POLICY BRIEF

Enhancing Semiconductor Supply Chain Resilience and Competitiveness: Recommendations for U.S.-EU Action

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The United States and the European Union (EU) have recently launched various initiatives to manage their competition and enhance their cooperation on trade and technology issues. The Transatlantic Leadership Network's Trade and Technology Working Group addresses these topics in its work, including recommendations for more effective action. This policy brief recommends ways for the two parties to enhance semiconductor supply chain resilience and competitiveness. One companion piece addresses broader supply chain issues, with recommendations for U.S.-EU action; another focuses more specifically on pharmaceuticals supply chains. I thank Working Group colleagues for our discussions on these issues; I take responsibility for the recommendations offered here. All products from the TLN Working Group may be found at https://www.transatlantic.org/transatlantic-technology-and-trade-working-group/.

Introduction

The leading supply chains of common interest to the United States and the EU revolve around semiconductors, which the two parties have called "the material basis for integrated circuits that are essential to modern-day life and underpin our economies."[1] U.S. Secretary of Commerce Gina Raimondo has called semiconductors "the water of the new economy, you can't do anything without them."[2] They are the spark to innovation and productivity across practically all economic sectors, and the backbone of military might and geopolitical influence.[3] Oxford Economics estimates that the $470 billion semiconductor industry is directly responsible for $2.7 trillion in total annual global gross domestic product (GDP) and helps generate $7 trillion in global economic activity. Together, the United States and the EU represented 21% of the world's semiconductor manufacturing capacity, and 30% of the world's demand for semiconductor chips, in 2020. U.S.-EU semiconductor trade totaled $4.8 billion.[4] That figure is significantly higher if one includes trade within many semiconductor-related companies whose operations straddle the Atlantic.

Semiconductor supply chains are perhaps the most complex of any in the world. The typical production process toward a final electronics product can see the underlying semiconductors within it cross international borders 70 or more times in a process that takes over 100 days and includes 3 full trips around the world. Each segment, on average, involves enterprises from 25 countries directly, and enterprises from 23 countries in support functions. The United States, Japan, South Korea, Taiwan, the EU, China and several Southeast Asian countries play critical roles within the semiconductor value chain. No country or region is able to source all necessary inputs and perform every process step on its own.[5]

In recent years these complex supply chains have been disrupted by uncertainties and stockpiling generated by U.S.-Chinese tensions, abrupt and significant swings in demand and government-mandated shutdowns in supply that have accompanied COVID-19, additional leaps in demand driven by the digital revolution, as well as natural disasters, truck shortages and global shipping backups. The ripple effects have been tremendous. Goldman Sachs estimates that around 169 industries globally have been impacted by current chip shortages.[6]

As governments have realized how reliant they are on these deeply intertwined semiconductor value chains, many have turned to semiconductor nationalism, looking for ways to disentangle themselves from such critical vulnerabilities and to build more capabilities at home. China ramped up such efforts early as part of its Made in China 2025 policy, and as Beijing-Washington frictions intensified under the Trump administration. More recently, countries in Asia, North America and Europe have followed suit.[7]

Given the deeply interdependent nature of semiconductor value chains, such efforts at self-sufficiency are unlikely to succeed entirely. To understand how the United States and the EU could be more effective in building more resilient and robust semiconductor supply chains, it is important to look at the key elements of such networks.

The United States, the EU, and the Global Semiconductor Network

At first glance, the United States and Europe together dominate the global semiconductor industry, with U.S.-headquartered semiconductor enterprises accounting for 47%, and European firms for another 10%, of the $155 billion in sales recorded in 2019. Enterprises from Asian countries essentially accounted for the rest: South Korea (19%), Japan (10%), Taiwan (6%) and mainland China (5%).[8] These figures, however, disguise important facts about these deeply intertwined semiconductor supply chains that render the United States and Europe highly vulnerable.

Semiconductors emerge from highly fragmented and highly-specialized global production processes. The key stages are design, fabrication, assembly and packaging, and production of manufacturing equipment. While specific companies and countries may be leaders in one or more elements of the overall process, none has a lock on all.[9] The high levels of specialization required to offset steep investment costs has led to just a handful of players dominating a few segments of the market. And dominant players in one segment are reliant on inputs from dominant players and smaller suppliers from other segments. Taiwan's TSMC and United Microelectronics Corporation (UMC), for example, specialize in contract chip making, yet they neither design the chips they produce nor build most of the equipment they use to manufacture semiconductors – two sectors of U.S. and European strength.

The Netherlands' ASML holds a monopoly over some of the world's most advanced lithography machines needed to build high-end chips that companies like TSMC must buy. ASML, in turn, is reliant on its San Diego-based affiliate Cymer, which it acquired in 2013, for lasers; German-based Carl Zeiss for lenses; and Dutch-based VDL for the robotic arms that feed wafers into its machines. These intricate transatlantic webs of value-added specialization and supply have generated astounding advances into ASML's capabilities, which in turn have spurred transformative advances in semiconductor technology.[10]

Design

When it comes to semiconductor design, the United States leads the world, accounting for 65% of this market and 85% of the specific area of electronic design automation (EDA). Taiwan ranks second, and mainland China third. European firms account for a mere 2% share of the semiconductor design market. Europe is "strongly dependent" on the U.S. for tools to design integrated circuits, which are needed to build chips, according to the Commission's latest assessment of the EU's dependencies. EU businesses source all their high-end chips from U.S. companies.[11]

However, for continued profit growth and domestic research and development (R&D) investment, U.S. companies are highly dependent on sales to China, which accounts for a quarter of global demand for semiconductors. In addition, U.S. design companies depend on limited sources of intellectual property (IP) from enterprises in countries like Canada, Germany, India, Israel, Singapore, South Korea and the United Kingdom. Moreover, while most advanced chips are designed in the United States, only around 12% is manufactured there, down from 37% in 1990. Most U.S. design companies have outsourced their manufacturing or located their facilities outside of the United States to avoid risks related to extremely high levels of capital expenditures for manufacturing facilities and manufacturing process technologies.[12]

Fabrication

The result is that the United States, the world leader in designing semiconductors, is extremely reliant on semiconductors produced abroad. High-end chip fabrication is centered in Asia and dominated by Taiwan's TSMC and South Korea's Samsung. Taiwan's TSMC has a 55% share of the semiconductor fabrication market and produces most high-end chips. Some argue that acute U.S. dependence on Taiwan's TSMC is Taipei's best instrument to ensure U.S. protection against aggression from mainland China. Former U.S. Undersecretary of Homeland Security Asa Hutcheson went so far to say that "Taiwan's 'silicon shield' makes it the 51st [US] state."[13]

In 2019, Taiwan accounted for 20% and South Korea for 19% of global installed semiconductor fabrication capacity. Japan accounted for 17%, and China 16%. Europe accounted for just 9% (down from 44% in 1990), and European foundries do not produce cutting-edge chips. They remain competitive, however, in lower-end sectors with fast-growing electronics production, such as automotive (27% global share), aerospace, defense and security (22%), and industrial electronics (20%).[14]

Thanks to substantial government subsidies, China's share of global chip manufacturing capacity is slated to double to 24% by 2030.Although China remains two to three generations behind cutting-edge producers in advanced semiconductor manufacturing capacity, it is intent on closing the gap.[15]

Assembly, Testing and Packaging

Both the United States and Europe have lost market share with regard to the most labor-intensive segment of semiconductor value chains, namely assembly, testing and packaging (ATP). Companies on each side of the North Atlantic have outsourced these elements to low-wage countries, particularly in Asia. As a result, Europe only has 3%, and the United States 2% of the global market in ATP services, whereas the Asia-Pacific region accounts for 64%. As chips become increasingly complex, advanced packaging methods represent a potential area for significant technological advances. The global advanced packaging market size is projected to roughly double from $24.2 billion in 2020 to $ 41.8 billion by 2030. Yet neither the United States nor the EU is likely be competitive, meaning continued reliance on other intermediate suppliers, while massive Chinese investments threaten to upend the market.[16]

Materials

The production of semiconductors requires hundreds of materials (including critical materials), not all of which are produced in the United States or Europe, thus introducing additional interdependencies into these supply chains. Few critical materials are produced on either side of the North Atlantic. Lack of domestic access to these materials has exacerbated current supply chain disruptions, yet efforts to ramp up domestic production would likely be lengthy and costly – and some materials simply are not available. Moreover, Asian suppliers dominate the market for such intermediate elements as silicon wafers, photomasks, and photoresists.[17]

Production of Semiconductor Manufacturing Equipment

U.S. and European enterprises are particularly strong when it comes to producing semiconductor manufacturing equipment (SME), including critical intermediate parts and components: U.S. companies generate more than half of global SME revenue, followed by companies from Japan (27%) and Europe (17%). The SME industry is dominated by companies in the United States (41.7% share by revenue), Japan (31.1%), and the Netherlands (18.8%). South Korea has 2.2% share, and the rest is shared among China, Germany, Taiwan, Israel, Canada, and additional countries in Southeast Asia and Europe. Specialized EU-based enterprises, such as the Netherlands' ASML and France's Riber, are sources of European strength in this area. China, in contrast, cannot make SME itself. Given its multibillion-dollar government programs to develop a chip industry, however, it has become the leading market for SME producers from the United States, Europe and Japan.[18]

In sum, the United States and the EU have acknowledged that they have "some important respective strengths as well as ongoing, significant mutual dependencies, and common external dependencies."[19] Potential therefore exists for complementarities and synergies, and both sides have attractive and unique capabilities. U.S. enterprises are global leaders in SME production and in semiconductor design and associated design tools. European firms also show strength in design and SME production, and in some materials key to the semiconductor manufacturing process. The EU has a strong position in certain sub-segments such as discrete semiconductors (global sales leader), analogue integrated circuits, micro-controllers, power electronics, sensors, chip architecture and advanced chip-making equipment. Europe is also well positioned in the 'More than Moore' market, (products made up of a mix of semiconductors), as well as in dedicated processors for applications in the automotive and industrial sectors (including machinery), which are all expected to grow significantly in the future.[20] Despite these respective strengths, each party relies heavily on others for highest-end chip manufacture, critical materials, and assembly packaging and testing.

U.S. Responses

The United States, under both the Trump and the Biden administrations, has sought to maintain or enhance areas of U.S. relative strength; reverse U.S. and allied dependencies; and thwart China's ambitions to become self-sufficient in semiconductors. The United States has instrumentalized some of its strengths by blocking exports of semiconductor manufacturing equipment, restricting sales of chips made with U.S. equipment, and blocking Chinese acquisitions of U.S. chipmakers, particularly by restricting Huawei in telecommunications, and restricting exports to Semiconductor Manufacturing International Corporation (SMIC), China's most advanced maker of computer chips." The U.S. government has also successfully influenced Dutch ASML and Japanese Electron to stop sales to SMIC.[21]

These actions have been accompanied by other initiatives to reduce U.S. vulnerabilities and maintain U.S. leadership in areas of strength. The United States Innovation and Competition Act (USICA), which has passed the U.S. Senate but is likely to remain the subject of congressional wrangling into much of 2022, would allocate $52 billion to incentivize domestic semiconductor production, including advanced semiconductor packaging. It would create a multilateral semiconductors security fund to support development of measurably secure supply chains, and unleash tens of billions more for basic research into a range of scientific fields. The United States has also signaled interest in making use of joint R&D opportunities with Europe, Taiwan, Japan, and South Korea.[22]

EU Responses

The EU is also taking action to reduce its dependencies and reinforce European strengths. Through the "European CHIPS Act," slated for adoption in the fall of 2022, the European Commission wants the EU to account for 20% of global market share (in value) in the fabrication of "cutting-edge and sustainable semiconductors" by 2030. EU policymakers say this goal would double the EU's current share – but this is problematic, since the EU's current share of high-end fabrication is actually close to zero, even if some inputs from the EU are important in the added value of high-end chips production. To reach this goal, the Commission plans a semiconductor "industrial alliance" with firms, researchers and other stakeholders. Microelectronics was identified as a key area for investment under the EU Recovery and Resilience Facility. However, given that the Commission has few resources to provide subsidies to EU companies, it is reliant on either private industry or member state governments. Its main contribution has been to allow national governments to provide otherwise prohibited state aid through so-called Important Projects of Common European interest (IPCEI). This funding remains relatively marginal. EU leaders, particularly EU Internal Market Commissioner Thierry Breton, have stated that the EU will match U.S. efforts to increase semiconductor production. According to Niclas Poitiers and Pauline Weil, however, thus far EU national recovery plans have included only $3 billion in direct funding, linked to another pool of about $2.8 billion. Even including an existing $7 billion in chip funds promised in previous budgets, EU funds are running at about one-quarter of anticipated U.S. commitments.[23]

Using the TTC to Enhance Supply Chain Resilience and Competitiveness

In addition to efforts the United States and the EU are undertaking individually and with other like-minded partners, each has committed to build a partnership, including through the TTC, to rebalance global supply chains in semiconductors, increase security of supply, and boost their ability to design and manufacture the "most powerful and resource efficient semiconductors."[24]

While the TTC's potential regarding semiconductors is currently limited by France's insistence that the focus remain on "short-term supply chain issues" rather than deep structural reform, it offers a chance for the two parties to harness their respective strengths and mitigate their respective dependencies within semiconductor supply chains. To seize the moment, they should first be careful to sidestep potential dangers, such as pursuing illusions of autonomy, harmful subsidy races or duplicative or conflicting efforts. Despite each side's push for self-reliance, achieving fully independent chip supplies is unrealistic, given the highly complicated, specialized and global nature of semiconductor supply chains.[25]

Avoid illusions of autonomy. Political leaders have framed their efforts to alleviate semiconductor supply chain dependencies as exercises in "decoupling" or "strategic autonomy." The decoupling metaphor is easy to understand, because it evokes a simple image of disconnecting a cable, in this case a worrying link to China. "Strategic autonomy" speaks to European anxieties that the EU has become overly dependent, not only on China, but on an unpredictable U.S. ally. While both are simple to understand, each is a misleading phrase that, if drawn to its ultimate conclusion, would wreak havoc on the U.S., European and global economies. Moreover, neither term is an accurate depiction of actual U.S. or EU policies. Neither party is really trying to break free of its interdependencies; each is more intent on redefining the terms of those interdependencies in ways that can enhance its relative security and prosperity. The best course for the United States and the EU to enhance security of semiconductor supply is not to "decouple" or become "autonomous" from all other semiconductor producers; it is to ensure that other semiconductor producers remain dependent on them, by doubling down on areas of strength.[26]

For the United States, this can mean some efforts to mitigate strategic vulnerabilities such as reliance on foreign semiconductor fabrication, and assembly packaging and testing. It means working with the EU and other like-minded countries to ensure reliability of supplies of critical materials, which is discussed in a companion policy brief. Most of all, it means reinforcing U.S. strengths in semiconductor design and SME production. For the EU, it means acknowledging that becoming completely autonomous in high-end semiconductor fabrication is just "not doable," as EU competition chief Margrethe Vestager has acknowledged -- not only because the EU has neither the incentives or the resources to overtake the world's leading high-end fabricators, but because the EU itself has relatively low demand. As a whole, the EU accounts only for 9% of global semiconductor imports, compared to Asia, which accounts for 83% of exports and 81% of imports. Instead, the EU should focus its resources on areas of strength by fostering semiconductor subsectors upon which other countries, including the semiconductor superpowers, are reliant. Those strengths include R&D projects in chip and software design, SME, and materials innovation for important chip manufacturing inputs, such as chemicals, sensors, power electronics, embedded security solutions and security chips.[27]

Avoid a subsidy race that could crowd out private investments that would themselves contribute to supply chain security and resilience. The USICA could result in tax credits being offered to companies engaged in domestic production, as well as federal financial support to match incentives being offered by individual U.S. states. The EU's CHIPS Act is likely to offer similar financial inducements. U.S. and EU officials have said they want to avoid a subsidy race. Unless they are careful, however, they could easily become embroiled in bidding wars to entice companies to invest locally. This could render such companies reliant on government hand-outs, exacerbate supply issues, and do little to enhance resilience of transatlantic supply chains. It would only benefit China.[28]

Improve transparency throughout the semiconductor supply chain. The two parties should be able to agree, in partnership with industry, on principles guiding transparency and enhanced information flow among producers, suppliers and end-users and to advance the adoption of effective semiconductor supply chain management and security practices by companies.

Conduct a joint assessment of supply chain vulnerabilities. The two parties have already agreed to jointly identify gaps and vulnerabilities, map capacity in the semiconductor value chain, and strengthen domestic semiconductor ecosystems, from, research, design to manufacturing, with a view to improving resilience, through consultation with stakeholders, and the right incentives. Having conducted separate studies of strategic dependencies, the next practical step would be for the United States and the EU to develop a common assessment of such vulnerabilities. A joint assessment could sharpen each party's understanding of common supply-chain risks, now and in the future, particularly in the context of strategic dependence on uncertain suppliers or unreliable sources. It could enable them to avoid overcapacity or duplicative investments to alleviate such dependencies; align on key definitions, such as what may be considered "critical minerals and materials"; and commit to common or complementary approaches to enhance supply chain resilience and robustness.[29]

Explore the feasibility of complementary foreign-investment investigative processes. The U.S. Committee on Foreign Investment in the United States (CFIUS) scrutinizes risks to U.S. national security posed by investments of foreign entities. It could serve as a model for reviewing imports that create critical dependencies. The EU has already expressed interest in the CFIUS investigative process, which finds no parallel within the EU and may offer ways to shore up the EU's patchy investment screening process. The two parties might explore the feasibility of complementary CFIUS-style investigative processes in the semiconductor industry.[30]

Align export controls of chip technologies, semiconductor manufacturing equipment, and critical inputs.[31] Restrictions on SME exports to China would be an effective way of maintaining a technological competitive advantage in this area of relative strength – 90% of global SME is produced by the United States, the Netherlands, and Japan. China is making huge investments to design and manufacture its own chips indigenously, but it needs foreign equipment and know-how to accomplish this goal. Optimally, U.S.-EU work on export controls would include adopting common licensing policies and standards; equivalent end-user approaches; common understandings with regard to extraterritorial application of export controls; and harmonized definitions of common terms. Such work can also inform efforts to strengthen broader coalition, for example the Wassenaar Arrangement, that work to enhance controls on exports of technologies that could pose risks to the security of nations.

Consider a Solidarity Pledge for Semiconductor Resilience. One driver of efforts to generate semiconductor self-sufficiency within the EU is concern, borne of recent experience, that either China or the United States could instrumentalize its hub position within critical supply chains to pressure other countries, including EU member states, to align with its views. The United States should address these concerns as it seeks to re-energize the transatlantic partnership. For instance, the two parties might consider a "solidarity pledge" not to cut off the other side of the Atlantic to key equipment, design IP, or scarce chips needed to power each side, and to not remain passive should one of the parties face such cut-offs from any third party.

Harness U.S.-EU potential on semiconductor R&D by building synergies between the National Science Foundation and the €93-billion Horizon Europe framework programs, including greater cooperation among leading research institutes, for instance the National Semiconductor Technology Center (NSTC) in Albany, New York, and Europe's research hubs like the Interuniversity Microelectronics Centre (IMEC) in Belgium, Fraunhofer in Germany and CEA-Leti in France. Explore semiconductor-related R&D opportunities with additional key partners, such as Taiwan, Japan, and South Korea.[32]

- ***Address the semiconductor energy challenge***. Semiconductor production consumes significant amounts of energy and produces significant amounts of carbon. By 2030, about 25% of the world's energy could be consumed by electronic devices if nothing is done to make them more energy efficient. Greater transatlantic cooperation holds the promise to design new microchips that could perform better – and require less energy – than silicon. Further details are provided in the companion paper, "Making the U.S.-EU Trade and Technology Council Work for Climate and Clean Tech: Recommendations for Action."[33]

U.S.-EU cooperation could form the core of a broader semiconductor consortium of like-minded nations, including Japan, Taiwan and South Korea, that could also consider forging a common innovation base with R&D of next-generation semiconductor designs and materials. A more ambitious step would be to open support under the USICA, the EU CHIPS Act, and the EU's Important Projects of Common European Interest to companies from other countries.[34]

Join with other key countries to support a next-generation expansion of the WTO Information Technology Agreement (ITA), an arrangement among 82 WTO members to zero out tariffs on 97% of world trade in information technology products, including most semiconductors. In 2015, 53 countries, including the United States and EU member states, joined together to expand the list of products subject to duty elimination under the ITA, valued at $1.3 billion in annual global trade. Given the tremendous pace of technological innovation, however, even this recent round of ITA expansion (ITA-2) now fails to cover a host of new products. An ITA-3 agreement could cover an additional 250 ICT products or component, including lithium batteries, 3D printing, charging stations for electric vehicles, patient monitoring systems, next-generation semiconductor technologies and manufacturing. The ITA has greatly accelerated global demand for semiconductor-enabled ICT products; expansion would further enhance the competitiveness of U.S. and European companies and those from other partner countries. Expanding geographic and product coverage under the ITA is a critical opportunity to further strengthen semiconductor and semiconductor-related supply chains.[35]

Strengthen rules for state-owned enterprises and distortive industrial subsidies. Chinese government equity infusions to indigenous companies, for example, can distort semiconductor markets and privilege Chinese companies. The United States and the EU could work through the TTC to develop a shared position on state-owned enterprises and government assistance disciplines that align with the U.S.-Japan-EU trilateral work to strengthen WTO subsidy rules.

Notes

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