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Governments' role in the global semiconductor value chain #3

Analysis of the EU Chips Act: The Crisis Response Toolbox

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Executive Summary

The interplay of complex global value chains with events such as the coronavirus pandemic and the Russian war of aggression against Ukraine has triggered disruptions that have led to supply constraints in almost every industry. As a result, the vulnerabilities of global value chains moved to governments' center of attention. Governments are facing the challenge of expanding their scope of action and adapting their policies to be able to act more effectively in future crises. In the wake of the severe 2020 chip shortages, the EU Commission started this endeavor with a particularly complex technology ecosystem, the semiconductor value chain. The so-called 3rd pillar of the EU Chips Act proposes tools to alleviate and mitigate shortages – marking a clear path towards a more active role of governments in this specific value chain.

This paper examines the effectiveness of these tools – such as priority rated orders and common purchasing – in relation to the characteristics of the semiconductor value chain. Our analysis shows that **the crisis response tools the EU Chips Act draft proposes are not fit for securing the supply of semiconductors in times of crisis**. The room for action for governments is simply very limited when it comes to crisis management in this highly complex value chain. The main reason for the ineffectiveness can be pointed back to the features of the semiconductor value chain, such as highly diversified products, a high degree of specialization in every process step and long manufacturing cycle times. Instead of focusing on crisis response and management, **governments need to shift their focus to a long-term strategy for crises prevention**. We suggest first steps that governments could take in several areas, such as increasing supply chain transparency and putting more emphasis on the responsibility of end-customer industries.

This is the third and last paper in our series that analyzes *governments' role in the global semiconductor value chain*. In our first paper, we provide an overview of the **key shortcomings of a governmental supply chain monitoring** as it is proposed in the EU Chips Act. We argue that governments should instead work with and push industry to own the issue of supply chain monitoring. The second paper elaborates why a **long-term government mapping of the global value chain** should be established to provide an analytical base for a variety of established policy tools.

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1. Introduction

Various unrelated events have put global supply chains under a lot of stress in recent years. Lockdowns due to a global pandemic, the Russian war of aggression against Ukraine, restrictive trade measures by several governments, and countless natural disasters have led to disruptions, shortages, and production loss in many industries. In response, governments and companies are beginning to unpack the complexities of today's global value chains, and the security of the supply of critical products has become front and center in recent policy debates.

From a European perspective, the European (EU) Chips Act[i] and the announcement of the Single Market Emergency Instrument (SMEI)[1] mark a clear path for the EU Commission (EC) toward a more active role in different value chains. With the so-called *Crisis Response Toolbox* in pillar 3 of the EU Chips Act, new tools, such as priority-rated orders, have been introduced to expand the room for action for government to better prepare for and respond to future crises.

However, as every value chain has distinct features and dynamics, the role governments can play in each one varies significantly. Instruments that work in one value chain may be completely ineffective in another. For example, the reasons for the 2020 chip shortages[ii] lie in the interplay of external factors and the characteristics of the semiconductor value chain. These characteristics also prevented the value chain from flexibly adapting to and quickly recovering from disruptions.[iii]

Unfortunately, the proposed Crisis Response Toolbox (i.e., priority-rated orders and common purchasing) in pillar 3 of the EU Chips Act has two important flaws: It does not take the characteristics of this value chain into account and more generally, does not prescribe responsibilities for end-customer industries.

i In February 2022, the EC proposed the European Chips Act, which is accompanied by four documents (Communication, Regulation, and Recommendation). In May 2022, the Staff Working Document (SWD) was published. The EU Chips Act is divided into three sections: (1) "Chips for Europe Initiative" with the goal of supporting investment in cross-border and open research, development, and innovation infrastructures; (2) mid-term security of supply actions to enhance semiconductor production capacity in Europe; and (3) a monitoring mechanism and instruments for crisis responses.

ii Jan-Peter Kleinhans and Julia Hess. 2021. "Understanding the global chip shortages." Stiftung Neue Verantwortung. https://www.stiftung-nv.de/de/publikation/understanding-global-chip-shortages.

iii The semiconductor value chain is characterized by features such as a high division of labor, high capital intensity, long manufacturing cycle times, and strong lock-in effects leading to two distinctive dynamics: increasingly high market entry barriers and the need for high fab utilization. This, in turn, results in conservative capacity investments, dependence on limited sources for inputs and manufacturing, as well as a high geographic concentration of certain production steps.

The latter points to the fact that end-customer industries play a key role in ensuring the future security of the chip supply through better supply chain management, including sourcing. Because of this, the proposed instruments will most likely show little to no effectiveness during future chip shortages.

In the first paper of this series, we depicted the challenges for governments to effectively monitor the supply chain to anticipate shortages and argued that this should be the responsibility of the industry. In the second paper of this series, we introduced the idea of mapping the value chain to identify and assess interdependencies, which is key to deploying policy tools.

In the third paper of this series, we analyze the Crisis Response Toolbox as proposed in pillar 3 of the EU Chips Act. We argue that the proposed tools will not be able to secure the semiconductor supply once there is a crisis. Instead, governments should shift their focus in pillar 3 to crisis prevention based on long-term actions. In the first section, we analyze the effectiveness of the proposed tools by taking into account the different levels of the semiconductor value chain to which these tools can be applied. In the second section, we explain why the focus should be shifted and provide recommendations for how to include the semiconductor industry and end-customer industries.

2. Analyzing the Crisis Response Toolbox

In pillar 3 of the proposed EU Chips Act and the Recommendation,[2] the EC introduces four tools meant to ensure the supply of chips during a shortage for European end-customer industries, such as automotive and medical device manufacturers. In this section, we analyze the effectiveness of the proposed tools (information gathering, common purchasing, export restrictions, priority-rated orders and national reserves[iv]) in achieving these goals. Importantly, we break down the effectiveness and feasibility of each policy tool into the different levels of the value chain, from products (chips) to production steps (front- and back-end manufacturing) and inputs (equipment and fab technology, as well as chemicals and wafers). We end the section with an interim conclusion.

2.1 Tools for tackling the next chip shortage

Information gathering

In the first paper[3] of this series, we analyzed the proposed monitoring mechanism based on data provided voluntarily by the industry with the objective of anticipating shortages. Information gathering complements the supply chain monitoring to better understand a crisis once it occurs. It obliges industry stakeholders "established in the Union" to share data that is necessary for evaluating the crisis and assessing appropriate, effective, and proportionate crisis response measures.[4]

Thus, information gathering is only a means to an end. In itself, it is not a measure for alleviating a chips shortage but is a precursory step to inform other tools, such as common purchasing. The challenges we described in the paper on supply chain monitoring[v] significantly overlap with the problems we see with information gathering, especially concerning the lack of analytical resources and expertise within the government to interpret the data. For a detailed overview of the challenges when collecting and interpreting highly granular industry data, we strongly recommend reading the first paper. In the following analysis, information gathering is omitted.

iv National reserves are not part of the EU Chips Act's Crisis Response Toolbox, but we included them in the analysis because they are often discussed as well.

v You can find the first paper on supply chain monitoring here: https://www.stiftung-nv.de/de/publication/eca-monitoring.

Common purchasing

Common purchasing enables the EC to act as a central purchasing body during a semiconductor crisis to secure the supply of crisis-relevant products for critical sectors.[5]

Export authorizations

Export restrictions are proposed as a possible instrument during a crisis.[6] According to the Recommendation, Member States should decide whether exercising surveillance over certain exports to secure a supply to the internal market is "appropriate, necessary and proportionate."[7]

Priority-rated orders

Semiconductor manufacturers that receive subsidies[vi] are obliged to accept and prioritize certain orders issued by the EC to ensure the security of the chip supply for "critical sectors" during a chip shortage.[8] *Such a priority-rated order may be extended to fab suppliers if critical chemicals, wafers, equipment, or fab technology are scarce.*

National reserves

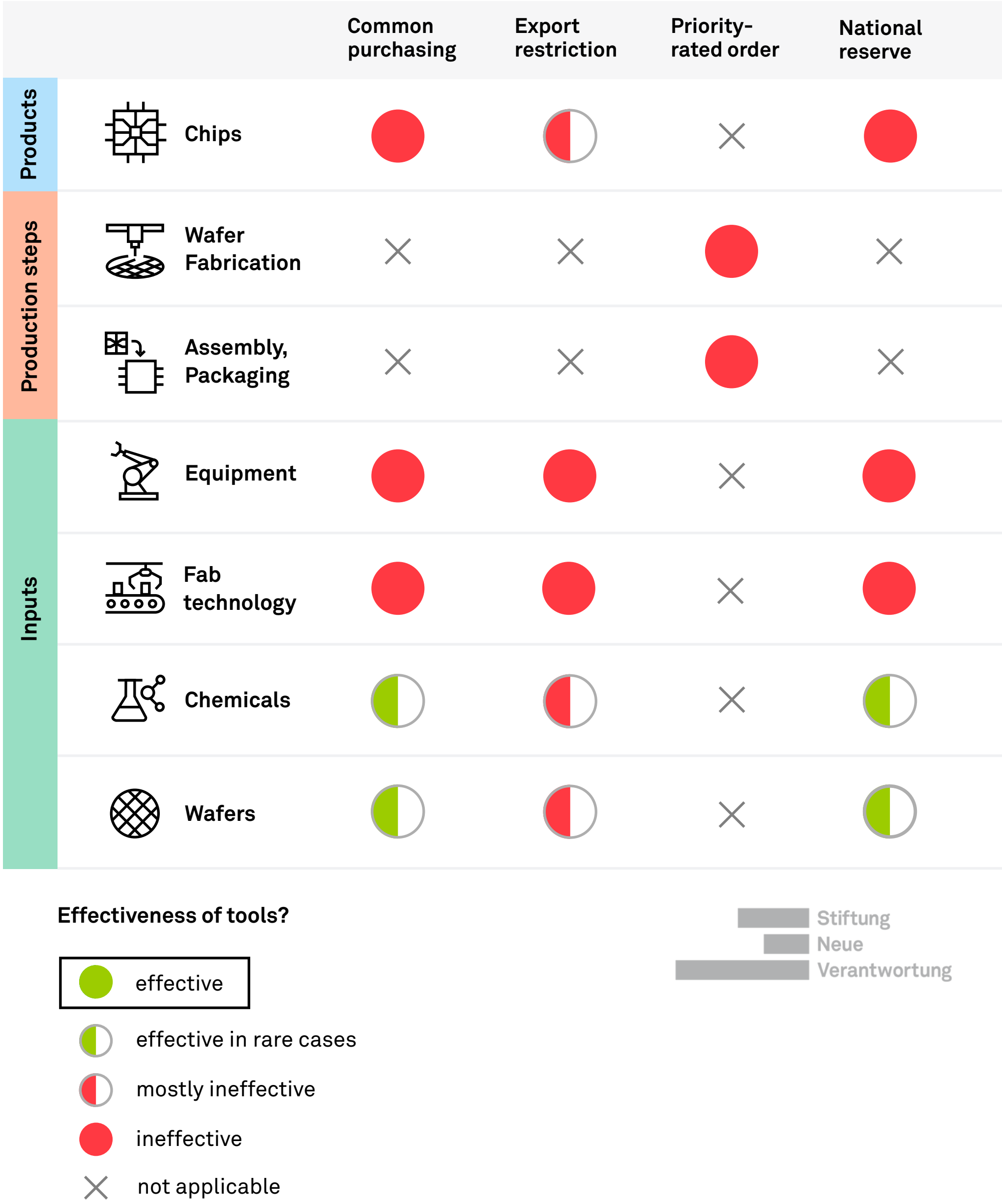
Although not mentioned explicitly in the EU Chips Act, some Member States (such as Spain) plan to establish national reserves for critical supplies, including semiconductors.[9]

2.2 Applying the tools to the value chain

The following is an analysis of the proposed policy tools across products (chips), production steps, and inputs. Importantly, none of the proposed tools can be considered effective (or feasible) for ensuring supply security during a crisis. In the table below, we summarize the analysis and show that, if anything, some of the proposed policy tools might demonstrate, at best, limited effectiveness in certain scenarios for semiconductor chemicals and materials. That said, the bureaucratic efforts and potential for further disrupting the value chain during a crisis are disproportionate to the hypothetical feasibility in edge cases.

vi This includes companies that "have applied to be recognized as '**Integrated Production Facilities' and 'Open EU Foundries',** other semiconductor manufacturing facilities which have accepted such possibility in the context of receiving public support, or undertakings along the semiconductor supply chain which have been subjected to a priority rated order from a third country to the extent this impacts significantly the security of supply to critical sectors" (p. 14). **If they cannot fulfill it even under priority treatment or if acceptance would entail unreasonable economic burden and hardship, the semiconductor manufacturing facility has the right to request the Commission to review the priority-rated order.** See European Commission. 2022. "Proposal for a Regulation of the European Parliament and of the Council. Establishing a framework of measures for strengthening Europe's Semiconductor Ecosystem (Chips Act)," p. 14. COM(2022) 46 Final. https://eur-lex.europa.eu/resource.html?uri=cellar:ca05000a-89d4-11ec-8c40-01aa75ed71a1.0001.02/DOC_1&format=PDF.

Can the proposed toolbox ensure security of supply during a chip crisis?



What you see
The matrix shows the effectiveness of the proposed crisis response tools across the different levels of the value chain: products, production steps, and inputs. **Importantly, there is no box filled with a green circle, as there is no case in which the proposed tools can be considered effective.**

Products: Chips

None of the proposed policy tools is effective when deployed at the level of individual chips, mainly for two reasons. First, many chips are highly specialized and customized for a specific end-product (a car model), sector (medical device manufacturers), or individual company and thus are not interchangeable or substitutable. Second, end-products consist of hundreds to thousands of different chips sourced from all over the world. A modern car relies on roughly one thousand chips that differ significantly not just between different car manufacturers but also between different models from the same manufacturer.

Common purchasing and national reserves: Following the argument that a variety of highly specialized chips is needed for a specific end-product, **common purchasing would be ineffective since companies in a "critical sector" would need to agree on a set of chips that they all rely on.** The same goes for national reserves that would need to anticipate which set of chips will most likely be in short supply in the future. Both are exercises in futility. From a policy-maker perspective, the aforementioned characteristics make chips fundamentally different from other goods, such as vaccines, food, personal protective equipment, or natural resources, and are why **semiconductor shortages cannot be meaningfully addressed with common purchasing or national reserves of chips**.

Export restrictions: The same characteristics also call into **question the effectiveness of export restrictions** on certain types of chips during a crisis. Assuming a European medical device manufacturer is in short supply only of some microcontrollers made within Europe, establishing and enforcing export restrictions on specific microcontrollers to ensure supply security seems like a heavy-handed approach that ignores a much simpler solution—building inventory. In most products, except information and communication technology, the semiconductor content is only a fraction of the total product cost. If a company cannot finish a product because of missing chips worth a small percentage of the entire bill of materials, policy makers should call for better supply chain management and strategic overstock instead of export restrictions.

A lesson learned from the current shortages must be that end-customer industries need to strengthen their supply chain management, including inventory levels, in the long-term.[10] **Common purchasing, national reserves, and restrictions on exports of chips potentially disincentivize end-customer industries to build overstocks.** Therefore, the EU Chips Act is sending the wrong signal to the market.

We do not mention priority-rated orders as the fulfillment of a priority-rated order for a certain type of chip is the responsibility of the respective fab and thus affects the subsequent production steps (semiconductor manufacturing).

Production steps: Semiconductor manufacturing (front- and back-end)

Semiconductor manufacturing can be divided into roughly two steps: wafer fabrication (also known as front-end manufacturing) and assembly, test, and packaging (also known as back-end manufacturing). Only priority-rated orders are applicable to these production steps. During a chip crisis, the EC would force front- and back-end fabs that received subsidies to prioritize chip manufacturing for certain critical sectors, such as the military, medical devices, etc.

Priority-rated orders: Using this tool for front- or back-end fabs will not be able to ensure supply security during a chip crisis, mainly for five reasons:

1. Semiconductor manufacturing takes four to six months, involving more than one thousand process steps. A chip that was ordered in January will not arrive at the customer before June of the same year under perfect conditions. This process cannot be sped up.
2. Semiconductor manufacturing is highly diversified, with very different manufacturing technologies for different types of chips. A process node manufacturing cutting-edge mobile chipsets for smartphones works very differently from a process node manufacturing silicon-carbide power semiconductors to charge an EV battery. Furthermore, chip designs are always based on and tied to a particular fab's process node. For example, an automotive microcontroller designed on TSMC's 28nm node cannot simply be manufactured on GF's 28nm node. Doing so would involve a substantial redesign of the entire chip—a process that quickly takes many quarters.
3. In particular, front-end fabs rely on high utilization rates (>80%) to quickly amortize investment costs. During the more than two years of ongoing chip shortages, there have been several quarters with utilization rates of 95–100%.[11] Thus, a priority-rated order would force fabs to reschedule production plans, resulting in additional delays and potential breaches of contracts with existing customers.
4. Front- and back-end manufacturing is often conducted in separate locations and by different companies. Even if a front-end fab in Europe prioritizes an order by government mandate, if that fab relies on another company for back-end manufacturing, it is unclear whether such a priority-rated order would extend to that third party.

5. The global chip shortages occurred not only because of capacity constraints at front- and back-end fabs but also because of shortages of crucial chemicals and materials, such as substrates. If a front- or back-end fab cannot keep up with demand due to the lack of certain gases, chemicals, or materials, a priority-rated order would be of little help.

In summary, **forcing fabs to prioritize orders for certain critical sectors is not effective** and is not a feasible solution to lessen the impact of chip shortages for those sectors. *We do not mention the other policy tools here (export restrictions, common purchasing, and national reserves), as they are applicable only to physical goods, not the manufacturing process.*

Inputs: Equipment and fab technology

Front-end manufacturing relies on more than 50 different types of increasingly complex manufacturing equipment, and back-end manufacturing relies on more than 10 different types.[12] Additionally, there is a plethora of suppliers for various fab technologies, such as valves and pipes to transport gases, carriers for automated wafer handling, vacuum pumps, and cleanroom technology. Equipment and fab technology suppliers are currently also struggling to fulfill orders because a record number of new fabs will be built in the coming years.[13] If a future chip shortage occurs again due to front- and back-end capacity constraints, and thus is followed by significant capacity expansions (new fabs and fab expansions), some of the proposed policy tools would potentially be applied to equipment and fab technology. Importantly, any of these measures would have only a mid- to long-term effect because it takes around 3 years to build a new fab and around 1.5 years to expand an existing one.[14] Thus, it would help very little in alleviating existing shortages. The following are the reasons why we think this would be neither feasible nor effective.

Export restrictions: **(1) A modern fab relies on equipment from (at least) Europe, the United States, and Japan.** Thus, even if a European fab could secure access to European equipment through export restrictions, the fab would still lack most equipment sourced from the United States, Japan, and other countries. Using export restrictions on manufacturing equipment or fab technology to speed up capacity expansion in the EU would (2) surely be **retaliated against by the United States and Japan.** This added risk of not being able to deliver during times of massive capacity expansions due to potential **export restrictions could (3) hurt the competitiveness of European suppliers** as they would be perceived as less reliable by foreign fabs. As only a handful of fabs (if any) are built in the same year in Europe, and the type of equipment needed depends on the type of process node being built, (4) an **export restriction on a specific type of equipment or fab technology would be for a single fab. Thus, putting into question the proportionality of such a measure**.

Common purchasing and national reserves: Both would also be of no help for securing access to manufacturing equipment and fab technology for similar reasons why these tools do not work on the level of individual chips. It would be next to impossible to anticipate which type of equipment or fab technology would be in short supply in the future. **And since just very few fabs are being built at the same time in Europe, even during massive capacity expansions, common purchasing would make no sense**.

In summary, **export restrictions, common purchasing, and national reserves for manufacturing equipment and fab technology are neither feasible nor effective in lessening the impact of chip shortages**.

We do not mention priority-rated orders as the tool is applicable only to the manufacturing process.

Inputs: Chemicals and Wafers

Semiconductor manufacturing relies on more than 400 different chemicals and materials,[15] including wafers, with purity requirements often in the range of 99.999% and higher[16] or contamination requirements of a few parts per trillion (ppt). For a specific "semiconductor-grade" gas or chemical, there are often only a handful of suppliers worldwide. Importantly, similar to manufacturing equipment and fab technology, fabs rely on a network of chemical suppliers, mainly from (but not limited to) Japan, Europe, and the United States. Furthermore, qualifying a new supplier for a specific chemical or gas can take more than a year, as even minuscule changes to the manufacturing process can negatively impact yield; one thing fabs want to avoid at all costs.[17] Following is our analysis for this supplier market:

Export restrictions: Looking at the proposed Crisis Response Toolbox, using export restrictions on chemicals to ensure a steady supply for European fabs comes with **some of the same challenges as in the case of manufacturing equipment and fab technology**. Even though chemicals and wafers are consumables and export restrictions would potentially ensure security of supply in the short-term, such a measure would surely be retaliated against by our allies, since European fabs also rely on chemicals and wafers from

Japan, the United States and Taiwan, to name just a few. European chemical suppliers could also be considered less reliable by foreign fabs, due to potential European export restrictions during future supply constraints.

Common purchasing and national reserves: Both measures seem to be **potentially the least *in*effective** when applied to chemicals and wafers. Imagine the national reserves for certain bulk or noble gases needed in every fab. They would not necessarily be built and maintained solely by the government but could also be organized through public–private partnerships. However, there are several open questions and challenges on different levels:

- Technology: Are gases and chemicals that can be stored for a long time in national reserves actually those that could be in short supply in a future crisis?
- Industry: Can enough fabs agree on a set of already qualified suppliers for these chemicals and gases?
- Incentives: Would national reserves or common purchasing disincentivize fabs to build their own overstocks and better coordinate within their regional clusters?

In summary, **export restrictions should not be used on chemicals and wafers as it would lead to a zero-sum-game in an interdependent transnational value chain.** Compared to other areas in the semiconductor value chain, **common purchasing and national reserves of chemicals, gases, or wafers could potentially lessen the impact of future shortages under very specific conditions, but many open questions remain**. Nonetheless, the bureaucratic overhead and heavy-handed regulation seem disproportionate to the potential, limited benefits in edge cases.

We do not mention priority-rated orders as the tool is applicable only to the manufacturing process.

2.3 Bottom line: The proposed tools are ineffective

Our analysis shows that none of the proposed crisis response tools can be considered generally effective in ensuring the security of the semiconductor supply.[vii] The main reasons for the ineffectiveness are the characteristics of the semiconductor value chain: highly diversified and customized products, a high degree of specialization in every process step and supplier market, a strong division of labor, transnational lock-in effects, and long manufacturing cycle times. As pointed out in our second paper,[18] there is not one global semiconductor value chain but numerous different value chains that overlap significantly in some parts but also have clear distinctions in others.

Governments should aim to incentivize end-customer industries to restructure their supply chains to make them more resilient. This will be costly for end-customer industries, as they need to invest in strategic overstocks, establish multiple sources, redesign end-products and chips, and fundamentally change their supply chain models. It is unfortunate that pillar 3 of the EU Chips Act currently almost entirely ignores the responsibilities of end-customer industries to avert future chip shortages.

vii If policy makers want to keep the Crisis Response Toolbox in the EU Chips Act, two things need to be addressed: First, it needs to be clear who under which circumstances would qualify to receive government support (in the form of export restrictions, common purchasing, or priority-rated orders) in times of scarcity. Therefore, the EC needs to precisely define the criteria that indicate a crisis and in which case a disruption is understood as "significant". Furthermore, "critical sectors" should be limited to ones that are crucial for maintaining vital societal functions (military, medical devices, and energy) and should not simply encompass all sectors economically important for the European Union. This would be crucial to clearly communicate to allies that these measures are reasonable and proportionate and are deployed as an "ultima ratio" and not mere protectionism. Second, end-customer industry due diligence must be a prerequisite to any government crisis response. With any of the proposed measures, there should be proof that an end-customer struggling with shortages did everything in their power to prevent being in short supply of a critical semiconductor for its end-product. The same applies for fabs if some of their chemicals and gases are in short supply, and the EC is considering common purchasing or national reserves.

3. Why governments should focus on crisis prevention

Based on the ineffectiveness of the proposed tools in pillar 3, it becomes evident that the room for government action in semiconductor crisis management is very limited.

Even for the industry itself, there are very few short-term solutions once a chip crisis occurs: Redesigning a chip to be able to switch foundries can take more than 9 months, qualifying new chemical suppliers may take more than 12 months, adding a new process node to an existing fab (clean room) takes around 18 months, and building a new fab (greenfield) takes more than 3 years.[19] Many companies are just starting the process of (re)designing their chips for resilience and availability.[20]

Although none of these measures are in the hands of governments, they are important to keep in mind when designing long-term regulations to strengthen the resilience of the semiconductor value chain, as well as incentivizing and pushing the industry to follow the same path. To accomplish this, the regulatory focus needs to shift from crisis management to long-term crisis prevention. This should be done in four areas in parallel: increasing (1) transparency and (2) better long-term supply chain management through standards and regulation with the semiconductor industry and end-customer industries, establishing (3) long-term mapping to better understand the value chain itself, and (4) strengthening international partnerships.

3.1 Transparency: Hold the semiconductor industry accountable

There is a lot the semiconductor industry can do to increase the transparency of its value chain. Mechanisms such as Product Change Notifications (PCNs) to inform customers of changes in their supply chain are not reliable,[21] and better communication between the semiconductor industry and end-customer industries is needed.

As the first step, governments can create fora to address the lack of transparency by bringing together policy, industry, and end-customer perspectives. It is unfortunate that at the time of writing, the EU Alliance on Processors and Semiconductor Technologies[22] still has not been established. Together with existing industry alliances, such a forum could co-develop standardized frameworks and best practices for supply chain transparency. These transparency initiatives should also be part of the EU's engagement with international partners, as in the EU-US Trade and Technology Council (TTC). The issue was addressed in the TTC Joint Statement in May 2022 stating that both governments would "promote private sector efforts to increase transparency in the semiconductors value chain and in demand to anticipate shortages."[23]

For more background on the challenges of monitoring the semiconductor value chain and how to increase transparency, we highly recommend reading the first paper of this series.

3.2 Supply chain management: Hold end-customer industries accountable

In light of the EU Chips Act, policy makers started engaging with the semiconductor industry to better understand their needs and the ecosystem, as well as to discuss responsibilities.

However, the act says little about the responsibilities of end-customer industries. Better supply chain management by end-customer industries is key to mitigating future chip shortages: the current chip shortages were partially due to poor purchasing decisions and supply chain management dominated by just-in-time deliveries.[24] Moving end-customer industries away from just-in-time supply chain models and purely cost-driven sourcing decisions cannot be done within a few years. It requires constant attention and engagement from policymakers across different industries.

The first step for governments is to engage more with end-customer-industries to get a better idea of whether they are improving their current supply chain models to better cope with future disruptions. This can be done via existing contacts in verticals, such as automotive or health. This exchange is important for governments to better understand potential risks to the security of the semiconductor supply. If end-customers do not adapt their business and supply chain models (in the mid- to long term) to increase resilience, governments should consider supply chain resilience regulation.

3.3 Long-term value chain mapping: Capacity building within the government

The global semiconductor value chain, including critical suppliers, technology trends, market dynamics, chokepoints, and interdependencies, is still poorly understood by many governments. At the same time, this value chain's importance will only increase due to the ongoing digitalization of industry and society. Increasing geopolitical tensions and natural disasters as a result of climate change and global warming also make it more likely that the semiconductor value chain will continue to be disrupted in the future. Thus, governments would do well to invest in their own resources to map the global semiconductor ecosystem in the long run and identify and assess interdependencies and chokepoints to develop meaningful long-term industrial, trade, and foreign policy measures.

For more background on how such a government value chain mapping could be established, we highly recommend reading the *second paper* of this series.

3.4 Strategic partnerships: Key to long-term supply chain resilience

The semiconductor value chain's high efficiency and innovation[25] are rooted in a complex transnational network based on a high degree of division of labor. In reverse, this means that strong interdependencies will continue to exist, regardless of the increased tendency to invest heavily in strengthening regional ecosystems. Therefore, addressing the resilience of the semiconductor value chain in the long term can be successful only if there is international collaboration. Based on mapping dependencies, as well as the strengths and weaknesses of a regional ecosystem, governments need to invest in long-term strategic partnerships with trusted allies.

Embedded in a long-term strategy for strengthening the EU ecosystem and in line with the concept of Open Strategic Autonomy,[26] the EC and Member States need to identify potential areas for collaboration to manage dependencies in a self-determined manner. This high relevance of strategic partnerships also becomes visible when looking at European semiconductor companies' and suppliers' significant investments in Asian countries, such as Malaysia, Singapore, South Korea, and Taiwan.

4. Conclusion

In recent years, the concatenation of large and small disruptions in various value chains amid rising geopolitical tensions and a global pandemic has forced many governments to enter crisis mode. Understandably, new legislation and regulations in different (technology) fields are characterized by protective and reactive actions, such as reshoring and re-nationalization, to secure the supply of critical products.

In the papers, we have shown that defining a new role for governments is a complex task that can be successful only when the distinct characteristics and dynamics of the technology ecosystem are considered. Pillar 3 of the EU Chips Act fails to do so. This is reflected in the EC's envisioned role as a key coordinator in times of crisis, putting in place new policy tools, such as priority-rated orders and common purchasing. In our three-part paper series, we have tried to deconstruct these envisioned roles and explain why governments have very limited room for action regarding semiconductor shortages.

In the first paper, we depicted the challenges governments will face when they want to monitor the supply chain with the goal of anticipating shortages. We argue that making sense of highly granular industry data should be the responsibility of the industry. Governments cannot assess what a certain disruption means for a particular product; they cannot adjust inventory levels, search for substitutes, or shift production. Consequently, governments are naturally always one step farther away from the value chain than semiconductor companies and end-customer industries.

In the second paper, we explain why governments should invest in their own understanding of this value chain. This mapping exercise takes time, commitment, and sufficient resources within the government. Such mapping would shift the focus from crisis response to long-term strategies that strengthen the resilience of the semiconductor value chain. The goal would be for dedicated units within the EC to assess strategic dependencies and capacities on an ongoing basis. (Geo)political contextualization would be done by units working on investment screening, export restrictions, sanctions, etc.

In this paper, we show that the government's role in the semiconductor value chain is very limited when it comes to crisis management during a chip shortage. The documented lack of effectiveness of the proposed instruments in pillar 3 raises the question of whether governments should continue to focus on crisis mitigation, as this will not secure the chip supply.

We argue that policy makers should focus on long-term strategies for crisis prevention. This goes hand in hand with a clear separation of responsibilities between governments, the semiconductor industry, and the end-user industries. Importantly, the latter are currently left out of policy discussions about how best to ensure the security of the chip supply in the future, although the actions and dominant supply chain models of end-customer industries contributed directly to the current shortages and supply chain disruptions.

Bringing together the results from the three papers analyzing the third pillar of the EU Chips Act, we make the following recommendations for the role of governments in the semiconductor value chain:

- **Address transparency with industry and end-customers** (new fora, international and industrial cooperation, best practices, and standards)
- **Hold the semiconductor industry and end-customer industries accountable for supply chain management and monitoring** (through potential regulation in the long term)
- **Invest in resources within the EC and governments to continuously map the global semiconductor value chain to develop an in-depth understanding of the interdependences and chokepoints** (this will be key to inform industrial, trade, national security, and foreign policy decisions)
- **Initiate and strengthen international partnerships with like-minded allies** (manage dependencies and address the resilience of the whole value chain through collaboration)

5. SNV's previous publications on the semiconductor value chain

Governments' role in the global semiconductor value chain #2 – Recommendation for the EU Chips Act: a long-term governmental mapping
Julia Hess and Jan-Peter Kleinhans, July 2022

→ We explain why governments should invest in their own understanding of the semiconductor value chain. Such a long-term governmental mapping would be the basis to assess strategic dependencies and capacities and to inform units working on investment screening, export restrictions, sanctions, etc.

Governments' role in the global semiconductor value chain #1 – Analysis of the EU Chips Act: Challenges of government monitoring of the supply chain
Jan-Peter Kleinhans, Julia Hess and Wiebke Denkena June 2022

→ We analyze the shortcomings of the European Commission's proposed semiconductor supply chain monitoring. We argue that a highly granular supply chain monitoring to foresee and alleviate short-term disruptions and shortages cannot be meaningfully done by governments.

China's rise in semiconductors and Europe: Recommendations for policymakers
Jan-Peter Kleinhans and John Lee, December 2021

→ We assess Europe's dependency on Chinese companies at certain stages of the value chain from the national security, technological competitiveness, and supply chain resilience perspectives. We argue that the EU's future semiconductor strategy should include three focus areas: chip design, back-end manufacturing, and supply chain resilience through constant mapping of interdependencies. This is a joint publication with the Mercator Institute for China Studies (MERICS).

Understanding the global chip shortages: Why and how the semiconductor value chain was disrupted
Jan-Peter Kleinhans and Julia Hess, November 2021

→ In this paper, we explain exactly what disrupted the global chip value chain and why it is not a single shortage but multiple shortages happening concurrently at different steps for different reasons.

[Mapping China's semiconductor ecosystem in global context: Strategic dimensions and conclusions]

John Lee and Jan-Peter Kleinhans, June 2021

→ Our report analyzes the competitiveness of China's chips industry across all production steps and supplier markets. We draw conclusions across three strategic dimensions: industry competitiveness, national security, and resilience. This is a joint publication with the Mercator Institute for China Studies (MERICS).

[Who is developing the chips of the future?]

Jan-Peter Kleinhans, Pegah Maham, Julia Hess, and Anna Semenova, June 2021

→ Our third paper dives into the national "R&D power" to better understand who is developing the chips of the future through a quantitative analysis of three of the leading global semiconductor conferences since 1995 (IEDM, ISSCC, and VLSI).

[The lack of semiconductor manufacturing in Europe: Why the 2nm fab is a bad investment]

Jan-Peter Kleinhans, April 2021

→ Our second paper explains why there is little business case for a 2nm fab in Europe, which, in turn, means that there is a real risk of wasting billions of Euros in public and private money.

[The Global Semiconductor Value Chain: A Technology Primer for Policymakers]

Jan-Peter Kleinhans and Dr. Nurzat Baisakova, October 2020

→ Our first publication on semiconductors provides an overview of the global semiconductor value chain, its interdependencies, market concentrations, and chokepoints. The process steps, their characteristics, and the major players are depicted to understand why this value chain is highly innovative and transnational but at the same time very fragile and thus, not resilient.

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