发展第十四个五年规划和2035年远景目标纲要_滚动新闻_中国政府网 (Outline of the People's Republic of China 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035). http://www.gov.cn/xinwen/2021-03/13/content_5592681.htm.
- Teer, J., & Bertolini, M. (2022). Reaching breaking point: The semiconductor and critical raw material ecosystem at a time of great power rivalry (pp. 1–150) [Research Report]. The Hague Center for Strategic Studies. https://hcss.nl/report/reaching-breaking-point-semiconductors-critical-raw-materials-great-power-rivalry/.
- The Standing Commitee of the NPC. (2021). 中华人民共和国科学技术进步法_中国人大网 (Law of the People's Republic of China on Progress of Science and Technology). http://www.npc.gov.cn/npc/c30834/202112/1f4abe22e8ba49198acdf239889f822c.shtml.
- To, Y. (2021). Rethinking China's Strategy of Technological Independence. Georgetown Journal of International Affairs. https://gjia.georgetown.edu/2021/06/22/rethinking-chinas-strategy-of-technological-independence/.
- U.S. Department of Commerce. (2022a). A Strategy for the CHIPS for America Fund. https://www.nist.gov/chips/implementation-strategy.
- U.S. Department of Commerce. (2022b). The National Semiconductor Technology Center Update to the Community. https://www.nist.gov/chips/national-semiconductor-technology-center-update-community.
- Wolf, M., & Kalish, I. (2021, December 21). Supply chain resilience in the face of geopolitical risks. Deloitte Insights. https://www2.deloitte.com/us/en/insights/economy/us-china-trade-war-supply-chain.html.
- Yu Q. (2022, August 20). 《二〇二二芯片与科学法案》：既治不了美国的 "芯病"，更不会遂了其 "芯愿." 环球网. https://www.huanqiu.com/article/49JjZ95Yy7T.
- Yue Zhang, M. (2023, February 28). The highly charged geopolitics of lithium. East Asia Forum. https://www.eastasiaforum.org/2023/03/01/the-highly-charged-geopolitics-of-lithium/.