

Fabrice Naumann and Monika Schnitzer

Rationales for Industrial Policy in the Semiconductor Industry

In recent years, private and public investments in the semiconductor industry have surged worldwide. In the European Union alone, a government subsidy package of €43 billion is under negotiation, while in the United States and East Asia, state support amounts to multiples of that figure. Economists view this subsidy race critically, as it could potentially lead to market distortions and inefficient allocations. In Germany, the substantial subsidies for new factories by Taiwan Semiconductor Manufacturing Company Limited (TSMC) and Intel are also the subjects of heated debate. Despite these concerns and the traditional reservations among economists against industrial policy in general, there are compelling reasons for pursuing such an industrial policy approach, particularly in the European semiconductor industry—provided the economic and political contexts are understood, and the policy is well executed.

Recent crisis

The semiconductor crisis has caused significant economic disruptions in European industry. The automotive sector was severely affected, with chip shortages leading to a global reduction in vehicle production by approximately 9.5 million units in 2021, of which around 2.4 million would have been produced in Europe (Verband der Automobilindustrie, 2023). These shortages resulted from complex supply chain issues, exacerbated by the automotive industry's reliance on a "just-in-time" production model, which quickly led to production halts when unexpected disruptions occurred (McKinsey, 2022).

In addition to the automotive industry, the high-tech and consumer electronics sectors were heavily impacted. The shortage of semiconductors led to a deterioration in the supply situation, forcing companies worldwide to reduce or completely shut down their production capacities. This crisis highlighted the vulnerability of the European economy resulting from its dependence on external suppliers

© The Author(s) 2024. Open Access: This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>).

Open Access funding provided by ZBW – Leibniz Information Centre for Economics.

Fabrice Naumann, Ludwig-Maximilians-Universität München, Munich, Germany.

Monika Schnitzer, Ludwig-Maximilians-Universität München, Munich, Germany.

and led to significant economic damage through production losses and revenue declines. Both the electronics and automotive industries continued to struggle with supply shortages, particularly semiconductors, well into 2023 (ifo Institut, 2023).

Current position of Europe

The European semiconductor industry plays a crucial role in the global supply chain but faces significant challenges. Europe excels in specialised areas like semiconductor manufacturing equipment, particularly with companies like Advanced Semiconductor Materials Lithography (ASML), a Dutch company that leads in lithography systems that are crucial to the production of semiconductors. However, Europe lags in key segments such as wafer fabrication, where the market is dominated by East Asia and the United States. This geographical concentration outside of Europe poses a strategic risk, as disruptions in global supply can severely impact European industries, especially those reliant on advanced semiconductor technologies, as experienced over the last years (Boston Consulting Group, 2024).

This strategic importance of semiconductors is going to increase manifold in the coming years and decades. Semiconductors are vital for achieving overarching European goals such as climate neutrality and digital transformation. They are essential components in renewable energy technologies, electric vehicles and smart grids, all of which are critical for meeting the EU's climate objectives. Moreover, semiconductors underpin the digital infrastructure necessary for advancing Europe's digitalisation agenda, which includes the deployment of 5G networks, artificial intelligence (AI) and the Internet of Things (IoT). AI advancements have been driven by significant progress in semiconductors. New studies show, however, that the computing power required to train cutting-edge AI is growing faster than semiconductor productivity, despite advances in line with Moore's law. The rapid growth in data used in training AI has led to an unprecedented demand for processing power, with Nvidia graphics processing units – crucial for training large language models – experiencing severe shortages. This shortage is seen by some as a clear indication that processing power could become a critical bottleneck in the development of advanced AI systems (Miller, 2024).

Moreover, experts predict that the demand for semiconductors in the automotive industry alone will triple

by 2030, further increasing the need for robust supply chains and amplifying the importance of semiconductor production for the European economy (Boston Consulting Group, 2024).

The ability to produce and innovate in semiconductor technologies is, therefore, not only an industrial necessity but also a strategic imperative for Europe's broader economic and environmental ambitions. But it is a global race. Global competition has driven governments to invest heavily in their semiconductor industries. China initiated the current wave of chip subsidies in 2014 by designating semiconductors as crucial to its "Made in China 2025" strategy and launching a National Integrated Circuit Industry Investment Fund to support semiconductor growth. In response, Japan has provided funding for foreign companies like TSMC and Micron to establish or upgrade facilities and has created a new chipmaker, Rapidus, to advance cutting-edge manufacturing. Similarly, the US and the EU have each introduced "Chips Acts," committing tens of billions of dollars to attract and expand chip investments (Miller, 2024).

Rationales for industrial policy

There are strong arguments for targeted industrial policy in the European semiconductor industry, particularly when considering the market failures that private companies alone are unlikely to address effectively. These arguments can be understood through the lenses of externalities, coordination failures and the need for specific public inputs, as described by Juhász and Lane (2024).

The complex global value chains in the semiconductor industry have become vulnerable due to the pandemic and various geopolitical conflicts. European companies are embedded in complex supply chains and do not internalise all the risks across the entire value chain. The supply chain disruption in the semiconductor industry described above illustrates the problems that arise if companies do not diversify their input suppliers because they underestimate the risk of such disruptions and do not consider the negative externalities a disruption causes beyond their own company. The problem is even more severe if all companies rely on the same source because it is the cheapest one.

To make local, usually downstream, value creation more resilient, it is beneficial to establish upstream production steps within the region. Building these capacities can also make additional upstream production processes or raw material extraction in Europe economically viable, further developing local value creation. The more steps in the value chain can be accessed with reduced risk, the

better crisis prevention can be managed through inventory and safety capacities – countering the often-voiced scepticism that critical dependencies on individual inputs or raw materials will persist. Incentivising and coordinating companies to diversify their input suppliers would also help solve this problem, as some critics have suggested. Yet, this would not be sufficient to internalise other externalities present in the semiconductor industry.

The semiconductor industry was recognised a long time ago for its high learning-by-doing rates and across-firm learning spillovers (Irwin & Klenow, 1994). Companies like ASML, a Dutch leader in lithography systems, exemplify this. Their continuous innovation benefits not only their own production processes but also the entire semiconductor ecosystem (Goldberg et al., 2024).

Moreover, technological spillovers occur substantially across borders when foreign direct investment (FDI) brings advanced technology into a region, allowing local firms to benefit from the expertise and processes developed elsewhere (Goldberg et al., 2024). The investment by TSMC, a leading semiconductor producer from Taiwan, in a new factory in Dresden is expected to bring such a knowledge transfer. Typically, European firms invest outside the EU, leading to technology spillovers in those regions. However, TSMC's investment reverses this trend, bringing cutting-edge technology to Europe. This FDI enables European firms to learn from TSMC's advanced production techniques, enhancing the region's technological capabilities.

The semiconductor industry has the potential to create high-quality jobs, which provide significant social benefits, known as the good-jobs externality. TSMC's expansion in Germany, for instance, is expected to create thousands of highly skilled positions with wages and conditions that far exceed those in many other sectors. Such jobs contribute to reducing inequality and enhancing social stability. However, private firms may not prioritise these broader social benefits in their investment decisions, making public intervention necessary to ensure these jobs are created and maintained (Rodrik, 2022).

Next, the semiconductor industry relies on a complex, highly specialised supply chain. For instance, the collaboration between European firms like Infineon and various suppliers is critical for maintaining production capacity. Without coordinated investments across the supply chain, firms may hesitate to expand or adopt new technologies, leading to inefficiencies. Government policy can play a crucial role in synchronising these investments, ensuring that the necessary infrastructure and capabilities are developed across the entire supply

chain. Again, TSMC investment in Dresden is a good example. The Taiwan-based company forms a joint venture with the locally active firms Infineon, Bosch and NXP. This secures them a substantial share in production capacity, which they could not afford individually due to high upfront costs.

Lastly, semiconductor manufacturing is not only capital-intensive but also requires a highly skilled workforce and cutting-edge research facilities. Companies like GlobalFoundries, which operates in Germany, depend on a strong educational and technological ecosystem to support their operations. Private firms alone may not invest sufficiently in these public goods, as the benefits are widely shared across the industry. Customisation is key here. Bartik (2020) has shown that instead of offering subsidies, providing current and potential investors with tailored business services and inputs is much more efficient. He estimates that public investments in infrastructure, manufacturing support, specialised training programmes, and brownfield redevelopment create new jobs at a much lower cost.

Letting losers go

Despite strong theoretical arguments supporting industrial policy for the European semiconductor industry, critics often point to negative examples of ill-guided industrial policy from the past, arguing that policymakers are not adept at selecting winners in advance.

Indeed, industrial policy often involves the challenging task of determining who should receive financial support and investment. A critical issue with this approach is the inherent difficulty in accurately identifying the “winners” before they emerge. Governments and policymakers typically do not have access to all the necessary information, and the future performance of industries or companies is notoriously hard to predict. This uncertainty makes it difficult to guarantee that public funds will be directed towards ventures that will succeed. The risk of misallocation is high, leading to potential inefficiencies where resources are wasted on projects that do not deliver the expected returns.

Yet, a more pragmatic approach to industrial policy does not focus on picking winners in advance but rather on establishing mechanisms that allow for the efficient identification and termination of failing projects (Juhász et al., 2024). This concept is rooted in the idea that it is often easier and more effective to design policies that let “losers” go, rather than trying to predict and select “winners” from the outset. Such an approach allows for the possibility of failure, which is an inherent part of innovation and economic experimentation, without locking in resources to unsuccessful projects indefinitely.

In fact, a well-constructed industrial policy acknowledges that some supported ventures will fail and that this is a normal and even necessary part of the process. The goal is not to avoid failure entirely but to create a dynamic system where unsuccessful projects can be identified and phased out, allowing resources to be reallocated to more promising opportunities. This requires the implementation of clear benchmarks, regular monitoring and the flexibility to withdraw support when it becomes evident that a project is not meeting its goals.

Despite high hopes for the future, there is no guarantee of success for the semiconductor industry. If new strategic options open up in global competition in the future or if the aforementioned externalities of the investments do not materialise to a sufficient extent, then projects will have to be dropped here, too, regardless of their size. Thus, following a more nuanced strategy, industrial policy should be designed to be adaptive, allowing for a portfolio of investments where some are expected to fail. In this way, the role of the state is not to guarantee success for every supported project but to ensure that the overall direction of investment is towards sectors with the potential for significant economic and social returns.

This approach also mitigates the risks of political capture and rent-seeking, where resources might otherwise be directed based on political favouritism rather than economic merit. By focusing on mechanisms that phase out failing projects, the state can avoid prolonged support for ventures that do not contribute to broader economic goals, thereby improving the overall efficiency and effectiveness of industrial policy. However, even this approach must consider the inherent political pressures and constraints within the political system, which are crucial to acknowledge, as discussed below.

Political economy

Beyond economic constraints, the governance challenges inherent in industrial policy mean that the policies implemented often diverge significantly from the theoretical economic ideals. In other words, the realities of political processes shape the policies we ultimately see, explaining why they frequently differ from the “optimal” policies that a theoretical social planner might choose.

For example, it is crucial to address the issues of political credibility and time inconsistency. Policies often require long-term commitments, but political cycles and changing governments can create uncertainty. This uncertainty can deter private sector investment if companies fear that future administrations might reverse or alter current policies. In the semiconductor industry, companies need as-

insurance that the government is willing to take substantial risks but also will consistently pursue its strategic goals, such as climate transformation, digital transformation, securing skilled labour, supporting R&D and providing physical infrastructure because otherwise they may be reluctant to commit substantial resources. To mitigate this, policies should include mechanisms that ensure long-term political stability, such as cross-party agreements or legally binding frameworks.

Another issue is that the benefits of industrial policies are often concentrated among specific groups, while their costs are spread more broadly, making them politically contentious. By altering economic equilibria, these policies can disrupt the political status quo. While individual companies like TSMC or Infineon receive substantial government funding, the general public bears the costs. To justify these costs, it is important to communicate that this support benefits an entire industry, which gains through the aforementioned externalities and simultaneously serves as the backbone for many other industries in different regions.

At the same time, it would be naïve to overlook the impact that political incentives have on the decisions on specific projects. The industrial policies we see are often those that align with the prevailing political context. Policymakers face pressure to prioritise short-term political gains or respond to powerful interest groups, and this can lead to policies that favour certain sectors or regions rather than focusing on the broader economic good. Understanding the political economy of policy decisions is essential for grasping why policies succeed or fail and should inform their design, as proposed by Juhász and Lane (2024). Effective industrial policy must navigate the political realities by creating transparent, inclusive processes that balance diverse interests and align short-term political incentives with long-term strategic goals, ensuring that policies are both politically feasible and economically sound.

Recent empirical evidence for industrial policy

Recent studies have re-examined sectoral industrial policies, focusing on historical case studies in textiles, shipbuilding, and heavy industries across various countries. For example, Juhász (2018) analysed France's cotton spinning industry during the Napoleonic blockade (1806–1813), finding that temporary protection fostered long-term industrial capacity. Hanlon (2020) explored shipbuilding in North America during the late 19th century, where natural barriers and protective tariffs facilitated the adoption of metal shipbuilding. Lane (2022) studied South Korea's heavy chemical industry drive in the 1970s, which drastically shifted the country's industrial structure

through targeted investments and subsidies. These examples demonstrate that sectoral policies can catalyse significant structural changes but often involve substantial experimentation costs.

Other studies suggest that mission-oriented R&D policies can drive substantial technological advancements and regional economic growth, though their success often hinges on targeting already innovative regions. Gross and Sampat (2023) analysed the impact of massive government R&D investments during WWII, finding long-lasting shifts in the geographic distribution of US innovation, particularly toward electronics and communications. Similarly, Kantor and Whalley (2023) studied the Apollo mission's economic effects, noting significant local increases in manufacturing value added.

Another strand of the literature focuses on place-based industrial policies targeting specific regions to stimulate economic development, often in distressed or lagging areas. Garin and Rothbaum (2024) examined US government-built manufacturing plants during WWII in non-traditional industrial hubs, finding long-term positive impacts on local employment and industrial activity. Mitrinen (2021) studied Finland's post-WWII reparations to the Soviet Union, which forced a rapid shift into complex metalworking industries, resulting in sustained industrial growth in targeted municipalities.

What can we learn from this new evidence for industrial policy in Europe's semiconductor industry? In many areas, the European semiconductor industry is not leading technologically and is too small. Ensuring that globally leading companies invest in Europe helps the local industry learn from the best and scale up. This also applies to research and development, which benefits from access to advanced technologies and newly acquired process knowledge and, in turn, contributes these insights across the entire value chain. Additionally, more people will be trained in this increasingly important industry, helping drive structural change.

Conclusion

Industrial policy is as widespread as it is controversial. In the context of the European semiconductor industry and subsidies like the one for TSMC's settlement in Dresden, critics argue that this support is inefficient and ineffective in securing access to much-needed semiconductors. Inefficient, it is argued, because the goal to become resilient against potential supply shortages could be achieved at lower cost by importing semiconductors from a variety of different regions abroad. Ineffective, because of the shortage of skilled workers, which means that subsidised

new settlements will compete with local companies, leading them to poach each other's talent. What this criticism misses is that the support of local production brings technological spillovers from foreign direct investment as well as knowledge from the learning-by-doing expertise of the market leaders, benefiting the local value chain and the region as a whole. Moreover, the shortage of skilled workers is, to some extent, endogenous. "Silicon Saxony" is home to renowned universities and vocational schools that attract and educate many students. Yet many graduates leave the region because other regions offer more attractive jobs. With better job opportunities, these skilled workers can be retained in the region or move up from local less productive firms.

Overall, the case for industrial policy in the European semiconductor industry seems compelling. But it is crucial that it is carefully designed. Effective industrial policy should be forward-looking, allowing for the phasing out of unsuccessful projects. This would help ensure that resources are allocated efficiently, supporting sustainable growth and technological advancement while avoiding common policy missteps. It would be naïve to assume that industrial policy decisions are immune to political interests and influences. Yet, it would be equally misguided to expect that policymakers will refrain from interfering and that firms by themselves will internalise all the externalities and coordination failures that arise in these industries. The conclusion thus has to be that political economy constraints need to be taken into account when designing the appropriate policies, with a focus on sunset clauses that avoid continued investment in projects that do not prove to be worthwhile. There are valuable examples from which lessons can be learned.

References

- Bartik, T. J. (2020). Using place-based jobs policies to help distressed communities. *Journal of Economic Perspectives*, 34(3), 99–127.
- Boston Consulting Group. (2024). *Emerging Resilience in the Semiconductor Supply Chain* [Technical Report].
- Garin, A., & Rothbaum, J. L. (2024). The Long-Run Impacts of Public Industrial Investment on Local Development and Economic Mobility: Evidence from World War II. *NBER Working Paper Series*, w32265. National Bureau of Economic Research.
- Goldberg, P. K., Juhász, R., Lane, N. J., Forte, G. L., & Thurk, J. (2024). Industrial Policy in the Global Semiconductor Sector. *NBER Working Paper Series*, w32651. National Bureau of Economic Research.
- Gross, D. P., & Sampat, B. N. (2023). America, jump-started: World War II R&D and the takeoff of the US innovation system. *American Economic Review*, 113(12), 3323–3356.
- Hanlon, W. W. (2020). The persistent effect of temporary input cost advantages in shipbuilding, 1850 to 1911. *Journal of the European Economic Association*, 18(6), 3173–3209.
- ifo Institut. (2023). *Material Shortages Ease in German Manufacturing* [Press release].
- Irwin, D. A., & Klenow, P. J. (1994). Learning-by-doing spillovers in the semiconductor industry. *Journal of political Economy*, 102(6), 1200–1227.
- Juhász, R. (2018). Temporary protection and technology adoption: Evidence from the napoleonic blockade. *American Economic Review*, 108(11), 3339–3376.
- Juhász, R., & Lane, N. J. (2024). The Political Economy of Industrial Policy. *NBER Working Paper Series*, w32507. National Bureau of Economic Research.
- Juhász, R., Lane, N., & Rodrik, D. (2023). The new economics of industrial policy. *Annual Review of Economics*, 16.
- Kantor, S., & Whalley, A. T. (2023). Moonshot: Public R&D and growth. *NBER Working Paper Series*, w31471. National Bureau of Economic Research.
- Lane, N. (2022). *Manufacturing revolutions: Industrial policy and industrialization in South Korea*, SSRN 3890311.
- McKinsey. (2022). *Semiconductor shortage: How the automotive industry can succeed* [White paper].
- Miller, C. (2024). Global chip war for strategic semiconductors. *Nature Reviews Electrical Engineering*, 1(1), 2–3.
- Mitrunen, M. (2021). *Industrial policy, structural change and intergenerational mobility: evidence from the Finnish war reparations*. Unpublished manuscript.
- Rodrik, D. (2022). *An industrial policy for good jobs*. Hamilton Project – Policy proposal. Brookings Institution.
- Verband der Automobilindustrie. (2023). *Voraussetzungen für künftige Relevanz, Kompetenz und Resilienz für Europa* [White Paper].