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RESEARCH NETWORK SUSTAINABLE GLOBAL SUPPLY CHAINS

Resilience in Sustainable Global Supply Chains: Evidence and Policy Recommendations

A study for the Research Network Sustainable Global Supply Chains

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Executive Summary

The COVID-19 pandemic-induced lockdowns and export restrictions highlighted the vulnerability of global trade and global value chains (GVCs). What is more, many commentators argue that the likelihood of exogenous shocks that threaten international trade and GVCs, such as natural disasters, pandemics, or political conflicts will increase in the future. In light of the new global context and due to the experiences during the COVID-19 pandemic, it is increasingly acknowledged in the scientific community and among policy-makers that the resilience of critical and vulnerable GVCs needs to be strengthened in order to guarantee security of supply. However, a major shortcoming of the current debate on how to improve GVC resilience is that it is not linked to the issue of environmental sustainability.

This report aims at addressing this link between GVC resilience and sustainability, both at the conceptual and the policy level. To this end, the report (a) provides a systematic overview of the literature, highlighting the trade-offs and compatibilities between GVC resilience, sustainability and efficiency; (b) assesses selected policy initiatives on GVC resilience and sustainability, including the US Executive Order 14017 on America's Supply Chains; (c) presents a case study on the medical products sector in order to provide a better understanding of the strategic aspects of resilience and sustainability in supply chain management in the context of the recently witnessed GVC disruptions; and (d) develops policy recommendations.

This report argues that since the emergence of GVCs, firms have primarily focused on GVC efficiency and largely disregarded GVC resilience and sustainability. In general, GVC efficiency, resilience and sustainability have important trade-offs as well as compatibilities that policy-makers need to take into consideration. In many GVCs, increasing GVC resilience and sustainability requires policy interventions since the desired societal level of GVC efficiency, sustainability, and resilience differs from firms' perspectives, particularly because increasing GVC resilience and sustainability can be very costly and challenging for firms.

To operationalize a stronger focus on resilience and sustainability, albeit to some extent at the cost of efficiency, this report introduces the concepts of resilient sustainability and sustainable resilience. Resilient sustainability prioritizes sustainability over resilience, and is thus characterized by low carbon-emissions of trade and (as a tendency) shorter supply chains, high levels of circularity and environmental standards, which is why this model tends to be more regionalized or localized. To account for resilience, these regional value chains (RVCs), in addition, are characterized by a certain degree of redundancies and possibly diversification in order to withstand shocks. Sustainable resilience, in contrast, prioritizes resilience over sustainability and focuses on increasing the resilience of (global) value chains in the most sustainable way. This is usually achieved by diversification of sourcing, both regionally and with respect to the number of suppliers, increasing redundancies as well as stockpiling, while at the same time promoting higher levels of resource and energy efficiency in the supply chain.

The policy goals of efficiency, resilience and sustainability and their associated GVC models, however, do not necessarily entail a classical trilemma situation, since one can, for example, opt for highly efficient and sustainable RVCs, or increase the resilience of today's efficient GVCs in a sustainable way (e.g., by sourcing from more sustainable production units in the context of diversification processes). The efficiency, resilience and sustainability of GVCs thus can be realigned to some extent, with economic policy and firms facing the task to optimize the most promising combinations between the three objectives.

The question of which GVC model should be pursued also depends on sector specifics. Against the current situation of highly globalized value chains in manufacturing industries and the expected high efficiency losses of regionalization strategies, the concept of sustainable resilience is arguably the most appropriate GVC model in many cases, if one wants to improve both resilience and sustainability. In this case, policy-makers may want to promote the sustainability and resilience of GVCs by focusing on reducing the environmental footprint and increase social sustainability standards as well as supply chain diversification and redundancies. In contrast, in already more regionalized production systems and selected strategic sectors, such as for instance in agriculture, resilient sustainability might be the preferable option.

The analysis of prevailing policies revealed that most of the policies assessed in this study do not link GVC resilience and sustainability in a comprehensive and systematic way. Instead, policies generally focus either on GVC resilience or on GVC sustainability. The most important exception is the US supply chain strategy under Executive Order 14017, which integrates elements of resilience as well as social and environmental sustainability. In contrast to most efforts in the EU, the strategy has a strong focus on promoting domestic manufacturing and reshoring for strategically important and critical products (e.g., batteries, APIs, semiconductors, various minerals). The definition of strategically important products is based on various factors, but also reflects sustainability concerns (e.g., the promotion of batteries production and the transformation towards electric vehicles).

The EU's open strategic autonomy concept increasingly incorporates aspects of GVC resilience. But, so far, extensive measures to promote GVC resilience (in terms of diversification and redundancies) on the EU level are missing. Instead, the EC's focus is on creating opportunities for diversification through trade policy. Extensive measures to promote GVC resilience and security of supply, including through reshoring, are being discussed only in the case of some sector-specific strategies such as the pharmaceutical and chemical strategies. With the notable exception of strategic stockpiling, it remains thus unclear how the EU aims to promote GVC diversification and redundancy.

The various supply chain and due diligence laws, in contrast, are arguably the most important initiatives to promote GVC sustainability. Even though the specifics and thus the effectiveness of many of these policies remain to be seen, preliminary lessons drawn from those sustainability initiatives already in place, such as the French Loi de Vigilance or the EU Conflict Minerals Regulation, highlights that the scope of the respective regulation, as well as liability issues and sanction mechanisms are particularly challenging in designing such policies. In many cases, the effectiveness of policies is curtailed by their limited scope and low liability obligations for firms.

The analysis of the medical products GVC has highlighted the large diversity of product-specific supply chain structures and bottlenecks, the latter being primarily related to sin-

gle sourcing and regional clusters. Overall, security of supply is an issue of particular relevance in the case of PPE. The main reasons for supply chain disruptions during the COVID-19 pandemic were related to a strong increase in global demand, production stops during lockdowns, and export restrictions as well as other COVID-19-induced global or regional trade barriers. In addition, we have argued that many medical product GVCs suffer from a large variety of social and environmental sustainability issues, including the high environmental impact of mostly single-use PPE in general and the poor working conditions in the medical gloves industry in particular.

The analysis of firms' resilience and sustainability strategies revealed that many firms in the medical products sector – so far – are not implementing a comprehensive resilience strategy to upgrade their supply chains. The main reason for this is that the costs of managing stocks and of introducing multiple sourcing strategies can be very high due to complex buyer-supplier relationships (in particular in the case of medical devices) in light of stringent EU regulations and buyer-requirements, lengthy and complex product accreditation processes for medical products, and often years of experience in working together.

Another major limiting factor is that buyers of medical products – including public institutions as the most important buyers – rarely pay a premium for security of supply and sustainability, which is why firms continue to focus on efficiency. This is also related to the rising problems of EU meltblown and facemask producers that increasingly struggle to withstand global competition, in particular from China.

Based on our analysis, we have developed the following set of policy recommendations:

1. Policy-makers need to promote sustainable resilience and resilient sustainability in selected GVCs. The trade-offs and compatibilities between GVC efficiency, resilience and sustainability need to be assessed on a sector-by-sector and product-by-product basis.
2. Policy-makers need to select a sector- and product-specific policy-mix.
3. Policy-makers need to take account of GVC-specific governance structures and (lead) firms' strategies.
4. Given the costs and challenges of GVC diversification, policy-makers need to incentivize and support sustainable diversification processes in selected sectors.
5. Besides GVC diversification, production-related measures including re- and near-shoring of selected critical products are both necessary and viable.
6. Extend the scope of supply chain and due diligence laws towards GVC resilience.
7. Public procurement should be used to promote both sustainability and resilience.
8. Ensure policy coherence for development.
9. Establish coordination as well as monitoring and evaluation mechanisms.

1. Introduction

The COVID-19 pandemic and its disrupting effects on international trade (e.g., Kejžar et al. 2021) intensified debates on the structure of global value chains (GVCs), which reflects decades of focus on the efficiency and not the resilience of GVCs (cf. Bogaschewsky 2020; Gölgeci et al. 2020).1 A major drawback of the current discussion on GVC resilience, however, is that it is not sufficiently linked to the debate on how to increase the sustainability of post-COVID-19 GVCs.

The question of GVC resilience was already discussed in the wake of the Asian financial crisis in the late 1990s and the 2007/08 global financial and economic crisis. While some viewed these crises as harbingers of the end of economic globalization, GVCs bounced back more quickly than expected after the Asian financial crisis and have also proven resilient during the global financial and economic crisis (Cattaneo et al. 2010). More than ten years later, however, the global context of the debate on GVC resilience has shifted significantly. This is because the perceived likelihood of exogenous shocks that threaten international trade and GVCs, such as natural disasters, pandemics, or political conflicts increased (MGI 2020; Raza et al. 2021a). The intensified geopolitical conflicts, and in particular the systemic rivalry between China and the US, to some extent question the current international division of labor and reignited the rivalry over global technology leadership. In the EU, this furthered a new debate on how to promote (open) strategic autonomy and technological sovereignty (EC 2020b, 2021a). The intensifying climate crisis, in addition, increases the likelihood of shocks related to natural disasters, but will arguably have repercussions also for the policy and institutional framework in which GVCs operate.

The COVID-19 pandemic induced lockdowns and export restrictions once again highlighted the vulnerability of global trade and GVCs, although industrial production and trade recovered even more swiftly compared to the 2007/08 crisis (EC 2021b; Felbermayr 2021). This is because the COVID-19 crisis clearly has had severe consequences on the economic system, but – unlike the global financial and economic crisis – it does not reflect failing market mechanisms per se (ibid.). But despite the quick recovery of global trade and GVCs, security of supply concerns for critical products2 have not vanished. This is so because most countries in the European Union (EU) and elsewhere faced shortages of various critical medical products in early 2020, with negative effects on patients and health care workers (e.g., Ranney et al. 2020; Truog et al. 2020).

In light of the new global context and due to the experiences during the COVID-19 pandemic, it is increasingly acknowledged in the scientific community and among policy-makers that the resilience of critical and vulnerable GVCs needs to be strengthened in order to

[1] In this document, GVC resilience is generally understood as "*the adaptive capability of supply chains to prepare for unexpected events, respond to disruptions and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function*" (Ponomarov and Holcomb 2009: 131).

[2] There is no general definition of "critical products", but often includes essential medicines, or specific medical products such as personal protective equipment.

guarantee supply security (EC 2021b; Javorcik 2020; MGI 2020; The White House 2021). Given the strong recovery of global trade and GVCs following the early shocks of the COVID-19 pandemic, many economists have argued that the security of supply is achieved best through ensuring the resilience of GVCs through flexibility, diversification and redundancies (e.g., increase inventories and the number of supplying firms and regions, etc.), without changing the global orientation of GVCs due to potential efficiency losses (Baldwin/Evenett 2020; Felbermayr 2021; Gereffi 2020). In order to ensure the well-functioning of GVCs during global crisis, they argue in favor of multilateral agreements and global cooperation during global crisis.

However, it remains unclear in how far increasing the resilience of GVCs should or will be a market-driven or state-driven process. Even though it is likely that multinational firms will aim to reduce exposure to shocks (cf. MGI 2020), for instance, through diversifying supplier networks, strengthening logistic systems and infrastructure, and improve their capacity to respond and recover, the scale and scope of these measures may be insufficient – from a societal perspective – given their high costs. In addition, many commentators and policy-makers highlight the political-economic challenge that increasing the resilience of GVCs may not suffice to establish security of supply during a global crisis that leads to large-scale global trade disturbances, in particular in the case of critical products (Raza et al. 2021a). This is because during crises, nationalism often prevails, leading to export restrictions and disputes on the global allocation of scarce products. For this reason, the creation of local or regional production capacities for critical products through policies that promote on-, re-, and nearshoring (i.e. building up local production capacities, or bringing previously outsourced production back or near to the 'home' country) are increasingly debated.

A major shortcoming of the current literature on GVC resilience and reshoring, however, is their strong emphasis on the trade-off between efficiency and resilience (cf. Gölgeci et al. 2020), without sufficiently focusing on the question on how to promote resilient, efficient and sustainable post-COVID-19 GVCs. The lack of sustainability considerations in the current debates is surprising, given the various initiatives to promote the sustainability of the global production and trade system in the last decade. In the EU, for example, the European Green Deal calls for more sustainable GVCs and a 'circular economy' (EC 2019b) and new due diligence laws on national and EU levels are increasingly debated and implemented. In addition, it is also increasingly questioned whether an increasing regionalization of production and a shortening of GVCs is necessary to reduce the negative environmental impact of global trade (cf. UNCTAD 2020).

This study aims to address this gap by linking the literature on GVC resilience and sustainability. In Section 2, we provide a systematic overview of the literature on GVC resilience and sustainability, highlighting the conceptual, economic and political contradictions and compatibilities of these concepts. Section 3 discusses selected policy initiatives and strategies on GVC resilience and sustainability. Section 4 presents a case study on the medical products sector in order to provide a better understanding of the strategic aspects of resilience and sustainability in supply chain management in the context of the recently witnessed GVC disruptions. The medical product sector and GVC is particularly relevant in this context, since countries in the EU and elsewhere faced shortages of various critical medical products, in particular personal protective equipment (PPE), in early 2020, with negative effects on patients and health care workers (e.g., Ranney et al. 2020; Truog et al. 2020). For this reason, PPE are often considered as critical products. PPE, in addition, is a major concern from an environmental and social sustainability perspective, since many of

these products (e.g., facemasks, medical gloves, etc.) are single use and produce large amounts of non-recycled waste. The compliance with labor standards, in addition, is also often a major challenge in these GVCs. Section 5 concludes and presents policy recommendations.

2. Conceptualizing GVC Resilience and Sustainability

This section links the resilience literature, with its strong emphasis on the trade-off between resilience and efficiency, and the sustainability literature in order to develop a common understanding and conceptualization and to highlight contradictions and compatibilities between these concepts and related policies (Figure 1). Our framework highlights that the GVC efficiency, resilience and sustainability triangle is characterized by important trade-offs, but that it should not be thought of as a classical trilemma, given the potential for compatibilities. The framework presented in this section is also the basis for the analysis of initiatives targeting GVC resilience and/or sustainability in section 3.

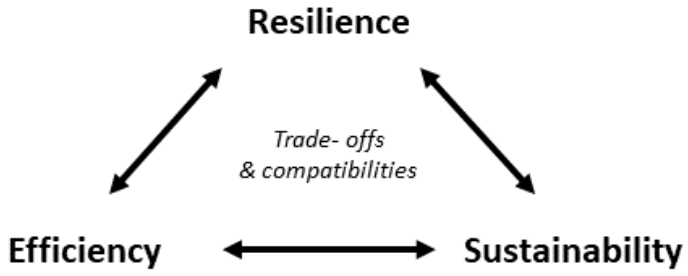

Figure 1: Linking the discourses. Own elaboration.

2.1 GVC resilience

There are a large number of different scientific fields conceptualizing resilience in different ways (IRGC 2018), including broader societal (OECD 2019) and more narrow supply chain perspectives. The supply chain literature has a strong focus on firms and typically differentiates, among others, between lean, resilient, agile and green supply chain management strategies (Carvalho et al. 2011; Govindan et al. 2015). In this context, Ponomarov and Holcomb (2009) define resilience "as the adaptive capability of supply chains to prepare for unexpected events, respond to disruptions and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function". Some authors more closely linked to the risk management literature, in addition, contrast the concept of resilience with that of robustness. While resilience is defined as the ability to return to normal operations over an acceptable period of

time post-disruption, robustness is the ability to maintain operations throughout a crisis (Brandon-Jones et al. 2014; Christopher/Peck 2004; Miroudot 2020; Sheffi 2005). From a company perspective, a risk management approach based on resilience may differ from one based on robustness. For example, when applying a resilience approach, a company might be willing to accept an interruption of operations during a crisis and instead focus on re-establishing operations quickly post-disruption. In this context, companies might prefer to pursue a single-sourcing strategy, as the long-term working relationship with one supplier will facilitate adherence by the supplier to risk management standards. In the case of vertically integrated production, companies might focus on developing plans and procedures for the swift re-establishment of operations post-disruption, while using buffer stocks to maintain supply during the disruption itself. A robustness approach, on the other hand, might instead lead companies to prefer multi-sourcing strategies to single-sourcing strategies, making it possible to switch between suppliers in the event of a crisis, and/or to establish multiple production sites in order to secure production redundancies. Robustness strategies, however, involve substantial costs, as working relations with multiple suppliers have to be established, quality issues settled, adherence to standards and lead times monitored, cost mark-ups for sourced inputs due to smaller orders accepted, and so on. Thus in many cases, companies might prefer resilience approaches in their supply chains. Although some strategies are common both to resilience and robustness, the fundamental difference is that resilient firms tend to reduce their risks while not investing significantly in anticipating and avoiding all forms of disruption. Such firms prefer to weather the disruptions and focus on minimizing their impacts (Miroudot 2020).

The OECD (2019) goes beyond the firm perspective and defines resilience as "the ability of households, communities and nations to absorb and recover from shocks, whilst positively adapting and transforming their structures and means for living in the face of long-term stresses, change and uncertainty. Resilience is about addressing the root causes of crises while strengthening the capacities and resources of a system in order to cope with risks, stresses and shocks." Based on systems thinking, the OECD's New Approaches to Economic Challenges (NAEC) group argues that efficiency and resilience are in a state of tension, and given the complex interrelations between sub-systems, policies must be geared towards creating absorptive buffers, capacity reserves and redundancies in order to prevent an initial, small-scale crisis from cascading and multiplying throughout the entire system and thus leading to a more serious crisis. This is particularly topical for systemic threats, such as pandemics or climate change, which are characterized by their capacity to percolate across complex interconnected systems – either through an abrupt shock or through gradual stress (IRGC 2018).

Systemic threats are particularly difficult to model and calculate via a risk-based approach. Systemic risk events are difficult to predict, and the disruption caused by such events tends to be indirect as a result of nested interaction effects. The global financial crisis of 2007/2008, for example, began as a collection of relatively contained failures at the hands of a limited number of financial firms but ended in substantial financial collapse across much of the world (OECD 2019: 6). In this context, traditional risk management is not enough, given its focus on crisis prevention and risk mitigation. It is, instead, critical to accept the inherently uncertain, unpredictable, and even random nature of systemic threats and to address them through building system resilience (OECD 2019).
Much of the literature generated on GVC resilience in the wake of the COVID-19 pandemic focused on the trade-off between resilience and efficiency (Gölgeci et al. 2020), underlining the need for flexibility, diversification and redundancies with regard to the number of suppliers and supplying regions, the creation of emergency/excess capacities, the size of

inventories, and more. However, this body of literature says little about how measures to increase resilience are interrelated with the sustainability of GVCs. The contradictions and compatibilities between resilience and sustainability thus remain undiscussed, and options for firms and policy-makers to combine these two goals under-explored.

2.2 GVC sustainability

Following the UN's 2030 Agenda for Sustainable Development, sustainability in the context of GVCs can be understood as the long-term viability of structures and processes, encompassing an economic, social and environmental dimension (cf. Blumenschein et al. 2017). Sustainable GVCs enhance people's material well-being and promote equality; respect and promote human rights of all actors involved in the chain, but in particular those of workers and communities affected by business operations; and contribute to the preservation of biodiversity and the mitigation of climate-change by minimizing their environmental impact. Sustainable GVCs thus contribute to the achievement of the 2030 Agenda's Sustainable Development Goals (SDGs) and the commitments made under the Paris Agreement.

The role of sustainability issues in the GVC and supply chain management literature was only integrated gradually during the last two decades. The early years of global commodity and GVC research that emerged since the late 1980s and 90s was primarily focused on the activities, development and interrelationship of firms in an increasingly globalized and dispersed production system, which is why the concepts of GVC governance and economic upgrading received the most attention (Bair 2005). GVC governance focuses on the power relations between companies within a chain (Gereffi 2005, 1995, 1994), while economic upgrading describes processes through which economic actors move from low value to relatively high-value activities in GVCs (Gereffi 2005; Gereffi et al. 2001; Humphrey/Schmitz 2002). Based on these concepts, GVC research improved our understanding of GVC dynamics, power relations within GVCs, and the developmental effects of globalization and GVC integration (Bair 2005; Gereffi et al. 2001), however, it did so primarily from an economic perspective with a particular focus on firms and regions/states as the primary actors in a globalized economy. In contrast, the role of and effects of GVC integration on other actors, such as workers, women and others, was largely neglected (Bair 2005).

Eventually, GVC research evolved and increasingly broadened its perspective and conceptual framework to include other actors. In the dominant GVC discourse, the concept of social upgrading was formulated as an essential complement to economic upgrading (Barrientos et al. 2011). While a firm-centered perspective considers workers only as a factor of production, the social upgrading approach integrates workers as productive and social actors into GVC analysis. It acknowledges that economic upgrading processes trigger changes in the labor processes and thereby may cause changes in demand for new, improved, or different skill sets of workers. Thus, GVC integration in the Global South can strengthen the workers' position, but – and depending on respective business practices – it must not necessarily be linked to an improvement of working and living conditions (social upgrading). Instead, GVC integration or economic upgrading may also be linked to a worsening of working and living conditions (social downgrading) (ibid.). Hence, economic and social upgrading are not connected in a one-dimensional way, but are mutually and ambiguously dependent on each other. The concept of social upgrading thus focuses on workers' rights and the quality of their working and living conditions as well as assesses changes within GVCs and on the firm level against this background.

Similarly to the social sustainability aspect of GVCs, ecological aspects and environmental sustainability concerns also have been largely absent in early GVC research. Only in the last decade, the role of the environment was increasingly considered in the GVC literature. De Marchi et al. (2019) attribute this to the increasing pressure of civil society on lead firms to reduce negative environmental impacts along their supply chains, stronger environmental consumer awareness, and more stringent public sanitary and phytosanitary standards. Within GVC research, questions related to the environment are mainly analyzed through the lens of environmental upgrading. Environmental upgrading is understood as a process by which economic actors move towards a production network that avoids or reduces environmental damage (De Marchi et al. 2013). Again, environmental upgrading is not necessarily linked to economic and/or social up- or downgrading. Environmental upgrading may cause higher costs for firms and weaken their price competitiveness. On the other side, it can also lead to advantages for firms, for example with regard to product placement and marketing.

A major characteristic of environmental upgrading is that it focuses on improving sustainability within GVCs, focusing on actions of individual firms, despite the structural and systemic nature of sustainability challenges. De Marchi et al. (2019) thus argue that environmental upgrading as such is not sufficient to address global challenges such as climate change, even though some authors have broadened the perspective and also emphasize the different scales of environmental impacts (Bolwig et al. 2010), and the role of other actors such as consumers and civil society organizations (Bush et al. 2015).

The increasing importance of environmental sustainability is also reflected in the firm-centered supply chain management literature, which has also increasingly focused on green supply chain management strategies since the mid-2000s, because many firms aimed to increase corporate profits and market shares through ecological efficiency and environmental risk reduction (Govindan et al. 2015; Rao/Holt 2005; Zhu et al. 2008). However, despite these advances, the links between lean, green and resilient supply chain management approaches continued to be relatively weak (Govindan et al. 2015).

In the last decade, the key concept that emerged in the debate on how to improve environmental sustainability in the economy and GVCs is circularity (Geissdoerfer et al. 2020). The concept of a circular economy, which developed based on the idea of closed-loop systems (Boulding 1966; Stahel/Reday-Mulvey 1977), and was particularly influenced by the framing of Pearce and Turner (Pearce/Turner 1990), was popularized by reports of the Ellen MacArthur Foundation that were published in cooperation with McKinsey (EMF 2015, 2014, 2012). Based on a review of a large variety of definitions, Geissdoerfer et al. (2020: 3) define a circular economy (Figure 2) as as an "economic system in which resource input and waste, emission, and energy leakages are minimised by cycling, extending, intensifying, and dematerialising material and energy loops. This can be achieved through digitalisation, servitisation, sharing solutions, long-lasting product design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling."

From a sustainability perspective, the goal is thus to transform linear and wasteful production models into circular ones. However, the main challenge for firms is that transforming linear production models is costly, risky and potentially uncompetitive/unprofitable, which is why the promotion of circularity often requires policy-support. In the EU, the circularity concept has been taken up by the European Green Deal (EGD) and the Circular Economy Action Plan (CEAP).

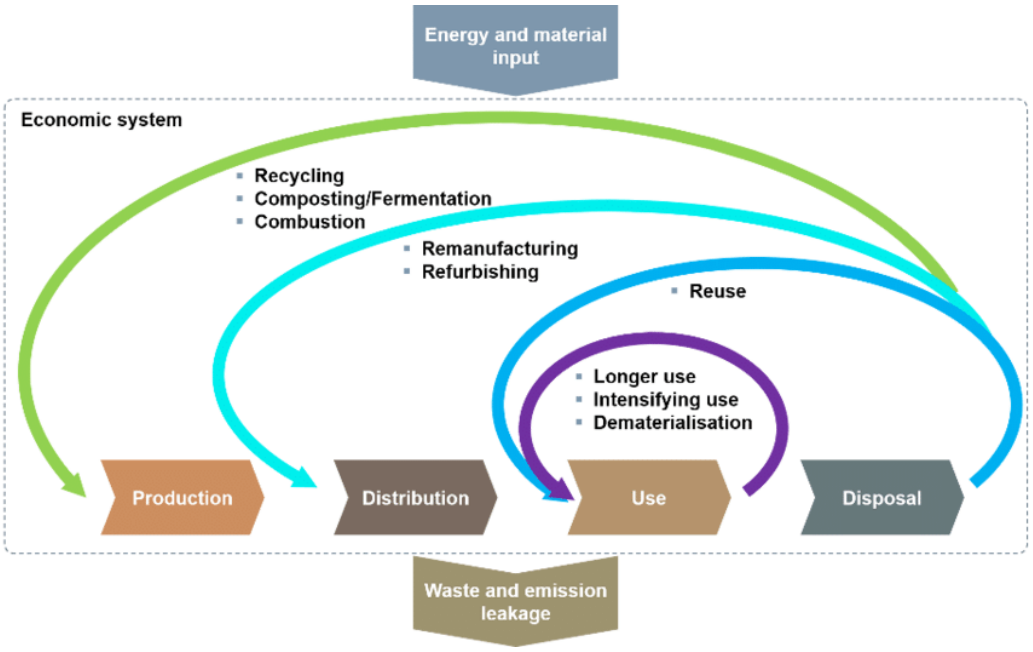

Figure 2: The circular economy. Geissdoerfer et al. (2020: 4).

2.3 Trade-offs and compatibilities

Supply chain strategies and policies can emphasize efficiency, resilience and sustainability to different degrees, and even though these concepts are to some extent conflicting and involve trade-offs, they have also elements of complementarity. Much of the debate that evolved during the COVID-19 crisis, however, focused on the perceived contradictions between efficiency and resilience (Gölgeci et al. 2020). In a Wall Street Journal commentary, for example, Galston (2020) argues that firms have focused too much on efficiency during the last decades. The latter was achieved through the optimal adaptation to the existing environment, undermining resilience, which requires the capacity to adapt to shocks and changes in the environment. Within this understanding, optimal adaptation to the existing environment is understood to undermine the capacity to adapt to disruptive changes (Rai 2020; Reeves/Varadarajan 2020; Remko 2020). Gölgeci et al. (2020), in contrast, argue that much of the debate on the trade-offs between efficiency and resilience is related to a focus on the short-term, whereas in the long-run, firms need to achieve both: coping with fierce market competition as well as unexpected disruptions.

The supply chain management literature (Carvalho et al. 2012, 2011; Govindan et al. 2015), in addition, discusses the contradictions and complementarities between efficiency, resilience and environmental sustainability from a firm perspective and based on the concepts of lean, green and resilient supply chain strategies (Figure 3). Within this framework, resilience-oriented strategies accept a lower degree of efficiency and sustainability in order to achieve more resilience. As a result, and from a firm perspective, resilience-oriented strategies may aim for higher buffer stocks or for a more diversified supplier network, and hence depend on a lesser degree on single sourcing or just-in-time solutions that are often preferred by lean strategies. Similarly, resilience-oriented strategies may accept more resource and energy consumption to ensure supply chain security

compared to strategies that put a greater emphasis on sustainability. There are, nonetheless, important compatibilities between the strategies. This is because, for example, lean and sustainable strategies may both have an interest in the reduction of wastage to decrease costs and the environmental footprint. Similarly, resilience-oriented strategies may aim to ensure resilience with the lowest environmental footprint (Carvalho et al. 2012, 2011; Govindan et al. 2015).

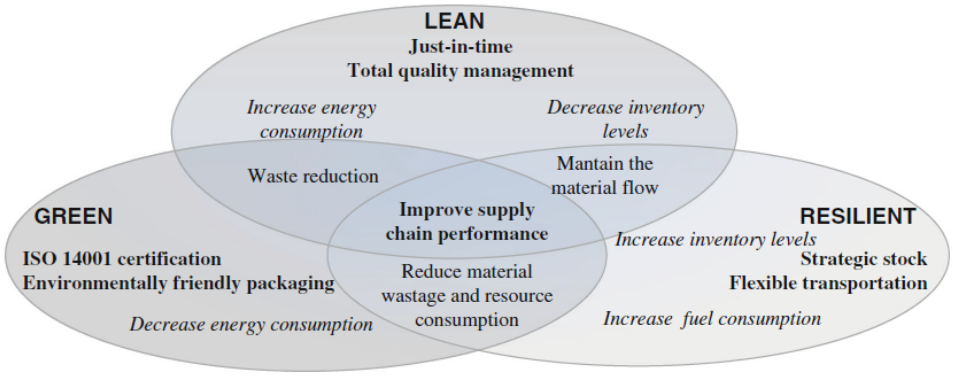

Figure 3: Lean, green and resilient supply chain management. Govindan et al. (2015: 17).

However, it is important to note that resilience and sustainability from a societal and thus policy-perspective can have a very different meaning compared to firm-centred approaches. This is because policy-makers and firms may evaluate the costs of supply chain disruptions or environmental pollution as well as the benefits of security of supply and sustainability differently. The perspective on efficiency, in addition, may also differ between policy-makers and firms, since the latter generally do not account for negative externalities in their cost-calculations. The mismatch between societal and firm perspectives, and the fact that increasing the resilience and sustainability of supply chains can be very costly and go beyond the capacities of individual firms, are the major justifications for policy interventions targeting supply chains.

The optimal policy response – in terms of their efficacy – to promote both resilience and sustainability in GVCs, thus, heavily depends on the specific policy objectives and how policy-makers assess the trade-offs between efficiency, resilience, and sustainability. From a policy-perspective, the emphasis put on these three policy goals is likely to differ between specific sectors and products, given that, for instance, the resilience of pharmaceutical and medical products GVCs might be considered more important than that of luxury goods GVCs. In this context, we developed a GVC typology that reflects a different emphasis on policy-goals (Figure 4). The biggest differences within this GVC typology are the degree of globalization, the degree of diversification and redundancies, and the size of the environmental footprint as well as the importance of socially responsible practices. This is related to a variety of trade-offs and compatibilities (Table 1).

A strong focus on efficiency and sustainability, for example, does not necessarily change the global orientation of supply chains, but is likely to result in socially responsible and green(er) GVCs by reducing the environmental impact of the current global production system through e.g., increasing input efficiency, better waste management, and circularity.

Increasing GVC sustainability can have positive and negative effects on GVC efficiency (Table 1). Furthermore, a strong focus on efficiency and resilience aims to make GVCs more resilient through the diversification of suppliers and regions and by increasing redundancies and buffers. Overall, increasing GVC resilience is likely to reduce GVC efficiency.

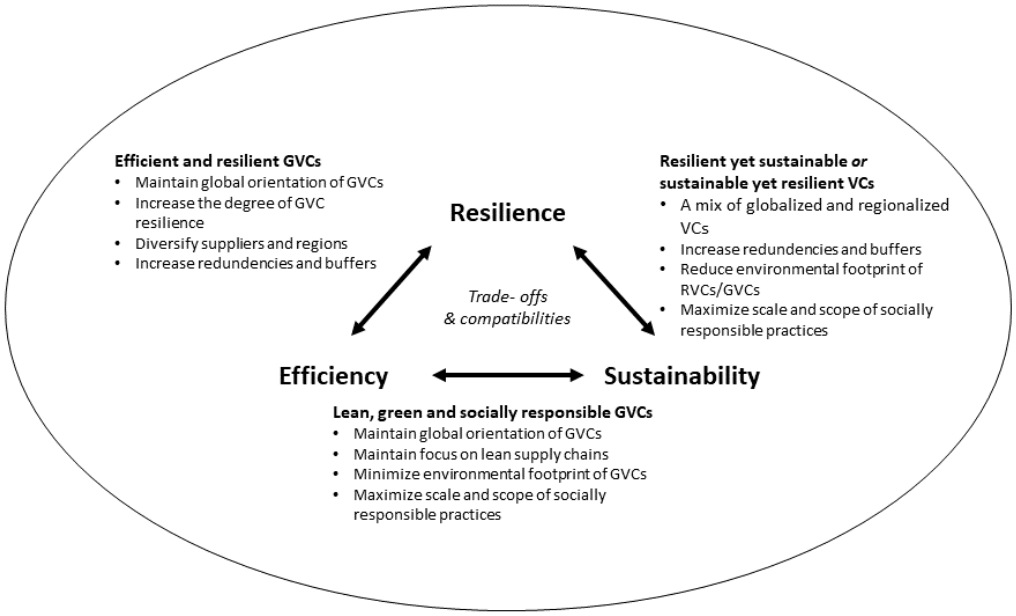

Figure 4: GVC models. Own elaboration.

A strong focus on resilience and sustainability, likely at the cost of efficiency, can result either in resilient sustainability, or in sustainable resilience. This is because increasing the degree of diversification and redundancies negatively affects the environmental sustainability of production since, for example, more production or storage facilities need to be build. Resilient sustainability prioritizes sustainability over resilience, i.e. one optimizes the resilience of a supply chain given a defined level of sustainability, and is thus characterized by low carbon-emissions of trade and thus shortened supply chains, circularity and high sustainability standards, which is why this model tends to be highly regionalized or localized. Subsequently, a certain degree of redundancies and possibly diversification in order to withstand certain shock is introduced to these regional value chains (RVCs). Regionalization or localization may thus benefit supply chain resilience in the case that during a crisis global trade is disrupted, export restrictions on critical products are introduced by major producing countries, and thus access to critical products via imports is curtailed (Raza et al. 2021a). However, regionalization may also decrease GVC resilience in case the regionalization process goes hand in hand with reducing the diversification of suppliers and regions (OECD 2021). The increasing exposure of RVCs to regional shocks could be reduced to the extent that multiple RVCs exist alongside each other.

Sustainable resilience, in contrast, prioritizes resilience over sustainability and thus focuses on increasing the resilience of (global) value chains in the most sustainable way. This could be achieved, for example, by increasing the diversification of suppliers while at the same time promoting the resource-efficiency of production of the various suppliers.

Focusing on sustainable resilience, in addition, could also affect the product-specific assessment of different measures or policies that aim to increase the security of supply (e.g., stockpiling, diversification & redundancies, emergency capacity, reshoring, etc.).
It must, however, be emphasized that the three policy-goals and associated GVC models, do not represent a classical trilemma, since one can, for example, increase the resilience of today's efficient GVCs in a sustainable way (e.g., by sourcing from more energy and resource efficient and at the same time geographically diversified production units/suppliers). The efficiency, resilience and sustainability of GVCs are thus better understood in relative terms, and not in absolutes. For this reason, the concept of sustainable resilience is of particular relevance since the regionalization of GVCs is currently not feasible in many cases due to expected efficiency losses. In these instances, policy-makers should aim to promote the sustainability and resilience of GVCs by focusing on the reduction of the environmental footprint and by increasing social sustainability standards as well as by promoting supply chain diversification and redundancies, respectively.

	GVC efficiency	GVC resilience	GVC sustainability
Higher degree of globalization	+	+ If GVCs are geographically diversified - If it leads to strong national import-dependencies; if, as in many GVCs, globalization leads to regional clustering of production and to single sourcing	+ Single sourcing and related economies of scale and scope on a global level decrease environmental footprint of global production High social and environmental sustainability standards of global buyers and comprehensive national standards as well as in trade regulations can improve sustainability of global production - Carbon-footprint of global trade and high degree of regional diversification increases environmental footprint of global production Low sustainability standards in many regions reduces social and environmental sustainability of global production
Higher degree of diversification and redundancy	+ Increasing competition between suppliers - Increasing costs in supply chain management (multi sourcing & buffers), decreasing exploitation of economies of scale and scope	+	+ **Resilient sustainability:** Increases resilience of sustainable supply chains (e.g. buffers to ensure that circularity can withstand shocks) - Increases resource-intensity of global production
Minimize size of environmental footprint and maximize the scale and scope of socially responsible practices	+ Decrease costs and negative externalities through better resource-efficiency, waste management, working conditions and more - Costly investments necessary	+ **Sustainable resilience:** Achieve resilience in the most sustainable way (e.g. by increasing diversification and improve resource efficiency and working conditions of production at the same time) - Negatively affects diversification and redundancies	+

Table 1: Indicative list of potential trade-offs and compatibilities between GVC efficiency, resilience and sustainability. Own elaboration.

3. Assessing GVC Resilience and Sustainability Initiatives

Based on the literature review and a conceptualization of GVC resilience and sustainability, the following section assesses a selection of different initiatives and policies that aim to improve GVC resilience and/or sustainability. In our assessment, we include the US Executive Order 14017 on America's Supply Chains and related documents, the EU's Open Strategic Autonomy strategy, the Supply Chain Resilience Initiative (SCRI) of Japan, India and Australia, various supply chain and due diligence laws, and the European Green Deal. Most of these policies do not link GVC resilience and sustainability in a comprehensive way. Instead, the assessed policies generally focus either on GVC resilience or on GVC sustainability.

3.1 Resilience-focused initiatives

3.1.1 US: Executive Order 14017: America's Supply Chains

In February 2021, President Biden issued Executive Order 14017, in which he calls for resilient, diverse, and secure supply chains to ensure the economic prosperity and national security of the USA. He argues that pandemics and other biological threats, climate shocks and extreme weather events, terrorist and cyber-attacks, geopolitical and economic competition, etc. can reduce critical manufacturing capacity and reduce the availability of critical products and services. For this reason, he calls to revitalize and rebuild domestic manufacturing capacity and invest in research and development to support the competitive advantage of the US. The policy initiative should not only create well-paying jobs, but also support the fight against climate change and encourage growth in communities of color and economically distressed regions. Greater domestic production, higher redundancies, adequate stockpiles, and secure digital networks as well as close cooperation with allies and partners to strengthen international capacities to respond to international threats should achieve the resilience of supply chains.

The inter-agency process to increase the resilience of supply chains is coordinated by the Assistant to the President for National Security Affairs (APNSA) and the Assistant to the President for Economic Policy (APEP). As a first step, the executive order called for a 100 Day Supply Chain Review by the Secretary of Commerce, the Secretary of Energy, the Secretary of Defense (as the National Defense Stockpile Manager), and the Secretary of Health and Human Services in order to assess the vulnerability of selected critical US supply chains and to develop policy recommendations. As a second step, a more detailed Sectoral

Supply Chain Assessments is to be presented by the same agencies within one year following the Executive Order, i.e. by February 2022. Based on the reports, APNSA, APEP and the heads of the relevant agencies should review the findings as well as further discuss and develop policy recommendations.

In June 2021, the 100-day review was completed and the high-level report titled Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth was published (The White House 2021). The report argues that resilient supply chains are needed, and that the prioritization of efficiency at the cost of supply security, sustainability and resilience needs to end, because it undermines the prosperity of US citizens and the ability to manage natural resources domestically and globally. This is why the report and the Biden-Harris administration call for a "new approach" that revitalizes the US manufacturing base and increases the resilience of GVCs, with a new focus on broad-based growth and sustainability. In this context, the report underlines the need to further promote investment in the US innovation system – also highlighting that labor is not a cost to be controlled but an asset to invest in – and foster relationships with US allies.

Regarding the robustness and resilience of supply chains, the report argues in favor of a diverse ecosystem of suppliers, and the need to rebuild the US small and medium-sized business manufacturing base, which has been hollowed out during the last decades in the context of globalization processes. In addition, the report clearly states that a diversification of international suppliers and reduction of regional clusters is needed, although no need nor desire to produce all critical products in the US is warranted. In order to achieve these goals, the report calls to abandon the focus on low wages, tax reductions and abolishment of regulations, and argues in favor of measures (taxes, labor protection, environmental standards, etc.) that can help to reshape globalization. Restructuring GVCs, in addition, is also deemed to be important for dealing with technological change, for confronting the climate crisis, and for ensuring US economic and national security, since "we cannot afford to be agnostic to where these technologies are manufactured and where the associated supply chains and inputs originate" (ibid.: 8).

The report further highlights that a sector-by-sector approach is necessary, since not all products are equally important and supply chain vulnerabilities differ. Consequently, four critical industry segments are identified: (i) semiconductor manufacturing and advanced packaging, (ii) large capacity batteries (esp. those for electric vehicles), (iii) critical minerals and materials, as well as (iv) pharmaceuticals and active pharmaceutical ingredients (APIs). Based on an analysis of key supply chain vulnerabilities, including (i) insufficient U.S. manufacturing capacity; (ii) misaligned incentives and short-termism in private markets; (iii) industrial policies of foreign countries; (iv) geographic concentration in global sourcing; and (v) limited international coordination, the report develops six key recommendations and proposes a set of actions in order to improve the resilience of supply chains and promote domestic manufacturing (Table 2).

First, the report argues to rebuild production and innovation capabilities by (a) enacting new federal legislation to strengthen critical supply chains and rebuild the industrial base of the US, (b) increase public investments in R&D and commercialization of key products, and (c) use immediate administrative authorities to support US producers and innovators (incl. SMEs and workers). For each of these measures, the report recommends product-specific policies. For example, it is argued that Congress should (a.i) support at least USD

50 billion in investments to promote domestic manufacturing of leading edge semiconductors; (a.ii) provide consumer rebates and tax incentives to promote consumer adoption of electric vehicles, approve USD 5 billion to electrify the federal fleet with US cars, and invest USD 15 billion in the national charging infrastructure; (a.iii) provide financing for US based businesses in the full battery supply chain, including by grants; (a.iv) establish a USD 50 billion supply chain resilience program to monitor, analyze and forecast supply chain vulnerabilities across a range of critical products as well as make transformative investments to strengthen US supply chains. In addition, the report argues to (b.i) invest in the development of next generation batteries in order to increase resource efficiency, accelerate technology advances, and promote the recovery and recycling of spent/consumed batteries or key input materials; (b.ii) increase funding of advanced pharmaceutical manufacturing technologies and use funds of the American Rescue Plan to promote production of key pharmaceuticals and intermediaries in the US. The report also suggests that state institutions should promote innovation and employment in the selected sectors through, for example, (c.i) on-the-job training linked to Registered Apprentice programs, (c.ii) supporting small and medium enterprises by the US Small Business Administration (SBA) in form of access to finance and other instruments, and (c.iii) implementing a new Domestic Financing Program by the US Export-Import Bank (EXIM) to rebuild US manufacturing and exports.

Second, the report aims to *support the development of markets that invest in workers, value sustainability, and drive quality***.** It is argued that standards and data are the key tools in order to differentiate market and make firms compete on more than price, potentially creating a market pull towards a "race to the top". In this context, it is suggested to (a) improve standards for extracting and processing of critical minerals by creating an inter-agency team to identify gaps in the current regulations, and to update regulation to environmental standards; strengthen consultation mechanisms with tribal nations; and find ways to increase the efficiency of the permitting process without compromising on sustainability benchmarks. In addition, (b) a high-level working group among ministries and other agencies, in collaboration with tribal nations, the private sector and other stakeholders, should identify sites where critical minerals can be sustainably and responsibly extracted and processed. Furthermore, it is argued that (c) the transparency in the pharmaceutical supply chain needs to be increased, and that a new authority should be implemented to track production of facilities and the sourcing of intermediaries (active pharmaceutical ingredient, API) and final products (final dosage form). It is also suggested that sources should be identifiable by labelling.

Third, the report argues that the government needs to leverage its role as a purchaser of and investor in critical goods, during both crises and normal times. Regarding (a) federal procurement, and in connection with the "Made in America" process, the report suggests that the Biden-Harris administration develops a list of critical products for which government procurement should prioritize US-made products, thus incentivizing the private sector to invest in US manufacturing. This proposal also needs to be seen in the context of the Buy American Act and the FAR Council regulations. In addition, it is argued that (b) federal grants for science and climate R&D need to be updated with regard to their domestic manufacturing requirements (e.g. related to lithium batteries), and that an inter-agency working group should identify best-practices and develop further improvements. The report also underlines that (c) strategic stockpiles in the US have been neglected, and that in addition to increase stockpiles of medical products and devices, it is also necessary to restore the National Defense Stockpile with critical minerals and materials, as well as implement mechanisms that strengthen stockpiling of critical products in the private sector to

increase the resilience of supply chains. With respect to the (d) US automotive battery production, the report calls for better working conditions, in particular with regard to workers' freedom to organize and to bargain collectively, amongst others. In this context, it is argued that tax credits, preferential lending and grants offered to businesses to produce batteries in the US should be linked to labour standards.

Fourth, the report argues to strengthen international trade rules in order to push back "pumping and dumping" practices (i.e. subsidized firms and/or 'underpriced' products flooding the market to gain market share and wipe out competition). This is to be done by (a) establishing a trade strike force to identify and combat unfair foreign trade practices, by introducing supply chain resilience in the US trade policy approach towards China, and by incorporating measures to increase supply chain resilience in existing and future trade agreements. The report also discusses to (b) initiate a Section 232 investigation (i.e. assessing the effect of imports on national security according to the Trade Expansion Act of 1962) for neodymium magnets.

Fifth, it is argued that cooperation with allies is required in order to decrease GVC vulnerabilities. In this context, the US aims to (a) expand multilateral diplomatic initiatives, in particular with partners such as the Quad (USA, Australia, Japan, and India) and the G7, and to convene a global forum on supply chain resilience. In addition, the report argues to (b) leverage different financing tools, such as the U.S. Development Finance Corporation (DFC), to support global supply chain resilience. In particular, the report calls for increasing support to investments in the production capabilities for critical products (with a particular mentioning of critical minerals).

Sixth, and finally, the report calls to monitor near-term supply chain disruptions following the reopening of the economy from the COVID-19 pandemic, suggesting to (a) set up an all-government supply chain disruption task force led by the Secretaries of Commerce, Transportation, and Agriculture to identify shortages, diagnose problems, and develop solutions. To support the task force, (b) a data hub to monitor supply chain vulnerabilities and disruptions should be created, improving information sharing of federal agencies and the private sector.

In sum, Executive Order 14017 and related documents outline a comprehensive strategy towards increasing GVC resilience and security of supply, but to some degree also considers GVC sustainability. In contrast to the dominant discourse in the EU, the US resilience strategy puts a strong emphasis on promoting domestic manufacturing of strategically important and critical products. The proposed measures, in addition, entail comprehensive government intervention and state support that could have a profound impact on US supply chains, with potential global side-effects.

1. **Rebuild production and innovation capabilities**
    a. Enact new federal legislation that will strengthen critical supply chains and rebuild our industrial base—including transformative investments within the American Jobs Plan
        i. Provide dedicated funding for semiconductor manufacturing and R&D (USD 50 billion)
        ii. Provide consumer rebates and tax incentives to spur consumer adoption of electric vehicles (USD 20 billion)
        iii. Provide financing across the full battery supply chain
        iv. Establish a new Supply Chain Resilience Program (USD 50 billion)
        v. Deploy the Defence Production Act (DPA) to expand production capacity in critical industries
    b. Increase public investments in R&D and commercialization of key products
        i. Invest in the development of next generation batteries
        ii. Invest in the development of new pharmaceutical manufacturing and processes
    c. Use immediate administrative authorities to support an ecosystem of producers and innovators including SMEs and skilled workers
        i. Work with industry and labour to create pathways to quality jobs, with a free and fair choice to join a union, through sector-based community college partnerships, apprenticeships and on-the-job training
        ii. Support small, medium and disadvantaged businesses in critical supply chains
        iii. Examine the ability of the U.S. Export-Import Bank (EXIM) to use existing authorities to further support domestic manufacturing
2. **Support the development of markets that invest in workers, value sustainability, and drive quality**
    a. Create 21st century standards for the extraction and processing of critical minerals
    b. Identify potential U.S. production and processing locations for critical minerals
    c. Improve transparency throughout the pharmaceuticals supply chain
3. **Leverage the government's role as a purchaser of and investor in critical goods**
    a. Use federal procurement to strengthen US supply chains
    b. Strengthen domestic production requirements in federal grants for science and climate R&D
    c. Reform and strengthen US stockpiles
    d. Ensure that new automotive battery production in the United States adheres to high labor standards
4. **Strengthen international trade rules, including trade enforcement mechanisms**
    a. Establish a trade strike force
    b. Evaluate whether to initiate a Section 232 investigation on imports of neodymium magnets
5. **Work with allies and partners to decrease vulnerabilities in the global supply chains**
    a. Expand multilateral diplomatic engagement, including hosting a new Presidential Forum
    b. Leverage the US Development Finance Corporation (DFC) and other financing tools to support supply chain resilience
6. **Monitor near term supply chain disruptions as the economy reopens from the COVID-19 pandemic**
    a. Establish a Supply Chain Disruptions Task Force
    b. Create a data hub to monitor near term supply chain vulnerabilities

Table 2: Key policy recommendations of high-level US report on supply chain resilience and US manufacturing. The White House (2021).

3.1.2 Japan, India and Australia: Supply Chain Resilience Initiative

In April 2021, the trade ministers of Japan, India, and Australia issued a statement to launch the Supply Chain Resilience Initiative (SCRI). In the context of the COVID-19 pandemic, the Ministers argued that the pandemic revealed regional and global supply chain vulnerabilities, and that some supply chains remain vulnerable due to a variety of factors. Therefore, the initiative "aims to create a virtuous cycle of enhancing supply chain resilience with a view to eventually attaining strong, sustainable, balanced and inclusive growth in the region" (SCRI 2021). Even though the statement remains vague on the issue of vulnerabilities, it is clear that the SCRI has a strong focus on increasing regional cooperation to reduce import-dependencies from China, in particular with respect to critical products. Japan, India, and Australia are also – together with the US – part of the Quadrilateral Security Dialogue (Quad) dialogue, which is generally understood as a strategic regional cooperation initiative to curtail the growing influence of China.

In order to strengthen supply chain resilience, the Ministers underlined the importance of risk management and continuity plans. In this context, they particularly highlighted two possible policy interventions: (i) supporting the enhanced utilization of digital technology; and (ii) supporting trade and investment diversification. Initially, the projects of the SCRI included (a) sharing of best practices on supply chain resilience; and (b) holding investment promotion and buyer-seller matching events to explore opportunities for supply chain diversification. Finally, the Ministers agreed to convene at least once a year to discuss the implementation and further development of the SCRI. However, more frequent day-to-day coordination will take place at the administrative level.

While the SCRI is only in its early stages, it needs to be understood against the background of the respective countries' national industrial and resilience strategies. Australia, for example, launched the Modern Manufacturing Strategy (MMS) (Figure 5), which includes the Modern Manufacturing Initiative (with funding of AUSD 1.3 billion) and an Australian-specific Supply Chain Resilience Initiative (with funding of AUSD 107.2 million). The Australian SCRI focuses on (bio)pharmaceuticals, personal protective equipment (PPE), and agricultural production chemicals and has two components: (i) assessing supply chain vulnerabilities and policy options to address vulnerabilities with the business sector, and (ii) support businesses to address supply chain vulnerabilities through grants. In the future, the scope of sectors could be broadened. A first in-depth assessment of supply chain vulnerabilities in the selected sectors was conducted in April 2021 and involved 45 companies.[3] The Australian SCRI grants aim at addressing to address the vulnerabilities in the selected sectors and has the following goals:

- Improve Australia's resilience to future supply chain shocks
- Facilitate diversification of supply options and increase investment in the economy
- Enable diversification into export markets and reduce reliance on domestic markets
- Improve collaboration between domestic and international manufacturers and suppliers
- Mitigate supply chain risks for critical products, and enhance visibility and transparency of the supply chain for identified critical products

[3] See https://www.industry.gov.au/data-and-publications/sovereign-manufacturing-capability-plan-tranche-1/building-supply-chain-resilience (28.10.2021).

- Accelerate digitalisation and deeper integration of technology to optimize supply chain performance

In this context, domestic manufacturing is seen as particularly relevant for selected critical products. Government investments in domestic manufacturing capabilities are considered appropriate in case the disruption of supply chains poses a substantial risk to national security and in case other measures and private-sector efforts are deemed non-sufficient. In order to build business capacities, the government also aims at reducing trade and regulatory barriers that may impede business actions and support access to information relevant to resilience-considerations by business actors. In addition, a newly established Office of Supply Chain Resilience will monitor vulnerabilities and coordinate government efforts towards supply chain resilience across different government agencies. The necessity to collaborate with other governments to share information, enable investment as well as to reduce trade barriers is also stressed.

By way of summary, it has to be noted that the Australian SCRI is comparatively small in financial terms, is not exclusively focused on GVC resilience, but should be seen as a more general program to strengthen the domestic manufacturing base. Notably, the sustainability dimension is also largely missing.

Figure 5: Australia's Modern Manufacturing Strategy. Australian Government (2020:3).

3.1.3 EU: Open Strategic Autonomy

The changing nature of the international system, and in particular the intensifying systemic rivalry between the US and China, as well as the eminent strategic import dependencies of the EU vis-à-vis China and other countries increasingly influences EU economic policies (cf. Anghel et al. 2020; EC 2021b). The strategic dependencies are particularly relevant in the case of foundational technologies such as semiconductors, cloud and edge technologies, and batteries, but also include active pharmaceutical ingredients, rare minerals and many other metals, which are not only important from a security of supply perspective but are essential for implementing digital as well as green technological innovation, the latter being key for achieving the objectives of the European Green Deal. Against China's more assertive stance in international affairs, which has already led the Commission to qualify China as a 'systemic rival' (EC 2019a), EU policy-makers have become increasingly concerned about the EU's import dependency vis-à-vis authoritarian regimes and its potential vulnerability to political blackmailing.

While at its origin, the strategic autonomy concept was primarily employed within EU security and foreign policy, more recently it has been been considered in a wide range of policies, including intrade, industry, energy, critical raw materials and technology policies (Van den Abeele 2021). In its Global Strategy for the EU's Foreign and Security Policy launched in 2016, the Commission introduced the concept of 'strategic autonomy'. The scope of the concept at the time remained limited and referred in particular to defense cooperation and the European defense industry. Against the backdrop of the COVID-19 crisis, former EU Trade Commissioner Phil Hogan referred to the term 'open strategic autonomy', highlighting that global supply chains would need to be diversified in some sectors, including, where necessary, through strategic stockpiling. At the same time, he stressed that this would require a deepening of the international rules-based trading system, and reiterated the EU's continued commitment to such a system. According to this view, a move towards strategic autonomy in certain sectors would have to be balanced with a continuing commitment to trade openness and the multilateral trade framework.

So far, various initiatives have links to the open strategic autonomy concept. The most important regulation introduced in this context is arguably the EU Foreign Investment Screening Regulation (Regulation 2019/452), which creates a mandatory information-sharing mechanism between Member States and allows Member States and the EC to consult on foreign investments foreseen in other Member States. With the Regulation, the EU aims to safeguard Europe's security and public order by introducing an EU-wide foreign investment screening mechanism and scrutinizing purchases by foreign companies that target the EU's strategic interests. A second important initiative, the EU's Raw Materials Initiative, aims to ensure a continuous supply of critical raw materials in light of the EU's heavy dependence on global sourcing (EC 2008). Furthermore, the sectoral initiatives under the Important Project of Common European Interest (IPCEI) umbrella are also attempts to strengthen the EU's autonomy and competitiveness in strategic technological sectors.[4] Most recently, the EU also announced to support global infrastructure projects (EUR 300 billion to be invested by 2027) under the Global Gateway Initiative. Even though not stated explicitly, the initiative can be interpreted as an attempt by the EU to position itself as a global player vis-á-vis China (Fleming 2021).

[4] See e.g., https://www.bmwi.de/Redaktion/DE/FAQ/IPCEI/01-faq-ipcei.html

Sector-specific strategies: The EU's pharmaceutical strategy

In addition to the EC's trade and investment policy, the strongest link between GVC resilience and the open strategic autonomy concept is visible in sector-specific strategies, for example in the case of the EU's new chemicals and pharmaceutical strategies. In the case of chemicals, for example, the EC calls for a more diversified supplier base and improved risk management with regard to disruptions, including strategic reserves and stockpiles for critical chemicals. In the case of pharmaceuticals, the EC also initiated a structured dialogue, which discusses potentials for reshoring of active pharmaceutical ingredients (APIs) – the intermediate products of medicines.

The stronger focus on open strategic autonomy and resilience in the EU's pharmaceutical strategy is linked to the COVID-19 crisis, which highlighted the already prevalent threat of trade disruptions and shortages. However, it should be noted that other than during the initial outbreak in early 2020, when health systems and hospitals were (at least partially) overwhelmed, COVID-19-induced drug shortages in the EU have so far been relatively rare. Instead, COVID-19 has served to highlight the existing phenomenon of drug shortages in the EU, which has become more frequent over the last decade. The European Parliament has sought to address the problems of medicine shortages in the EU since already in 2017.[5] According to a recent report prepared by the European Parliament's Committee on the Environment, Public Health and Food Safety, it is estimated that the number of shortages increased 20-fold between 2000 and 2018, and have increased 12-fold since 2008 (EP 2020a). In addition, an OECD study on shortage notifications in 14 OECD countries between 2017 and 2019 showed that the number of notifications of expected or actual shortages increased by more than 60 % (OECD 2020). The drugs affected by these shortages include a large variety of products (including cancer treatments, antibiotics, vaccines, anesthetics and medication for hypertension, heart disease and disorders of the nervous system) which is why the reasons for these shortages also differ. Shortages result in particular from manufacturing problems, quality issues, unexpected spikes in demand, and parallel imports/exports (EP 2020a). However, it is now increasingly acknowledged that the consolidation of the industry and outsourcing processes over the last decades, in particular with regard to low-value generic products, has added to the problem (Council of the EU 2019; EP 2020a).

The increasing shortage of medicines has also caught the attention of policy-makers on EU and national levels. As a result, a task force on the Availability of Authorised Medicines for Human and Veterinary use (TF AAM) led by the European Medicines Agency (EMA) and the Heads of Medicines Agency (HMA) was set up in 2016 to investigate shortages and supply chain disruptions. The main goal of this task force is to reduce supply shortages, in particular through improved EU coordination. In addition, with the EU4Health Programme, part of the Next Generation EU recovery plan, the EU also aims to improve the availability of medicines through the development of a European monitoring, reporting and notifying system (EC, 2020a). Furthermore, Members of the European Parliament have called for financial incentives to increase API production in the EU and create an EU contingency reserve of medicines with strategic importance (EP 2020b).

The recently published (November 2020) Pharmaceutical Strategy for Europe by the EC (2020c) encompasses four strategic pillars: (i) addressing unmet needs of patients; (ii) improving access to affordable medicines for patients; (iii) promoting a competitive and

[5] See https://www.europarl.europa.eu/doceo/document/TA-8-2017-0061_EN.html (04.11.2020)

innovative European pharmaceutical industry; and (iv) enhancing the resilience of the pharmaceutical supply chains. The latter aims at fostering the EU's open strategic autonomy in the pharmaceutical sector by diversifying production and supply chains, promoting strategic stockpiling, and increasing production and investment in Europe.

This flagship initiative on open strategic autonomy includes a revision of the pharmaceutical legislation by 2022 to enhance the security of supply through earlier notification of shortages, stricter obligations for supply and transparency, enhanced transparency of stocks and improved EU coordination and mechanisms to manage and avoid shortages. The strategy also initiates a structured dialogue with the actors in the pharmaceutical GVC, including manufacturers, public authorities, research communities, and Non-Governmental Organizations (NGOs) in order to assess the vulnerabilities of the GVC and to discuss other potential options for improving supply security, such as reshoring. The strategy, however, so far remains vague on how GVC resilience or reshoring will be promoted in concrete terms.

Summary of discussion

By way of summary, we have seen that the discussion on (open) strategic autonomy has addressed security of supply concerns mainly through the proposed investment screening policies and the EU raw materials initiative. Investment screening might lead to a slowing-down of offshoring activities, with the knock-on effect that production is reshored. The explicit goal of investment screening is, however, to inhibit the loss of control over key technologies and industries to foreign interests. More recently, and particularly in the context of the COVID-19 pandemic, supply chain resilience has been increasingly linked to the open strategic autonomy concept. In this context, the diversification of suppliers and thus GVC resilience is to be supported through trade policies, for instance, through the EU raw materials strategy and recent initiatives in bilateral trade agreements to introduce export restrictions for partner countries with respect to raw materials and other products. Thus, at the EU level, a broad and comprehensive resilience strategy comparable to the US strategy on America's Supply Chains is so far missing. Only sector-specific strategies, such as the chemicals and pharmaceuticals strategy, consider more comprehensive measures towards promoting security of supply and GVC resilience. However, it remains relatively unclear how the diversification of suppliers is to be achieved. In contrast to the US, re- and nearshoring are currently not explicitly supported. Possibly, for this reason, some EU member states, such as France, have initiated national-level strategies to promote reshoring. The "France Relance" Recovery Plan has a budget of EUR 100 billion and – inter alia – aims to strengthen reshoring in the health and electronics sector, in the agrifood industry, and in the production of inputs essential to industry and industrial 5G applications.[6]

3.2 Sustainability-focused strategies

3.2.1 Supply chain and due diligence laws to increase sustainability

Since the early 2000s, public awareness about the responsibilities of companies to ensure supply chain responsibility has increased. The UN Guiding Principles on Business and Human Rights were the first high-level governmental initiative to address the responsibility

[6] See https://www.diplomatie.gouv.fr/en/french-foreign-policy/economic-diplomacy-foreign-trade/promoting-france-s-attractiveness/france-relance-recovery-plan-building-the-france-of-2030/

of companies to respect human rights throughout their value chain (UN 2011). The UN's principles aim at contributing to socially sustainable globalization processes by enhancing human rights standards of business practices and GVCs. The principles demand that companies avoid infringing on the human rights of others and address human rights impacts with which they are involved. In this context, the principles refer to the International Bill of Human Rights and the International Labor Organization's (ILO) Declaration on Fundamental Principles and Rights at Work as minimum standards. In order to meet their responsibilities, companies should have i) a policy commitment to respect human rights, ii) a human rights due diligence process to identify, prevent, mitigate and account for how they address their impacts on human rights, and iii) processes to enable remediation of any adverse human rights impacts. In terms of remediation, the principles call for state-based judicial mechanisms, state-based non-judicial grievance mechanisms and non-state-based grievance mechanisms. A major limitation of the UN's Guiding Principles is that they are non-binding, which limits their impact on changing firms' supply chain practices. Following the UN's Guiding Principles, the OECD updated its Guidelines for Multinational Enterprises in 2011 (OECD 2011). The non-binding guidelines are recommendations of OECD governments to multinational companies and provide principles and standards for responsible business conduct. The OECD guidelines build on the UN Principles, but also add an additional range of aspects such as employment and industrial relations, environment, and consumer interests.

In addition, the OECD also started to target sector-specific sustainability issues through the non-binding Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (OECD 2016). Also formulated in 2011, and now in its third edition, the Due Diligence Guidance concentrates on the supply chains of minerals and their possible connection to conflicts. Its intention is to assist companies in implementing due diligence practices with regard to their procurement of raw materials (Küblböck/Grohs 2017a). The guidance proposes a five-step framework for risk-based due diligence, which includes i) the establishment of a strong company management system to support due diligence; ii) the identification and assessment of risk in the supply chain; iii) the design and implementation of a strategy to respond to identified risks; iv) the carrying out of independent third-party audits; and v) the reporting on supply chain due diligence (see Figure 6).

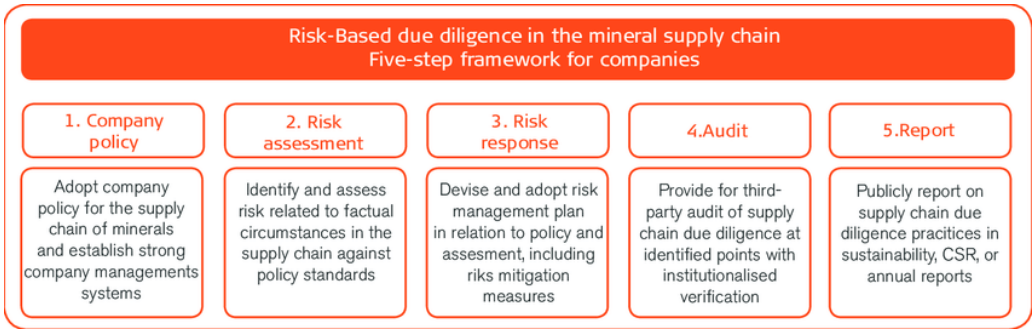

Figure 6: Risk-based due diligence in the mineral supply chain. Küblböck/Grohs (2017a) based on OECD (2016).

Even though the OECD Due Diligence Guidance for Minerals only has a voluntary character for companies, it illustrates how initiatives on a multilateral level can propel policy debates on national levels. In 2012, Section 1502 on "Disclosures on conflict materials in or near the Democratic Republic of the Congo" of the US Dodd-Frank Act implemented the first legally binding rules for the mineral supply chain. The Dodd-Frank Wall Street Reform and Consumer Protection Act as such depicted a fundamental revision of the US financial regulation in the aftermath of the global financial and economic crisis of 2007/8. Section 1502 was included as a "Miscellaneous Provision". It covers the four minerals tantalum, tungsten, tin and gold (3TGs) and obliges companies listed on the US stock exchange to disclose on a yearly basis whether their products contain these minerals and whether they originate from the Democratic Republic of Congo (DRC) or neighboring countries. If both apply, a report must be submitted to the Security and Exchange Commission (SEC), documenting the steps taken to minimize the risk that extraction of those minerals contributes to conflict (Küblböck 2021). The law also foresees that companies have to declare publicly whether their minerals have been found 'DRC conflict free' or not. However, following objections from companies and a subsequent court decision, companies are not obliged to use these labels and to indicate the status of the minerals they use, but can do so on a voluntary basis (Küblböck/Grohs 2017b).

Following these developments, the European Commission (EC) published a first draft regulation on conflict minerals in 2014, with the final regulation coming into force in July 2017 (EC n.d.). The regulation introduced legally binding due diligence requirements for EU-based importers trading a certain minimum quantity of raw tin, tantalum, tungsten and gold (3TGs) or respective smelter products. The regulation requires companies to ensure that they import minerals and metals from responsible and conflict-free sources only. In doing so, companies have to follow the OECD's five-step framework (see Figure 6). The EU's Conflict Minerals Regulation applies to all importers, no matter where their minerals and/or metals originate. The regulation requires that importers of the respective minerals – amongst other things – need to indicate which country the minerals come from, the quantities imported, and when they were mined.[7] The regulation included a transition period of four years, ending in December 2020. The first reports on companies' due diligence measures in 2021 based on the OECD Guidance have to be handed in by the end of the year. An evaluation of the regulation is foreseen for the beginning of 2023 (cf. Küblböck/Grohs 2017a).

When comparing the US' Section 1502 and the EU Conflict Minerals regulation, it is striking that the EU regulation exclusively focusses on the upstream sector (importers of mineral ores, concentrates or processed metals). In contrast, Section 1502 also applies to the downstream industry, as long as the respective companies are listed at the US stock market. However, in geographical terms, Section 1502 falls behind the EU regulation, since it only applies to the DRC and neighboring countries and not to conflict-affected and high-risk areas in general. A major subject of debate is that both regulations do not allow for

[7] Additionally, minerals have to be listed by trade name and type; names and addresses of suppliers have to be provided. When minerals come from conflict-affected and high-risk areas (based on an indicative regularly updated list), companies must provide extra information, e.g., specifying the mine the minerals come from; where the minerals were consolidated, traded and processed; and the taxes, fees and royalties paid. Resulting documents and audit reports will be examined by member states' authorities, which can also carry out on-the-spot inspections if needed. If a company does not comply with the regulation, authorities may order the firm to address problems within a given deadline and follow up to make sure that it does so. The legal text does not specify any further rules applicable to infringements of the regulation, but leaves it to member states to define such.

meaningful sanctions, which is why enforcement capabilities are weak. The German implementing law, for example, only provides a penalty in case companies do not comply with official requests – such as the submission of reports (Küblböck 2021). The only consequences for non-compliance under Section 1502 may come in the form of brand damage associated with public shaming initiatives by NGOs (Cuvelier et al. 2014; Stoop et al. 2018). The lack of sanctions and the limited (albeit different) scope of the two laws have been repeatedly criticized by NGOs. In the case of the EU regulation, another point of critique are the high thresholds that must be exceeded by importers before the law takes effect (Küblböck 2021).

While a first evaluation of the implementation of the EU regulation can only take place after the submission of reports by the end of the year 2021, for the USA experience with reporting has been available since 2014. The United States Government Accountability Office's (GOA) report on the first reporting year 2013 concluded that most companies were unable to determine the source of their minerals (67 %).[8] 24 % declared that their minerals in use did not come from the DRC or neighboring countries. Only for 4 % reported the opposite. These companies, however, were not able to determine, whether their sourcing of minerals benefitted armed groups. In addition, only 1,321 companies handed in a report, which was considerably lower than SEC's estimate of 6,000 companies likely to be affected by the regulation (GAO 2015). For the reporting year 2020, 1,057 companies handed in a report. This time, 29 % were not able to determine the source of their minerals, 16 % stated that they do not source from the covered countries, and 42 % declared that their minerals might have been from covered countries (GAO 2021). Overall, the decreasing proportion of companies not able to determine origin is a positive development. From a scientific perspective, Dalla Via and Perego (2018) conclude that the reporting compliance regime introduced by Section 1502 has been partially effective in ensuring increased levels of public disclosure. However, higher compliance would have been possible, if more tangible sanctions and fines for non-compliance had accompanied the existing 'naming and shaming' enforcement rationale.

In addition, a number of studies point to possible unintended effects by the law such as a de-facto embargo of the DRC and its neighboring countries (see e.g., Radley/Vogel 2015). Koch and Kinsbergen (2018), in contrast, disagree that Section 1502 harms the people it is meant to protect. They point out that since the introduction of Section 1502 (i) the number of functional audit schemes increased significantly; (ii) the number of mining sites in the DRC that were certified, and thus had legal exports, continued to rise; and (iii) exports of 3T minerals (tantalum, tungsten, tin) continued to increase. From their perspective, the unintended effects of the law are exaggerated. At the same time, they do not deny that some companies moved out of the region. For this reason, the authors criticize the geographically limited scope of Section 1502. In a review of early impact assessments of the law, Rüttinger and Scholl (2016), also point to negative developments in the region, but emphasize that changes on the ground should not be associated with Section 1502 prematurely. They conclude that the law has proven to be a window of opportunity for various processes and regulations in the field of conflict minerals, and has increased the understanding of due diligence in mineral supply chains – on the local and the firm level. They note that arguably positive structural changes have been initiated, but that these so far hardly had an impact on the general population or the environmental and social conditions in the mining sites.

[8] Numbers are estimates based on random sample of 147 reports. For the GOA (2021) publication, a sample of 100 reports was chosen by the agency.

While initial assessments of the effectiveness of the EU regulation are eagerly awaited, the debate on more comprehensive supply chain due diligence initiatives has become increasingly dynamic in the EU during recent years. On a national level, France was the first European country to introduce a cross-sectoral and cross-thematic[9] law on due diligence in 2017. The Loi de Vigilance requires all French companies with over 5,000 employees in France or over 10,000 employees worldwide to implement due diligence measures with regard to their companies and all their contractors and suppliers. It obliges companies to develop a so-called vigilance plan in consultation with trade unions. These plans need to comprise a mapping of risks, regular risk assessment procedures, mitigation and prevention actions, an alert mechanism and a monitoring mechanism (Zamfir 2020). In its original version, the French act provided that companies could be fined up to EUR 10 million for both failure to establish and failure to comply with the plan, depending on the seriousness of the breach and the circumstances. However, the French Constitutional Council declared this provision unconstitutional and it was removed from the act. While administrative sanctions are still possible, civil liability of firms is now constrained to cases where it can be proven that the lack of a plan resulted in damage (Koch 2020).

In January 2020, the Loi de Vigilance was assessed by the French government (Duthilleul/Jouvenel 2020). The respective report concludes that the act has not yet developed its full effectiveness. While some companies installed due diligence measures and made considerable progress in taking up the issue, others still fail to do so and do not yet apply the act effectively. A report by French NGOs Sherpa and Terre Solidaire (2020) investigated 265 companies, highlighting that 27 % of these firms did not yet have a plan of vigilance in place. In face of these results, the French minister for economy and finance – Bruno Le Maire – underlined the importance of an EU wide legislation to strengthen the implementation of the French act.[10] The scope of the French act, however, is still to be informed by the outcome of a court case currently being pursued by various French cities and NGOs against the mineral oil company Total. The accusation is that the environmental plan is not suitable for achieving the climate targets of the Paris Climate Agreement of 2015. They thus demand that Total takes more effective measures to protect the environment from destruction (cf. Koch 2020).

In June 2021, Germany also implemented a national supply chain law. The Lieferkettensorgfaltspflichtengesetz (LkSG) applies to companies with over 3,000 employees (from 2023 onwards) and over 1,000 employees (from 2024 onwards). The German Federal Ministry for Economic Cooperation and Development (BMZ) estimates that the law will apply at first to 900 firms in the year 2023, and 6,800 companies in the year 2024. The scope of application will be evaluated after 2024. The due diligence requirements comprise nine steps (see Figure 7) and cover human rights violations as well as environmental protection. Companies that do not comply with the act may be confronted with administrative sanctions, i.e. fines or – in cases of severe infringements – the exclusion from public contracts for up to three years. The act does not create any new civil liability rules. Civil liability under German and foreign law continues to apply independently from the law (BMZ 2021; Initiative Lieferkettengesetz 2021a).

[9] Examples for laws on particular human rights violations are the Dutch Child Labor Due Diligence Act in 2017 and the UK's Modern Slavery Act in 2015.

[10] See https://www.economie.gouv.fr/files/files/directions_services/cge/communiqu%C3%A9%20de%20presse.pdf

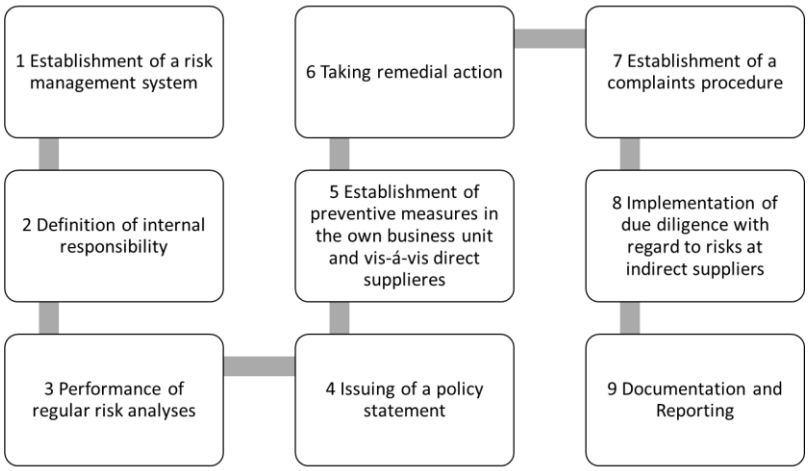

Figure 7: Due Diligence Requirements – LkSG. Own elaboration based on LkSG.[11]

Many NGOs and civil society actors have voiced their concern regarding the effectiveness of the law (DGB 2021; Initiative Lieferkettengesetz 2021b). While the first drafts of the act in February 2019 and June 2020 were considered quite ambitious, the final legislation has withdrawn some requirements and obligations. According to civil society actors, this is due to lobbying by companies and industry associations (Initiative Lieferkettengesetz 2020; Paasch/Seitz 2021). In the first draft, the act was planned to apply for firms with over 250 employees. In the second draft, the threshold was increased to 500. Additionally, both drafts held companies fully responsible for due diligence infringements in their entire supply chain, including indirect suppliers as well as the recycling and disposal of products.

In the final version, company's obligations are differentiated and standards are higher or lower depending on whether infringements have occurred in the firm's own operations, by direct suppliers, or indirect suppliers (Initiative Lieferkettengesetz 2021a). In the case of indirect suppliers, companies have to conduct a risk analysis and implement a plan to stop or minimize violations, when they become aware of infringement. However, companies do not have to monitor indirect suppliers proactively or take preventive and risk-based action as, for example, is demanded by the UN Guiding Principles, since the majority of human rights violations take place in the upstream segments of supply chains. A civil liability clause, in addition, was also removed from the draft. The act includes administrative sanctions, but companies are not liable for the damage caused related to disregarding due diligence obligations. Directly affected individuals thus have limited access to legal remedies to sue for compensation, as the provisions under already existing German and European laws, as is argued by civil society organizations, pose a very high threshold to hold companies liable for human rights abuses (ibid.; Paasch/Seitz 2021). Jahn (2021) also points out that the German Act clearly falls behind the draft treaty of the UN's OEIGWG[12] to globally regulate the activities of multinational firms.

[11] See http://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl121s2959.pdf

[12] Open-ended intergovernmental working group on transnational corporations and other business enterprises with respect to human rights.

In general, EU policy-makers, firms, and civil-society organizations agree that national legislation is only an intermediate step towards EU regulation. In April 2020, the EU Commissioner for Justice – Didier Reynders – announced that the Commission had started consultations on an EU wide and comprehensive supply chain law that will target social and environmental sustainability issues along the whole chain. The law could potentially include sanctions under public law and improved access to damage payments for affected individuals. The ecological focus is related to the European Green Deal (Chapter 3.2.2), which commits the EU to link all its actions and policies to environmental objectives (Zamfir 2020).

A draft legislation of a supply chain law by the EC was originally foreseen for June 2021, but was postponed to autumn and is still pending. In mid-2021, Commission President Ursula von der Leyen opted for joint responsibility in drafting the legislative proposal between Didier Reynders and the EU Commissioner for Industry, Thierry Breton. In this context, the debates on EU regulation mirror those from national and international discussions on binding due diligence regulations. In its non-legislative resolution from March 2021, the European Parliament called for a comprehensive supply chain law that captures the entire supply chain and includes substantive sanctions, liability regimes, and grievance mechanisms. Corporate actors, on the other side, are more cautious with respect to the scope of application and civil liability clauses (Francis 2021).[13]

Finally, it should be highlighted that some authors question supply chain laws in general. In a written statement on the draft of the German supply chain act and with reference to the European debate, Felbermayr, Langhammer and Sandkamp (2021) criticize unintended 'side-effects' of these laws. In their opinion, supply chain laws might negatively affect countries of the Global South (e.g., through the relocation of production and the deepening of the divide between formal and informal labor markets) as well as member states of the European Union (e.g., by weakening the competitive position of firms due to high economic costs associated with implementing due diligence regulations). Finally, they consider that supply chain due diligence measures are potentially counterproductive in terms of resilience: Supply chain laws could incentivize companies to increasingly rely on well-established supply relationships. However, supply chain resilience would require more flexibility and diversity. According to the authors, states and the EU should thus opt for an approach that relies on regional as well as bi-, uni-, and multilateral trade policy, effective development cooperation, and so called negative lists. The latter would be managed by public authorities and include foreign companies, which are found to infringe upon certain human rights or social/environmental standards. Trade with these companies would consequently be forbidden.

3.2.2. The European Green Deal and the Circular Economy Action Plan

The European Green Deal (EGD) aims at transforming the EU economy in order to support the implementation of the EU's climate goal of reducing net emissions of greenhouse gases to zero by 2050 (EC 2019b). Carbon neutrality is to be achieved by decoupling resource use from economic growth. The EGD entails a variety of different actions, targeting industry, trade, industrial and agricultural production, the energy sector, mobility, housing, finance, research and development, and more. The EGD Investment Plan (also referred to as Sustainable Europe Investment Plan) is set to achieve at least EUR 1 trillion in sustainable investments over the next decade, and roughly half of the funding will be coming from the

[13] See https://www.europarl.europa.eu/doceo/document/TA-9-2021-0073_EN.html

EU budget (EUR 503 billion).[14] The EGD entails and has links to a large set of different strategies with implications on the sustainability and resilience of GVCs, including the Industrial Strategy, Carbon Border Adjustment Mechanism (CBAM), the Circular Economy Action Plan (CEAP), and various sector specific strategies, such as the EU Strategy on Clean Steel and the Chemicals Strategy for Sustainability, to name a few.

In March 2020, the European Commission adopted a new CEAP that builds on the CEAP of 2015 (EC 2020a). The new CEAP aims to accelerate transformational change related to the EGD through, amongst others, a product policy framework as well as policies to encourage the transformation of consumption patterns, enhance waste policies and reduce waste, and a monitoring mechanism.

The core of the legislative initiative on sustainable products is to widen the 2009 EU Ecodesign Directive,[15] which includes mandatory design requirements for energy-using and energy-related products. The new directive goes beyond energy-related products, since it is estimated that roughly 80 % of all products' environmental impact is determined during the design period (EC 2014). It is scheduled to be adopted by the EC in the first quarter of 2022.[16] The initiative towards a new directive prioritizes electronics, ICT, textiles, furniture, and high impact intermediary products (steel, cement, chemicals), but additional product groups may be identified in the future. The new directive will build on the EU Ecolabel Regulation, the Product Environmental Footprint (EFP) method and the EU green public procurement (GPP) criteria. The former is a voluntary environmental labeling scheme to support consumer choices. It is awarded to products and services, which have a lower environmental impact than other products in the same group.[17] The EFP method is in development since 2013 and depicts a life cycle based method to quantify the environmental impacts of products, goods and services with the aim to reduce these impacts (Zampori/Pant 2019). Finally, the voluntary EU GPP criteria aim to guide European public authorities to choose environmentally friendly goods, services and works when purchasing. In this context, the EC contemplates to introduce mandatory requirements linked to environmental and social aspects along the value chain, from production to end of life. A common European Dataspace for Smart Circular Applications with data on product information and value chains is to be established, and the enforcement of requirements is to be coordinated with national authorities (EC 2020a).

In order to empower consumers and public buyers, the EC proposed a revision of EU consumer law in order for consumers to receive relevant information on products at the point of sale (e.g., regarding life span, availability of repair services, spare parts, and repair manuals). In addition, consumer protection against green washing and premature obsolescence may be strengthened by setting minimum requirements for sustainability labels and information tools. A new 'right to repair' is also considered. Following a feedback phase

[14] The EU budget will trigger national co-financing for environmental projects of EUR 114 billion. In addition, it is planned to mobilize private and public investments through investments (InvestEU Programme) by the European Investment Bank Group (EIB) and other financial institutions (EUR 279 billion). An EU budget guarantee will allow the EIB to invest in higher risk investments, crowding in private investors. The plan also includes funds from EU emissions trading (EUR 25 billion). Finally, the Just Transition Mechanism of EUR 100 billion (from 2021-2027; or EUR 143 billion until 2030) will target regions most impacted by the transition.

[15] See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0125&from=EN

[16] See https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en

[17] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM%3Aco0012

and public consultation, the initiative, which was scheduled for the second quarter of 2021, is still pending.[18]

The new CEAP also highlights the importance of implementing GPP criteria, given that public authorities' purchasing power represents roughly 14 % of EU GDP per year (EC 2016). The EC is to propose minimum mandatory GPP criteria and targets in sectoral legislation, and also phase in a monitoring framework on the uptake of GPP. In this context, the "Public Buyers for Climate and Environment" initiative aims to disseminate good practices and encourage public buyers towards GPP implementation. According to the CEAP, actions for mandatory GPP criteria should be taken as of 2021 (EC 2020a). So far, the EC, however, only published revised voluntary GPP criteria for certain products and sectors.[19]

In addition, the new CEAP in connection with the Industrial Strategy and SME Strategy aims to promote circularity in production processes through (i) an assessment of the Industrial Emissions Directive, which regulates the permission and control of large industrial installations and the application of best available techniques (BAT); (ii) industrial-led reporting and certification system to facilitate industrial symbiosis; (iii) the implementation of a Bioeconomy Action Plan to support a sustainable and circular bio-based sector; (iv) digital technologies for tracking and mapping of resources; and (v) the registering of an EU Environmental Technology Verification scheme in order to support the uptake of green technologies (ibid.).

Further, the CEAP is linked to a selection of sector and product-specific policies (electronics and ICT; batteries and vehicles; packaging; plastics; textiles; construction and buildings; food, water and nutrients). For electronics and ICT, for example, the EC will present a Circular Electronics Initiative in line with the Ecodesign Directive. According to the EC's work program the non-legislative initiative should be put forward in the fourth quarter of 2021.[20] The initiative aims to improve the product design towards energy efficiency, durability, reparability, upgradability, maintenance, reuse and recycling for selected products (mobile phones, tablets, laptops, printers, etc.). The sector will also be a priority for implementing the right to repair. Other measures include regulatory measures to introduce a common charger and an EU-wide take-back-scheme for selected electronic products. Similarly, the evaluation of the Batteries Directive (a new draft was published in December 2020[21]) may change requirements on recycled content and introduce measures to increase recycling rates and the recovery of valuable material. In addition, due diligence (with regard to human rights violations and environmental pollution during production processes) and transparency requirements for batteries (e.g., regarding the carbon footprint of battery manufacturing) as well as the phase-out of non-rechargeable batteries are proposed (ibid.).

The EGD and all linked strategies are subject of critical debate (EuroMemo Group 2021, 2020), which is often related to the scale and scope of policies. The draft revision of the Batteries Directive (December 2020), for example, was welcomed by many civil society organizations (AK Rohstoffe 2021). However, they criticize that

[18] See https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12467-Consumer-policy-strengthening-the-role-of-consumers-in-the-green-transition_en

[19] See https://ec.europa.eu/environment/gpp/index_en.htm

[20] See https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-circular-electronics

[21] See https://ec.europa.eu/environment/topics/waste-and-recycling/batteries-and-accumulators_en

1. the due diligence requirements are not extensive enough since they do not cover all batteries and the whole value chain;
2. the directive only links to the OECD due diligence guidelines for minerals from conflict-affected or high-risk areas, and not to the more general UN Guiding Principles on Business and Human Rights and the OECD Guidelines for Multinational Corporations, since most raw materials for batteries are from regions that are not considered to be high-risk, even though these chains also suffer from social and environmental sustainability issues;
3. the list of included raw materials is not extensive enough;
4. firms need to improve stakeholder processes in order to assess sustainability issues on local levels better;
5. requirements regarding environmental due diligence are not precise enough, which could be improved by, for example, linking them to EU laws or international agreements;
6. the access to damage payments of affected actors in the value chain needs to be improved, e.g. by making firms liable under civil law;
7. firms' actions need to be verified;
8. the definition and human rights and environmental sustainability standards needs to be broadened by introducing an additional list of international instruments;
9. relevant state institutions need to have investigative authority, and should aim at assessing firms' practices along the whole value chain.

In sum, the CEAP is an important step toward promoting circularity, in particular by introducing sector- and product-specific regulations with a strong impact on the respective sector/product. These sector and product-specific changes are important and will, over time, have significant sustainability effects, in particular if the scope of policies will be broadened further. However, an industry-wide and fully-fledged transformation of GVCs towards circularity should not be expected in the near future, since the scope of most policies is currently very limited. The Batteries Directive, for example, highlights that important and major regulatory changes are under way, but also that more extensive regulations are currently blocked by the corporate sector.

In addition, the analysis highlights that current sustainability initiatives – so far – are not linked to supply chain resilience in a comprehensive way. However, some sustainability measures of the EGD and CEAP, such as a prolonged durability of products and reusability, will also benefit the resilience of GVCs.

4. GVC Resilience and Sustainability: The Case of Medical Products

In this section, we discuss the medical products[22] GVCs, with a particular focus on the EU medical product sector, the impact of COVID-19, and sustainability issues. In addition, we assess resilience and sustainability strategies of firms in the medical products sector as a result of COVID-19.

4.1 The medical products GVC

Medical products, i.e. medical equipment excluding pharmaceuticals, cover a wide range of different product categories (Hamrick/Bamber 2019). They include products with limited complexity such as bandages, syringes and Personal Protective Equipment (PPE) (e.g., surgical gloves, facemasks, coveralls or safety glasses), and technically complex medical devices such as MRI scanners or ventilators. The main segments of the medical products GVC include (i) research and product development (R&D); (ii) components manufacturing; (iii) assembly; (iv) distribution; (v) marketing and sales; and (vi) post-sales services (ibid.) (Figure 8).

R&D represents the highest value-added stage of the value chain, whereas, in most instances, manufacturing delivers the lowest value-added. The R&D process of medical devices is complex and time-intensive because each element and functionality of a product must receive regulatory approval by the authorities in the relevant markets. Investment in R&D is much more important for complex medical devices as compared to PPE. Typically, R&D departments are located in high-income economies providing the necessary human capital and the benefit of knowledge spillovers from universities or related companies.

Official standards apply to virtually all medical products. Standard requirements increase with the potential hazards associated with the malfunctioning of the respective medical product. Even though regulation for PPE is less strict than for medical devices, regulation issues remain highly relevant. In the EU, standards of medical products are subject to the Medical Devices Regulation (MDR). Following a risk-based scheme, it divides medical products into four classes (see Figure 9).[23]

[22] This section is based on Raza et al. (2021a) and Grumiller et al. (2021).

[23] The MDR entered into force in in 2017 and is applicable since May 2021. It replaced the Medical Device Directive (MDD), which was adopted in 1993 and repeatedly updated. The MDR maintained the classification scheme of the MDD with minor changes.

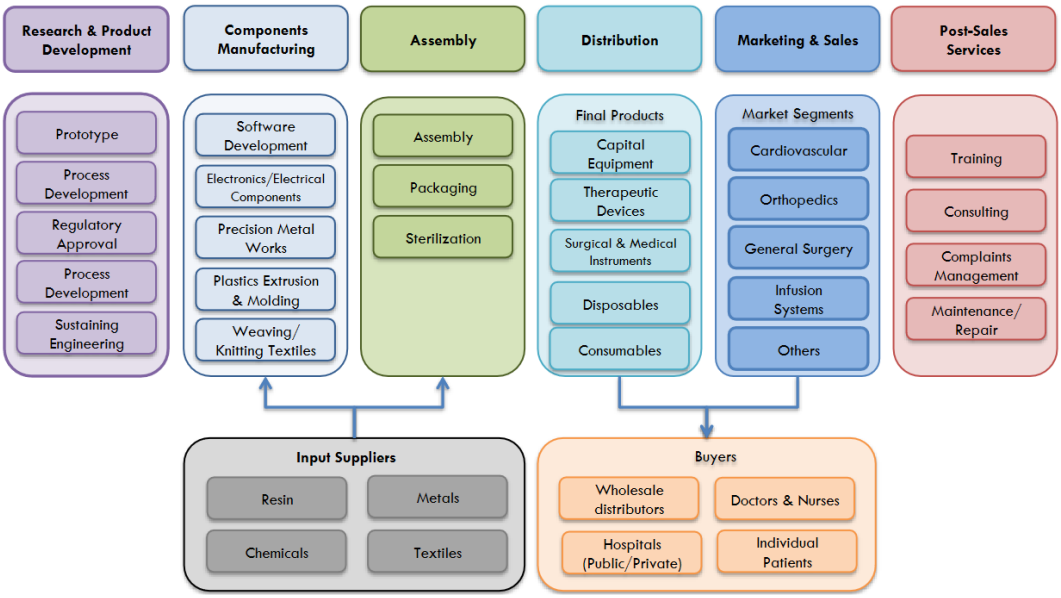

Figure 8: GVC of medical products. Hamrick/Bamber (2019)

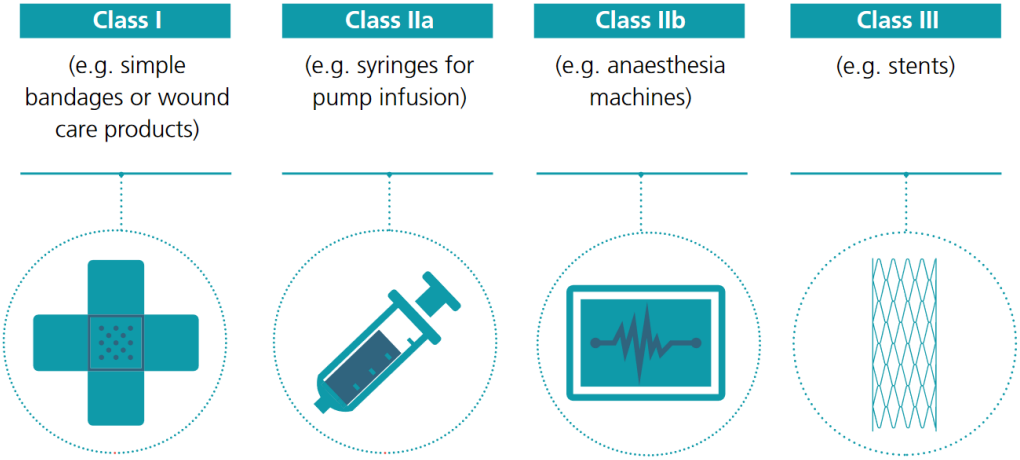

Figure 9: EU Classification of Medical Products. MedTech Europe (2021).

During the last decades, outsourcing and offshoring processes had important effects on the structure of the medical product GVC. Compared to other industries, the process of outsourcing and offshoring medical products to lower-cost countries has been relatively slow because of the need to deliver high and consistent quality in line with demanding regulatory frameworks (Bamber et al. 2020). Outsourcing and offshoring to lower-cost countries has been more pronounced in the case of low-tech medical products, but it is also on the rise with respect to more complex medical devices (ibid.). While medical device companies have traditionally been vertically integrated to protect intellectual property, this has changed over the last decades, and outsourcing to contract manufacturers is on the rise. The same holds true for just-in-time production and single-sourcing (i.e. buy-

ing inputs from one supplier only), both of which are strategies employed to increase efficiency and reduce costs (Ebel et al. 2013; Park et al. 2020). However, medical device GVCs are still dominated by a small number of multinational lead firms primarily based in the EU and the US. The lead firms in the PPE chains, in contrast, are highly diverse and come from the Global North and the Global South. For example, 3M is a major US firm with operations in 70 countries, selling more than 60,000 different products across 200 countries, including facemasks in Europe, Asia and the US.[24] In contrast, Malaysian-based Hartalega is a leading global producer of surgical gloves with no manufacturing plants outside of Malaysia.[25]

Today, China plays a particularly important role as a producer and consumer in medical products GVCs. Even though facemasks are produced in a variety of countries, China remains the market leader. In addition, China's role in the medical device sector is constantly increasing. This can be explained by the country's vast domestic market, its growing demand for medical products, and an ambitious industrial policy aimed at building up a globally competitive medical device industry, thereby reducing the country's import dependency. Medical devices figure prominently in the industrial policy strategy 'Made in China 2025' with the aim of increasing domestic content of advanced medical devices to 70 % (Congressional Research Service 2020). An important policy instrument has been to instruct local hospitals to buy domestically produced medical devices from Chinese firms (Collins 2019). So far, the strategy seems to have been successful, and the country's medical device sector is experiencing a period of upgrading dynamics: Once dominated by low-value-added activities, FDI projects in China are now driven by activities with high-value-added, and the exports of medium to high-tech medical devices have been exceeding low-tech exports since 2012 (Torsekar 2018). Companies such as Mindray, founded in 1991 and located in Shenzen, have managed to become lead firms in the GVC, and the shortages during the pandemic enabled Chinese firms to enter European markets in areas such as ventilators, a market segment from which Chinese products had previously been shunned (Kamp 2020).

Given the large differences between products, the governance structures of medical product GVCs also differ. Producer-driven chains in which the producers themselves are the powerful firms structuring the GVC are typical for more complex medical devices (Hamrick/Bamber 2019). Market-driven chains (i.e. chains in which the transactions are not very complex and can be easily codified, and the suppliers have the capabilities to produce without significant input from the buyers), in contrast, are common for PPE products.

The market for medical products is a global growth market. Between 2002 and 2016, global imports of medical products increased by 227 % with even higher growth rates in upper and lower middle-income countries (382 % and 454 % respectively). By comparison, total imports of the world economy grew by about 147 % over the respective time-period. High-income countries still account for the largest share of medical imports (81 % in 2016) with the EU-15 being the major buyer of global production followed by North America and East- Asia-Pacific (ibid.).

The medical products market in the EU continues to be rather large. It is estimated at around EUR 140 billion in 2020, with more than 33,000 manufacturers employing almost

[24] See https://www.3m.com/3M/en_US/company-us/about-3m/history/ (04.11.2020)
[25] See https://hartalega.com.my/about-us/ (04.11.2020)

760,000 people. Based on manufacturer prices the European market accounts for 27.6 % of the world market (MedTech Europe 2021). In 2019, the EU trade surplus in medical products amounted to EUR 115 billion (Eurostat 2021).[26] This surplus is mainly attributable to medical consumables (EUR 80 billion), instruments and apparatus used in diagnostic testing (EUR 20 billion), medical devices and equipment (EUR 10 billion), and medical vehicles and furniture (EUR 8 billion). Trade deficits are observable in the product categories protective garments (EUR 4 billion) and disinfectants and sterilization products (EUR 0.5 billion). However, import values are also high for product categories with a trade surplus (see Figure 10). This highlights import dependencies for specific products or inputs.

In general, the main final buyers of medical devices in the EU are public hospitals or associations of hospitals at the regional or federal level. They source complex products such as ventilators directly from medical device producers and PPE via wholesale distributors. The final buyers have only limited knowledge about the actual organization of production processes, which limits their capacity to evaluate potential risks in the supply chain. Hospitals also recently moved towards adopting just-in-time inventories and sourcing from fewer suppliers to reduce costs, which has negatively affected the security of supply of many hospitals during the COVID-19 pandemic (Gereffi 2020; Vecchi et al. 2020). This, of course, mirrors the efforts to introduce just-in-time production by producers and illustrates the cost pressures that diverse actors face in the medical device value chain.

4.2 GVC resilience and impact of COVID-19

Before the COVID-19 pandemic, supply chains for most medical products worked smoothly, delivery times were short, and delays the exception. The pandemic mostly affected the medical product supply chains relevant for fighting the pandemic, in particular PPE. With the exception of ventilators, medical devices played a minor role in fighting the pandemic. The sudden surge in demand for medical products such as surgical gloves, facemasks, respirators and ventilators triggered by the outbreak of SARS-CoV-2 led to supply and production bottlenecks for these products. In addition, prices skyrocketed as governments competed to get as much equipment as possible. For example, export prices for respirators and surgical masks from China increased by 182 % from February 2020 to March 2020 (Bown 2020).

Comparing EU exports and imports of COVID-19 related medical products of 2019 and 2020, the trade surplus decreased by EUR 21 billion to EUR 94 billion (Eurostat 2021). The decrease is in particular attributable to sharp increases in imports of protective garments by EUR 26 billion to EUR 30 billion. A trade surplus increase is observable for medical consumables (EUR 90 billion; + EUR 10 billion) as well as for instruments and apparatus used in diagnostic testing (EUR 22 billion; + EUR 2 billion). However, in all other product categories trade surpluses decreased or trade deficits increased (see Figure 10). On a product level, the overwhelming increase by 156 % of the imports of protective gar-

[26] There are no specific HS codes for different types of medical products. Rather, medical products are subsumed in different HS codes. The Eurostat 'EU trade since 2015 of COVID-19 medical supplies' database provides a dataset that aggregates products from different HS code groups in categories corresponding to the different types of medical products (see Figure 10). In many cases, the HS codes cover more products than just the respective medical products. The here presented data should thus be interpreted with caution.

ments is mainly attributable to facemasks. Their import volume increased from EUR 2 billion to EUR 22 billion, that is, by 1000 %.[27] This increase, however, is not only due to higher trading volumes, but also due to the skyrocketing prices of facemasks during early periods of the crisis (e.g., Bown 2020). In contrast, imports of rubber gloves increased by about 72 % from EUR 2 billion to EUR 3.5 billion, and prices for rubber gloves remained mostly stable within this period (Eurostat 2021).

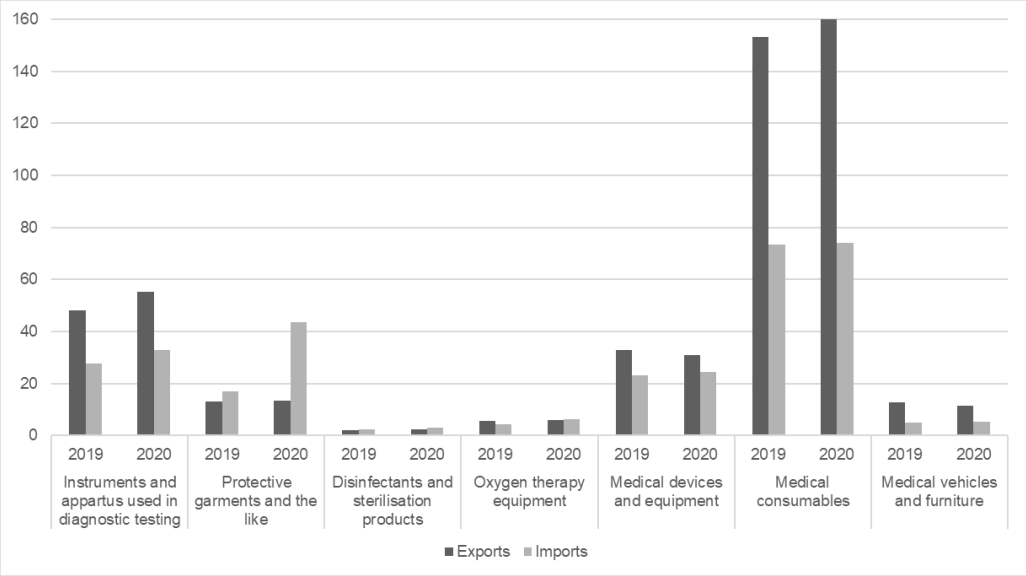

Figure 10: Comparison of EU exports and imports of medical products in 2019 and 2020, in billion EUR. Eurostat (2021) + HS codes 63079010, -98. Note: excl. intra-EU trade.

Even though the sudden surge of demand during the pandemic was the main challenge for medical product supply chains, the pandemic also revealed product-specific vulnerabilities. In the case of respirators and surgical gloves, for example, the supply chain vulnerability is particularly related to the geographic concentration of production in China and Malaysia. China, the main producer of respirators, was the first country affected by the COVID-19 pandemic and seized masks produced in China for domestic use, while also increasing production and exports of masks in the period March-April 2020 (Fuchs et al. 2020). In terms of inputs, the main bottleneck to the upsurge of mask production in Asia, the EU and the US was the limited supply of meltblown non-woven fabric (Dallas et al. 2021). Export bans, logistical problems and shortages of packaging materials due to company shutdowns in the pulp and paper industry also added to the problem (Park et al. 2020).
For a variety of reasons, including climatic conditions necessary for production, access to raw materials, low wages, and industrial policy support, the global production of surgical gloves is mostly concentrated in Malaysia (Yazid/Yatim 2014). While many Malaysian

[27] Until 2021, FFP and other protective masks of textile material did not have their own HS code, but were subsumed under HS 63079010 and -98 together with other made-up textile articles. Therefore, it is not possible to track exclusively facemasks in the trade data. However, given that there has been an extreme increase in trade under this HS code since April 2020, it is very likely that this is primarily due to an increase in trade of facemasks (see also Dallas et al. 2021 for this argument). In 2021, HS codes for FFP masks and other protective masks of textile material were introduced (HS 63079093, -95) and included in the Eurostat database.

manufacturers operated well within their emergency capacities, bottlenecks ensued during the first phase of the pandemic when shutdowns affected the supply of packaging material. The geographic concentration of surgical gloves in Malaysia represents a substantial cluster risk. If for any reason production in Malaysia collapses, severe shortages will occur on global markets, in particular since setting up new production lines is extremely costly, requires a time horizon of 2-4 years, and hence surge capacity in periods of crisis is limited.

The EU's trade data reflect the geographic concentration of facemasks and rubber gloves and reveals its high dependence on China and Malaysia with respect to these products. From January to August 2021, the EU imported FFP2 and other protective textile facemasks in the equivalent value of EUR 2 billion. 87.7 % of these imports originate from China. In the same period, EUR 4 billion was spent on imports of (surgical and non-surgical) rubber gloves. Malaysia's share of these imports is 59 %. (Eurostat 2021).Ventilators are a different example in terms of geographic dispersion of production and GVC vulnerability. Three European lead firms, which together account for roughly 60 % of the global ventilator market, dominate the industry (Müller 2020). Thus, know-how as well as productive capabilities are available within the borders of the EU-27. However, the suppliers of these firms are scattered around the world (Netland 2020). The surge capacity of the ventilator producers was limited because automation of production is low and hiring workers with the relevant skills at short notice is difficult. The strict regulatory framework as well as the complexities of ventilators create barriers to entry for new, inexperienced producers (Azmeh 2020). Just-in-time production and single sourcing are further sources of vulnerability. Furthermore, several components are produced by just one global supplier. As a result, one of the major reasons for delays in the production of ventilators was due to the temporary closure of a major Asian chip producer.

4.3 Sustainability issues

Most of PPE consists of cheap single-use products made of plastic and synthetic fibres (Prata et al. 2020). Face masks and gloves are commonly made of plastics such as polypropylene, polyurethane, polyacrylonitrile, polyethylene, and polyethylene terephthalate, which can take up to 450 years to fully decompose (Zhang et al. 2021). The environmental damage of plastic products was already discussed before the COVID-19 pandemic. Without proper recycling, disposed PPE contributes substantially to hazardous environmental pollution (Singh et al. 2020). Microplastics end up in food chains and maritime systems and endanger the health of humans as well as animals (Saliu et al. 2021; Zhang et al. 2021). Reports about abusive working conditions in the glove industry also highlight a lack of social sustainability in some medical product GVCs (Bhutta/Santhakumar 2016).

During the crises, the demand for PPE surged by 300-400 % (FCDO 2021)[28] and clinical and household waste increased accordingly. Estimates suggest that 65 billion gloves and 129 billion facemasks have been used every month since the outbreak of COVID-19 (Prata et al. 2020). In Wuhan, at the height of the pandemic, about 240 tons of medical waste were generated per day, six times more than before the outbreak (Singh et al. 2020). In many countries, the volume of waste outstripped the capacity of incinerators and the much more problematic use of landfills, with the result that the improper discard of PPE

[28] See https://www.ifc.org/wps/wcm/connect/Industry_EXT_Content/IFC_External_Corporate_Site/Manufacturing/ Priorities/PPE +Production+and+Uses/

increased (Zhang et al. 2021). Recent environmental research reports show that PPE litter has been increasingly found on land, in the stomach of animals and in the oceans (Hiemstra et al. 2021).

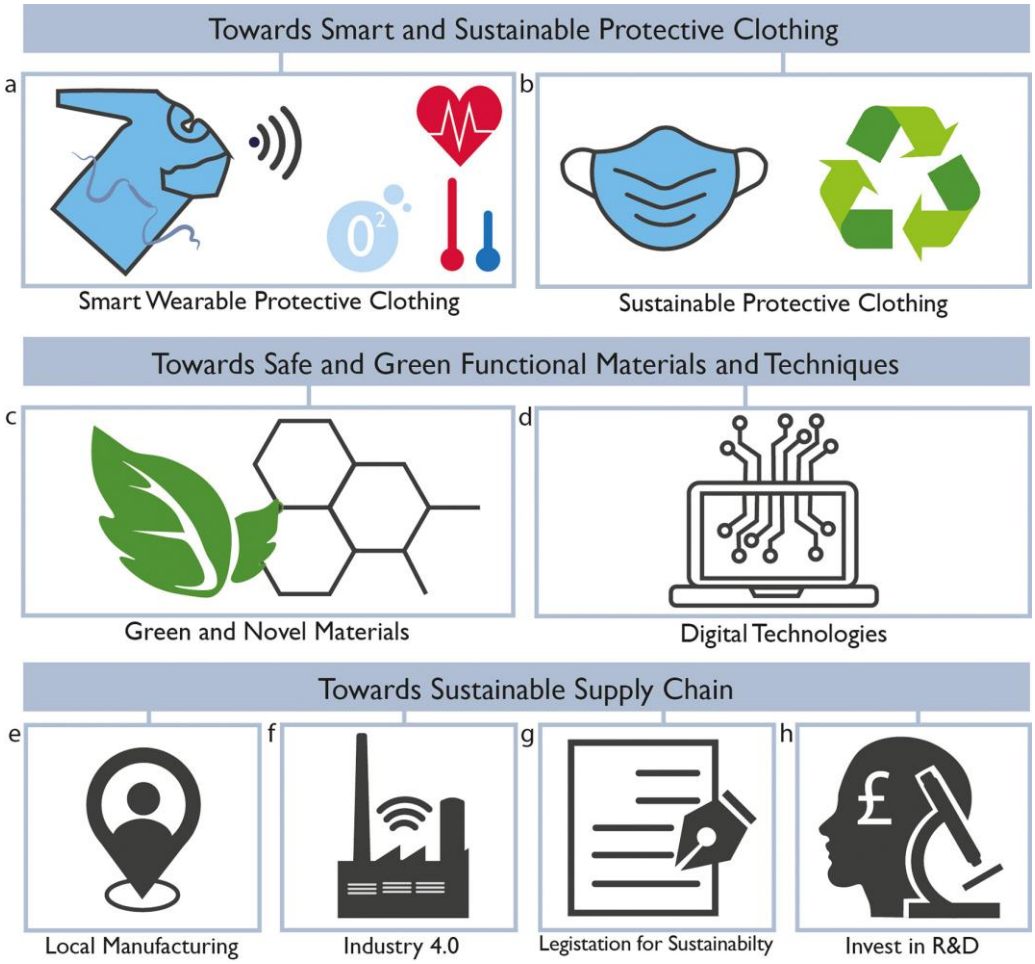

Figure 11: Sustainability in the PPE sector. Karim et al. (2020).

Yet, it is not just the disposal of PPE-related waste but also the emissions generated by the production process that have profound ecological implications. For instance, the production of gloves is very resource intensive and requires either oil or rubber latex, high temperatures and substantial amounts of chemicals and water as critical inputs. In contrast, many medical products such as ventilators have a comparatively long life cycle of about 10 to 15 years and environmental issues do not seem as problematic. Yet, historically this life cycle shortened, product design developed in way that favored the interests of ventilator companies, that is, ventilators became more complex and harder to maintain (Azmeh 2020). The rising spatial dispersion of the production network also led to more transport by planes and ships. Shorter life cycles induce hospitals to scrap increasingly large numbers of ventilators, which subsequently are predominately donated to hospitals in low-income countries. Because they lack skills and equipment, "up to 70 percent of these equipment lies idle, and eventually are thrown away and treated as waste" (Feng 2020),

thereby contributing to the increasingly pressing problem of discharging e-waste in the Global South.

Even though there has been some progress in increasing the environmental sustainability of medical products GVCs, in particular with regard to recycling rates and more sustainable products and processes[29], there has been no structural shift towards increasing environmental sustainability. In this context, calls for introducing circular processes, in particular in the PPE industry, are wide-spread (see e.g., Debnath et al. 2021; Teymourian et al. 2021; Yuan et al. 2021). However, introducing circularity in PPE GVCs would require a systematic rethinking of product design, production, usage, waste management, and more ('5Rs') (Fang et al. 2021). Similarly, Karim et al. (2020) argue that the shift towards more sustainability in the PPE sector needs to be threefold (Figure 11): i) smart and sustainable protective clothing (e.g., reuseable, washable, and recyclable), ii) safe and green functional materials and techniques to produce clothing; and iii) sustainable supply chains relying on local manufacturing, industry 4.0 and sustainability oriented legislation and R&D. In this context, it is argued that introducing reusage and recycling in PPE GVCs could also benefit security of supply and alleviate crisis-induced shortages (Potter 2020).

4.4 Post-COVID-19: Resilience and sustainability strategies

In this section, we present a summary of the explorative semi-structured interviews that were conducted with representatives of 27 firms, industry associations, and public institutions in, and related to, the medical products sector between August and October 2020, and between October and November 2021 (see Annex). The interviews aimed at assessing the role of resilience and sustainability in their supply chain management, in particular in light of the COVID-19 pandemic. The following key conclusions emerged from the interviews:

- Buyers of medical products rarely pay a premium for security of supply and sustainability, which is why firms continue to focus on efficiency

Overall, similar to most other sectors, buyer requirements in the medical products sector continue to focus on price, quality, and reliability, and to a lesser extent on resilience and sustainability. However, the medical product sector is special since public institutions are by far the most important buyers, and product regulations are highly stringent. For this reason, public procurement practices and public buyer requirements are of particular relevance in order to promote the resilience and sustainability of medical product GVCs. So far, however, also most public buyers rarely pay a premium for security of supply or sustainability. As a result, the CEO of an EU medical products trader with over 250 suppliers in the EU, Asia and the US argues that – so far – no comprehensive shift of firms' strategies has taken place: "There is no change (in PPE GVCs, added by the authors). You only have to look at the buying criteria. They (health insurances, hospitals, private medical practitioners, etc., added by the authors) buy the cheapest products. It's as simple as that (translated by the authors)." This is also reflected in the experience of a large and vertically integrated European medical glove manufacturer: "We developed a [more sustainable medical glove] (product name changed by the authors), but nobody wanted to buy it because it was 15-20 % more expensive compared to the normal and less sustainable products. […]

[29] See https://www.theguardian.com/corporate-sustainability-in-practice/2021/sep/17/face-masks-ppe-and-throwaway-cutlery-after-covid-wheres-next-for-sustainable-packaging

For this reason, buyer-requirements are the major obstacle for us to produce more sustainable products (translated by the authors)."
Similarly, a large and vertically integrated German mask manufacturer highlights that it has invested in meltblown and surgical mask production, can offer better security of supply due to regional value chains, higher quality, a lower environmental footprint (in particular with regard to CO2 emissions) and better certifications (environmental and dermatological) compared to most foreign competitors, in particular from China, and still offer his products at a competitive price. However, it remains to be seen whether buyers are willing to pay the premium of 20-25 % relative to Chinese competition after the pandemic.

- Many firms in the medical products sector – so far – are not implementing a comprehensive resilience strategy or measures to increase the resilience of their supply chains

So far, our interviews do not indicate that a comprehensive strategic shift of companies towards increasing supply chain resilience has happened in the medical products sector. Even though the interviewees indicate that some firms have increased or aim to increase redundancies such as stocks, the following statement of a large EU medical products trader summarizes the general sentiment of the interviewed firms: "Additional storage is not competitive and often also not practical. In addition to the high cost, a major problem is that in the case of medical products, you need to flexibly configure and individualize products, even in cases you would not expect that to be necessary (translated by the authors)."

In addition, the interviews indicated that the efforts to diversify supply chains to reduce regional clusters or single sourcing are currently very limited, because supply chain diversification can be extremely costly and challenging. This is because supply chain management costs in case of multiple sourcing can be very high due to complex buyer-supplier relationships in light of stringent EU regulations and buyer requirements, lengthy and complex product accreditation processes for medical products, and often years of experience in working together. Nonetheless, a supply chain manager of a leading medical product manufacturer in the EU indicated that efforts for incorporating multiple sourcing strategies for new products have been stepped up, since the existing product portfolio is already accredited and it is not feasible to change sourcing strategies for these products. Overall, the sentiment is that multiple sourcing strategies could thus play a more important role in the future, but that the high cost of multiple sourcing for many products (particularly depending on the complexity of buyer-supplier relationships) is an important limiting factor.

The diversification of suppliers can also be limited by other factors, for example in the case that only few suppliers of specific products exist. Manufacturers of ventilators, for instance, cannot diversify their sourcing of semiconductors easily, given the lack of alternative suppliers. The diversification of production locations, in addition, is particularly costly in the case of vertically-integrated firms. The regional cluster of medical glove production in Malaysia, for example, is likely to persist without strong government incentives, since currently the business case for manufacturers to expand capacities and produce elsewhere simply does not exist.[30] In addition, many bottlenecks and trade disruptions that firms experienced during the COVID-19 pandemic were out of their reach, e.g. due to lock-

[30] This is also related to the already existing excess capacities of many Malaysian manufacturers.

downs, export restrictions, or a lack of alternative suppliers. In this context, many managers do not feel like they can tackle these risks without incurring the risk of non-feasible investments.

Notwithstanding these limitations on strengthening GVC resilience in a comprehensive way, trends towards increasing the transparency and the digitalization of supply chains have accelerated. In this context, linking suppliers through electronic management systems to better track inbound freight and manage inventories has increased in importance. To some extent this strengthens the resilience of supply chains.

- Currently (as of November 2021), most firms do not or only indirectly combine their strategies on resilience and sustainability

Based on our interviews, there is no indication that firms' in the medical product sector tend to have a comprehensive and combined strategy on resilience and sustainability. This seems to be related to a variety of reasons. In many cases, this is because many firms generally lack a comprehensive resilience or sustainability strategy. Despite lacking comprehensive strategies, firms do engage in corporate social responsibility practices such as supplier firm audits and have implemented some measures to increase supply chain resilience. Larger firms, in particular, often have a distinct sustainability strategy that targets the practices of the whole company, but they often lack a comprehensive supply chain resilience strategy.

Larger firms and corporations listed on the stock exchange also often engage in Corporate Sustainability Reporting (as will be mandatory for almost all companies in the EU by 2023/2026, depending on the size of the firms). These firms also tend to have a sustainability framework with clearly defined goals in place. However, supply chain and related management branches within firms generally seem to implement their strategies without directly taking into consideration sustainability issues. Instead, supply chain management is mostly driven by efficiency considerations and the impact of supply chain practices on sustainability is often not assessed during the strategy formulation process.

However, the recent (debates on) due diligence laws have to some extent increased awareness of supply chain managers. Various measures to increase the efficiency of supply chains, such as more efficient transportation logistics, also have positive effects on environmental sustainability, but are often not implemented in the context of environmental sustainability concerns. Some interviewed managers believe that major change is only likely to happen in the context of more profound government interventions, such as a CO2 tax. Measures to increase resilience, in contrast, are generally often limited due to economic feasibility concerns, and thus mostly discussed in the context of efficiency gains or losses. Overall, supply chain resilience and sustainability are so far not systematically integrated in the supply chain management practices of most firms.

- Long-term security of supply for locally-produced and critical COVID-19 products is under pressure

During the COVID-19 pandemic, many firms in the EU invested – often with the help of the government – in new production facilities of critical COVID-19 products, in particular for meltblown and facemask production. This included both firms that already had experience in the business, firms that had expertise in similar businesses, and newcomers that

did not have any related experience. Following the early period of the COVID-19 pandemic, these new suppliers helped to satisfy demand in addition to imports in particular from China. However, over time, global and EU capacities increased, stocks were filled, and demand in the EU reached its peak. Today (December 2021), European meltblown and mask producers are under strong pressure from Chinese competition. Many firms also argue that China is currently dumping their facemasks on the EU market in order to destroy newly established competitors. For this reason, many newly established firms are already out of business (in particular newcomers). But also other firms are currently evaluating whether the operation of their business will be viable in the future. This is because production prices in the EU are roughly 20-25 % higher compared to China, and it remains unclear whether public buyers will pay a premium for security of supply as well as higher quality and sustainability standards in the future.

5. Conclusions and Policy Recommendations

This report argued that since the emergence of GVCs, firms primarily focused on GVC efficiency and largely disregarded GVC resilience and sustainability. In many GVCs, increasing GVC resilience and sustainability requires policy interventions since the desired societal level of GVC efficiency, sustainability, and resilience differs from firms' perspectives, not the least because increasing the resilience and sustainability can be very costly and challenging for firms. Overall, GVC efficiency, resilience and sustainability have important trade-offs and compatibilities that policy-makers need to be aware of. In general, a strong focus on resilience and sustainability, to some extent at the cost of efficiency, can be operationalized in terms of either resilient sustainability or sustainable resilience. Resilient sustainability prioritizes sustainability over resilience, and is thus characterized by low carbon-emissions of trade and (as a tendency) shorter supply chains, high levels of circularity and environmental standards, which is why this model tends to be more regionalized or localized. To account for resilience, these regional value chains (RVCs), in addition, are characterized by a certain degree of redundancies and possibly diversification in order to withstand shocks. Sustainable resilience, in contrast, prioritizes resilience over sustainability and focuses on increasing the resilience of (global) value chains in the most sustainable way. This is usually achieved by diversification of sourcing, both regionally and with respect to the number of suppliers, increasing redundancies as well as stockpiling, while at the same time promoting higher levels of resource and energy efficiency in the supply chain.

The policy-goals and GVC models, however, do not necessarily entail a classical trilemma between efficiency, resilience and sustainability, since one can, for example, opt for highly efficient and sustainable RVCs, or increase the resilience of today's efficient GVCs in a sustainable way (e.g., by sourcing from more sustainable production units in the context of diversification processes). The efficiency, resilience and sustainability of GVCs are thus better understood in relative terms, with economic policy and firms facing the task to optimize the most promising combinations between the three objectives.

The question of which GVC model should be pursued also depends on sector specifics. Against the current situation of highly globalized value chains in manufacturing industries and the expected high efficiency losses of regionalization strategies, the concept of sustainable resilience is arguably the most appropriate GVC model in many cases, if one wants to improve both resilience and sustainability. In this case, policy-makers may want to promote the sustainability and resilience of GVCs by focusing on reducing the environmental footprint and increase social sustainability standards as well as supply chain diversification and redundancies. In contrast, in already more regionalized production systems and selected strategic sectors, such as for instance in agriculture, resilient sustainability might be the preferable option.

5.1 Assessment of GVC resilience and sustainability policies

The assessment of policies of particular relevance for GVC resilience highlighted that they were motivated by the COVID-19 pandemic but increasingly also by geopolitical considerations. Strategies like the US Executive Order 14017, the EU's open strategic autonomy concept, and the regional SCRI by Japan, Australia, and India are all linked to geopolitics, and in particular to the economic rivalry with, and import-dependencies from China. Sustainability policies in contrast have traditionally been motivated by public pressure as well as consumer preferences for promoting social justice and environmental standards, the latter being reinforced more recently by the climate crisis.

The analysis revealed that most of the policies assessed in this study do not link GVC resilience and sustainability in a comprehensive and systematic way (Table 3). Instead, most policies focus either on GVC resilience or on GVC sustainability. The most important exception is the US supply chain strategy under Executive Order 14017, which integrates elements of resilience as well as social and environmental sustainability. In contrast to most efforts in the EU, the strategy has a strong focus on promoting domestic manufacturing and reshoring for strategically important and critical products (e.g., batteries, APIs, semiconductors, various minerals). The selection of strategically important products has various reasons, but also reflects sustainability concerns (e.g., the promotion of batteries production and the transformation towards electric vehicles). Notably, the strategy includes a comprehensive set of instruments, including, amongst others, (i) financial support to promote domestic investment in manufacturing, R&D and workers' skill development, (ii) consumer rebates and tax incentives to expedite consumer adoption of electric vehicles, (iii) adjustments of public procurement to strengthen US supply chains (e.g., domestic production requirements), (iv) increasing of US strategic stockpiles, (v) improve the transparency of selected GVCs, and finally (vi) potentially profound institutional changes to strengthen the public management of GVC resilience. In addition, the strategy also stresses the importance of trade policy and international cooperation in tackling bottlenecks in GVCs during crisis situations.

In contrast to the US, the EU's open strategic autonomy concept increasingly incorporates aspects of GVC resilience. But, so far, extensive measures to promote GVC resilience (in terms of diversification and redundancies) on the EU level are missing. Instead, the EC focus is on creating opportunities for diversification through trade policy. Only in the case of some sector-specific strategies such as the pharmaceutical and chemical strategies, more extensive measures to promote GVC resilience, security of supply, and potentially reshoring, are being discussed. With the notable exception of strategic stockpiling, it remains thus unclear how the EU wants to promote GVC diversification and redundancy.

The supply chain and due diligence laws, in contrast, are arguably the most important initiatives to promote GVC sustainability. In this context, the UN, OECD and various national initiatives – such as Section 1502 of the Dodd-Frank Act, or the German *Lieferkettengesetz* – have implemented due diligence laws, though with notable differences. In the EU, the most important initiative towards increasing environmental sustainability is undoubtedly the European Green Deal (EGD), with important implications for EU policies in general, including industrial and sector-specific strategies. Even though the specifics and thus the effectiveness of most of these policies remains to be seen, preliminary lessons drawn from those sustainability initiatives already in place, such as the French *Loi de Vigilance* or the EU Conflict Minerals Regulation, highlights that the scope of the respective regulation, as well as liability issues and sanction mechanisms are particularly challenging in designing

such policies. In many cases, the effectiveness of policies is curtailed due to their limited scope and low liability obligations for firms.

		Resilience	Sustainability
Resilience-focused initiatives			
Executive Order 14017: America's Supply Chains	US	+++	+
Open Strategic Autonomy	EU	++	o/+
Supply Chain Resilience Initiative	Japan, Australia, India	+++	o
Sustainability-focused initiatives			
European Green Deal and the Circular Economy Action Plan	EU	o/+	+++
Supply chain and due diligence laws	Various	o	+++
Sector-specific EU strategies			
Pharmaceutical Strategy	EU	?	+

Table 3: Overview on resilience- and sustainability-focused strategies. Own elaboration. Note: +++ = strong focus; ++ = medium focus; + = low focus; o = no focus; ? = to be negotiated

5.2 GVC resilience and sustainability in the medical products GVC

The analysis of the medical products GVC has highlighted the large diversity of product-specific supply chain structures and bottlenecks, the latter being primarily related to single sourcing and regional clusters. Overall, security of supply is an issue of particular relevance in the case of PPE. The main reasons for supply chain disruptions during the COVID-19 pandemic were related to a strong increase in global demand, production stops during lockdowns, and export restrictions as well as other COVID-19-induced global or regional trade barriers. In addition, we have argued that many medical product GVCs suffer from a large variety of social and environmental sustainability issues, including the high environmental impact of mostly single-use PPE in general and the poor working conditions in the medical gloves industry in particular.

The analysis of firms' resilience and sustainability strategies revealed that many firms in the medical products sector – so far – are not implementing a comprehensive resilience strategy to upgrade their supply chains. The main reason for this is that supply chain management costs of stocks and multiple sourcing can be very high due to complex buyer-supplier relationships (in particular in the case of medical devices) in light of stringent EU regulations and buyer-requirements, lengthy and complex product accreditation processes for medical products, and often years of experience in working together. The diversification of suppliers can also be limited by other factors, for example in case that only a limited number of suppliers of specific products exists. A major limiting factor, in addition, is that buyers of medical products – including public institutions as the most important buyers of medical products – rarely pay a premium for security of supply and sustainability, which is why firms continue to focus on efficiency.

Another issue is that the recent efforts in many EU countries to support domestic manufacturing of critical products during the COVID-19 pandemic, in particular meltblown and facemask production, are under pressure. Domestic manufacturers in Germany and elsewhere may close down their operations due to strong international competition, in particular from China, in light of enlarged global capacities and sluggish demand development due to full stocks of many private and public buyers. In this context, much will depend on (public) buyers and their willingness to pay a premium for domestically produced products that benefit security of supply and are – generally speaking – often of higher quality and have better sustainability certifications compared to imported products from China.

5.3 Policy recommendations

Based on our assessment, but also drawing on Grumiller et al. (2021) and Raza et al. (2021a, 2021b), we have developed the following policy recommendations:

1. Policy-makers need to promote sustainable resilience and resilient sustainability in selected GVCs. The trade-offs and compatibilities between GVC efficiency, resilience and sustainability need to be assessed on a sector-by-sector and product-by-product basis.

Since the emergence of GVCs, firms have put a strong emphasis on supply chain efficiency, and mostly disregarded resilience and sustainability. From a policy perspective, the mismatch between firms' and societal perspectives on the desired levels of efficiency, resilience and sustainability will require a comprehensive policy-mix in many cases. This policy-mix needs to take account of sector- and product-specific characteristics. In general, policy interventions should be more comprehensive in case of strategically important and critical sectors and products. In this context, the emphasis on GVC efficiency, resilience and sustainability, respectively, needs to be calibrated according to the specific strategic goals. In the case of critical products required during crises such as a pandemic, for example, policy-makers could opt for a strong emphasis on resilience, but still seek to adopt measures that minimize negative impacts on efficiency and sustainability (efficient and sustainable resilience). Contrariwise, the promotion of more sustainable production systems and GVCs, as envisioned in the EGD, should ensure to the extent possible that a defined sustainability standard is achieved in the most efficient way, and that the sustainability measure employed, such as e.g. re-use, recycling, product quality standards, are organized in a resilient way (efficient and resilient sustainability).

Admittedly, policy-makers will not be able to avoid trade-offs at all, because, for example, promoting resilience through a diversification of suppliers and increasing redundancies will very likely have negative impacts on sustainability and efficiency. Policy-makers will thus need to accept certain efficiency losses and costs arising through policies that increase resilience and/or sustainability in selected GVCs. In this context, policy-makers should aim to exploit the compatibilities between efficiency, resilience and sustainability. A diversification of suppliers, for example, could go hand in hand with measures to promote a higher level of energy efficiency in new production facilities. Moreover, increasing GVC sustainability could be combined with regionalization processes that reduce CO2 emissions in transport (and potentially also in production), but also support security of supply for critical products in case of crises and global trade disruptions.

2. Policy-makers need to select a sector- and product-specific policy-mix

Even though horizontal policies such as a CO2 tax will have profound impacts across sectors, a policy mix promoting sustainability and resilience will need to take into account sector- and product-specific characteristics. The current US initiatives under Executive Order 14017, and the EU efforts in the CEAP and sector-specific strategies highlight this necessity. The promotion of security of supply and GVC resilience for pharmaceuticals, medical products, semiconductors, and the promotion of sustainability in batteries or textile and apparel production require a different mix of policies, given sector- and GVC-specific structures and dynamics.

Product-specific supply chain regulations, in addition, are likely to have the strongest impact on resilience and sustainability. Given the potentially high economic costs and administrative burdens associated with such regulations, product-specific regulations should be implemented with caution and should specifically target critical (e.g., selected medical and pharmaceutical products) or strategically important products (e.g., batteries, semiconductors, etc.).

3. Policy-makers need to take account of GVC-specific governance structures and (lead) firms' strategies

In general, policy-makers will find it easier to influence GVC structures and dynamics in cases where (lead) firms' and government strategies align more closely. In this context, it is also important to consider the main difference with regard to the drivers of firms' strategies on GVC sustainability and resilience. Firms' strategies related to increasing supply chain sustainability are more often related to consumer preferences and pressure from civil society, in addition to increasingly more stringent government interventions. In contrast, strategies on supply chain resilience are so far almost exclusively related to intra-firm preferences regarding the trade-off between efficiency and resilience, without being particularly influenced by government regulations and consumer preferences. Policy-makers should also be aware of different supply chain trends, given that, for example, in the case of resilience, it is likely that sectors and (lead) firms that are more strongly affected by recent supply chain shortages are also more likely to adjust their strategies and be responsive towards government incentives.

In addition, policy-makers should consider GVC governance structures when drafting policies, in particular with regard to current lead-firms' (sourcing) strategies as well as the degree of outsourcing and offshoring in the respective GVC. In general, policy-makers in the EU will have greater influence on GVC dynamics in cases where lead firms and production facilities are located within the EU. This is because, for example, sustainability regulations on production in the EU affect vertically-integrated lead firms with a lower degree of global offshoring differently compared to lead firms in buyer-driven chains (e.g., textile and apparel, footwear, etc.), in which production is generally outsourced and offshored to a global and decentralized network of suppliers. In the latter case, regulations might want to target the global sourcing strategies of lead firms. A higher degree of offshoring thus limits the room of maneuver for policy-makers to influence firms' practices in the EU, shifting the focus from regulations on production to regulations on due diligence and risk management obligations as well as sourcing and government procurement practices.

4. Given the costs and challenges of GVC diversification, policy-makers need to incentivize and support sustainable diversification processes in selected sectors

For most products, including a large variety of potentially critical medical and pharmaceutical products, supporting diversification and redundancies will be key to increase security of supply, given the high cost of stockpiling as well as re- and nearshoring. In this context, it needs to be stressed that diversifying suppliers to counter bottlenecks such as regional clusters and single sourcing can also be – depending on the product/sector/GVC – extremely costly and challenging, as has been highlighted by our medical product case study. Overall, it is likely that government support will need to be larger in cases where firms currently do not have a strategic interest to adjust their sourcing practices, even though societal interest in increasing security of supply does exist.

According to Flach et al. (2021), and based on a survey of 5,000 firms in Germany, 41 % of manufacturing firms plan to adjust their sourcing strategies, including through the diversification of suppliers (29.5 %), the increasing transparency of the supply chains (26 %), an increase in stockpiling (23 %), the expansion of domestic sourcing (12 %), and the insourcing of production (6.9 %). The study also indicates that sectors affected by raw material shortages are particularly inclined to change their sourcing strategies. However, the scope of the resilience measures implemented by these firms remains unclear. The results of this study also indicate that supply chain diversification is particularly costly for SMEs, limiting their room of maneuver, and that the majority of manufacturing firms are currently not considering to adjust their sourcing strategies. Whether the latter indicates that there are no threats to the supply chains of these firms or that firms do not correctly assess the issue, remains open.

Overall, the available empirical literature as well as our case study suggest that increasing GVC resilience for selected critical products according to a publicly defined security of supply standard will require substantial governmental support, and that companies by themselves are unlikely to take the necessary steps in many instances. This is particularly evident in the medical products GVC that is characterized by stringent product regulations and – in the case of medical devices – by highly complex buyer-supplier relationships. The prevailing GVC structure in medical products has not yet changed, and the establishment of COVID-19 induced local manufacturing in the EU is likely to become outcompeted by traditional imports in the near future without additional public support.

5. Besides GVC diversification, production-related measures including re- and nearshoring of selected critical products are both necessary and viable

The current EU policies on resilience put a strong emphasis on trade policy and international cooperation. Given, however, the preponderance of national interests during the early phases of the pandemic, the proliferation of export restrictions has demonstrated that the EU should not rely too strongly on global cooperation during crisis situations (Raza et al. 2021a). Instead, import-dependencies for selected critical products need to be reduced through the creation of production capacities in the EU and through building-up reserve capacities, similar to the current US strategy. In view of the high cost of government-induced re- and nearshoring policies, this is likely to be possible for a small number of products only. Recent assessments have shown that problematic EU import dependencies exist only for a rather limited number of products and inputs. The promotion of re- and nearshoring should thus be financially viable for some selected critical products (EC

2021b; Reiter/Stehrer 2021). In this context, the EU needs to ensure that the promotion of GVC resilience, re- and nearshoring, or stockpiling is done in the most sustainable way (sustainable resilience), for example by linking financial incentives to promote resilience to environmental sustainability requirements.

6. Extend the scope of supply chain and due diligence laws towards GVC resilience

The current supply chain due diligence laws only focus on GVC sustainability. Policy-makers could thus extend the scope of these laws towards promoting sustainable resilience in GVCs for selected sectors and products. This is particularly relevant in the case of critical products that are not stockpiled or reshored.

The due diligence requirements related to sustainable resilience could entail monitoring and evaluation mechanisms such as reports and audits regarding firms' risk management and supply chain transparency, with a particular focus on bottlenecks (single sourcing, regional clusters, etc.) and redundancies (e.g., supplier diversification, internal stocks, financial buffers, excess/emergency capacity, etc.). In this context, firms should also explain how they link their resilience and sustainability strategies, and, in particular, how they plan to minimize the negative environmental impact of increasing redundancies (sustainable resilience).

7. Public procurement should be used to promote both sustainability and resilience

Overall, the public sector is a crucial factor in the EU's economy and its procurement practices heavily influence a wide-range of sectors and GVCs. Although legal possibilities in EU procurement law already exist (cf. Madner et al. 2021), so far many public institutions do not, or only to a very limited extent, include sustainability requirements in the purchasing policies. This is even truer for resilience requirements, as has also been highlighted by our case study on medical products. Given that public institutions have so far in general not been willing to pay a premium for sustainable and resilient products and services, firms continue to prioritize supply chain efficiency and low prices. Considering the high business cost related to stimulating more domestic production of critical products, of entertaining reserve capacities in domestic production facilities, or of increasing stockpiling within companies, demand-side economic policies will need to complement regulation and supply-side policies of expanding local production of critical products. Reformed public procurement practices could be a key lever to this end.

8. Ensure policy coherence for development

Policies on GVC resilience and sustainability in the Global North may have non-intended effects on third countries, including the Global South. Due diligence laws, for example, can lift sustainability standards along the supply chain, but also make GVC integration more challenging for countries with low sustainability standards. In the case of re- and nearshoring to the EU, the non-intended effects are likely to be particularly severe, depending on countries' position in the respective GVCs. For instance, reshoring of production of critical products can have a negative impact on income and employment levels in the producing countries, since the additional build-up of EU production could also create overcapacities and reduce prices and thus the profitability of existing companies. A displacement of some of these companies is also probable. On the other hand, import-dependent countries,

e.g. in large parts of Sub-Saharan Africa, could benefit from policy-induced overcapacities if this reduces prices and procurement costs. In addition, some countries with geographical proximity to the EU, e.g. in North Africa, could benefit from nearshoring strategies of European companies (i.e. strategies that promote reshoring to regions close to the EU) and build up or expand production for EU export.

In this context, it should also be noted that countries in the Global South have limited influence on lead firms' strategies, and thus upon the structure and dynamics of GVCs. EU policies that require lead firms headquartered in the EU to improve on their resilience or sustainability will thus have repercussions upon suppliers in third countries, with the latter having to bear the associated adjustment costs. If the EU thus is to fulfil its commitment to promote policy coherence for development, that is, to account for development objectives in policies likely to affect countries in the Global South (EC 2019), it must consider these aspects when formulating any strategy on GVC resilience and sustainability. The EU should thus aim at mitigating potentially negative economic impacts on the countries of the Global South and enhance positive effects.

In addition, the EU should actively promote that supply security of critical goods can be ensured on a global level. Since national strategies often gain the upper hand in times of global crises, lessons should be learned from the COVID-19 pandemic to increase the Global South's supply security of medicines and other critical goods. This may include expanding stockpiling efforts by international organizations such as the World Health Organization (WHO), the availability of crisis facilities at international financial institutions for the procurement of urgently needed goods, or medium- and long-term support for the development of national production and stockpiling capacities in the Global South. Clearly, measures to strengthen public health should be given a higher priority in European development cooperation post-COVID-19.

9. Establish coordination as well as monitoring and evaluation mechanisms

On an organizational level, the creation of high-level and inter-ministerial institutions – as is for example envisioned in the US (The White House 2021) – are important measures to strengthen state capacities on supply chain management, and thus state-state as well as state-business relations. Policy-makers should establish state-business coordination mechanisms on a sector or product level, similar to current practices in the EU's pharmaceutical strategy, to improve policy-makers' understanding of sector and product specific challenges, and support cooperative state-business relationships. Such coordination mechanisms should regularly monitor the supply of critical products, identify and address bottlenecks via targeted policies. Stress tests, digital technologies and data platforms could be of particular importance to increase the transparency of GVCs and develop appropriate measures. Last, but not least, national-level coordination needs to be complemented by EU-level coordination, with the European Commission supervising and coordinating national-level policies.

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Annex

All interviews were conducted in person or by telephone (digital communication software). The interviews were supplemented by inquiries via email.

Type of company	Date
European manufacturer of facemasks and meltblown	November 2021
European manufacturer of various medical products/devices	November 2021
European manufacturer of various medical devices	November 2021
European merchant of various medical products	October 2021
European manufacturer of medical gloves	October 2021
European merchant of various medical products	October 2021
European manufacturer of meltblown	October 2021
Austrian Chamber of Commerce –Association of Medical Products	August – October 2020
Austrian Chamber of Commerce – Association of Textile, Fashion, Shoe and Leather Industry	August – October 2020
Austrian Red Cross	August – October 2020
European manufacturer of facemasks	August – October 2020
European manufacturer of chemical inputs	August – October 2020
European manufacturer of ventilators	August – October 2020
European manufacturer of inputs (plastic)	August – October 2020
European manufacturer of meltblown	August – October 2020
European manufacturer of machinery for various medical products	August – October 2020
European manufacturer of ventilators	August – October 2020
Landeskrankenanstalten-Betriebsgesellschaft – KABEG	August – October 2020
European manufacturer and trader of various medical products	August – October 2020
European manufacturer of various medical products	August – October 2020
Oberösterreichische Gesundheitsholding GmbH (OÖG)	August – October 2020
European manufacturer of medical gloves	August – October 2020
European manufacturer of electronic equipment	August – October 2020
Technical University of Graz – Expert	August – October 2020
European trader of various medical products	August – October 2020
Vienna University of Economics and Business – Expert	August – October 2020
European manufacturer of facemasks	August – October 2020

Table 4: List of Interview Partners

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