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The Case for Globalization and Robust Global Value Chains Grows Stronger

Shahid Yusuf

Abstract

Discontent has dogged globalization for over two decades even as it has tangibly contributed to growth and poverty reduction worldwide with global value chains (GVCs) serving as its sinews. The Covid-19 pandemic demonstrated the degree to which countries depend upon an international network of suppliers for a wide range of commodities and services. That crisis, climate change and other existential threats in the offing, bring home the need for countries to hang together, or they will hang separately. No country however large, will benefit from the overzealous pursuit of greater self-sufficiency and for the majority, attempting to achieve even a moderate degree of autarky would entail sacrificing decades of material progress, although under the circumstances, the pursuit of strategic industrial policies by some countries may be prudent. A fracturing of the institutional infrastructure undergirding globalization and a turning inward, would also materially hamper efforts to cope with urgent national problems and international crises. Thus, the imperative for the leading economic powers is to defuse the threats to globalization and to promote resilience of GVCs. In this endeavor, the economic advantages of globalization will be pitted against strong political currents breeding domestic distrust among nations and making it harder to agree on policies necessary for economic flourishing in a planetary environment the viability of which is no longer assured. The paper makes the case that the flows of trade, capital, and technology should be safeguarded, and that dealing with the downsides of globalization is not beyond the wit of humankind.

The Case for Globalization and Robust Global Value Chains Grows Stronger

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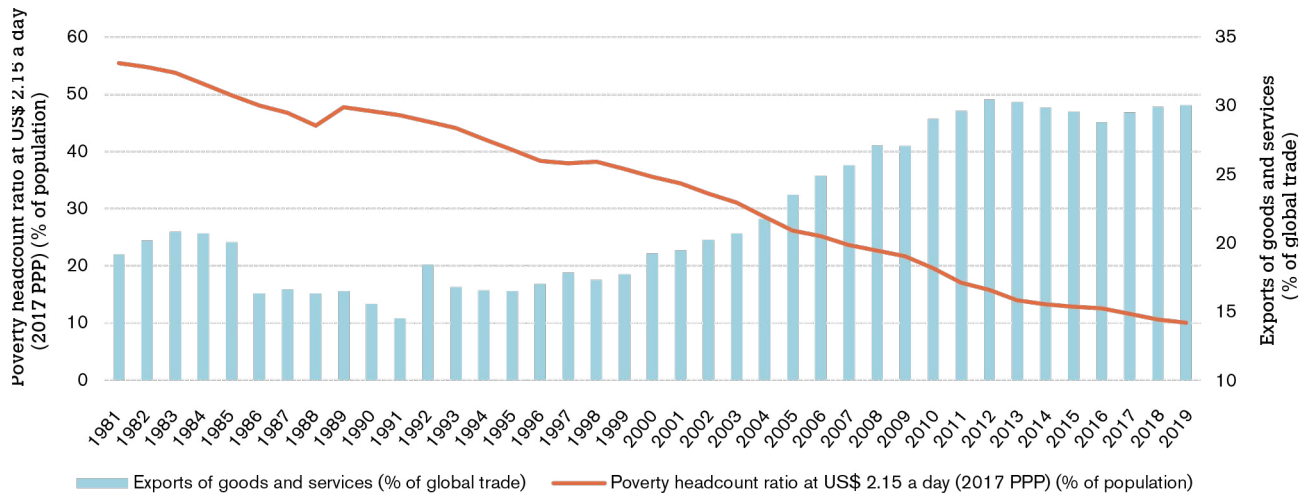
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A new normal is coming into focus. A normal in which destructive extreme weather events will recur throughout the world with greater frequency, the likelihood of pandemics will increase, geopolitical tensions are causing policy uncertainty and could lead to periodic outbreaks of violence on a regional—or broader—scale,¹ migration caused by climate change or a collapse of the socio-political order in societies, could prove to be highly stressful for countries especially those at the receiving end, misinformation and deepfakes (with AI serving as an accelerator) could exacerbate political polarization and a snowballing of the “democratic recession,”² and the upward trend in private and public debt, which was 238 percent of global GDP in 2023,³ will hamstring macroeconomic and development policies.⁴ Rising populations in some of the most climatically vulnerable regions, depletion of natural capital and the ongoing environmental degradation, will compound the pressures on the global system (Dasgupta 2021; Helm 2023). The 10-year forecast by the Global Risks Report for 2024 (WEF 2024) spells out these risks and it shows how they can become intertwined triggering potentially devastating polycrises.⁵

1. Globalization: Rumors of its impending demise have been exaggerated but survival requires collective effort

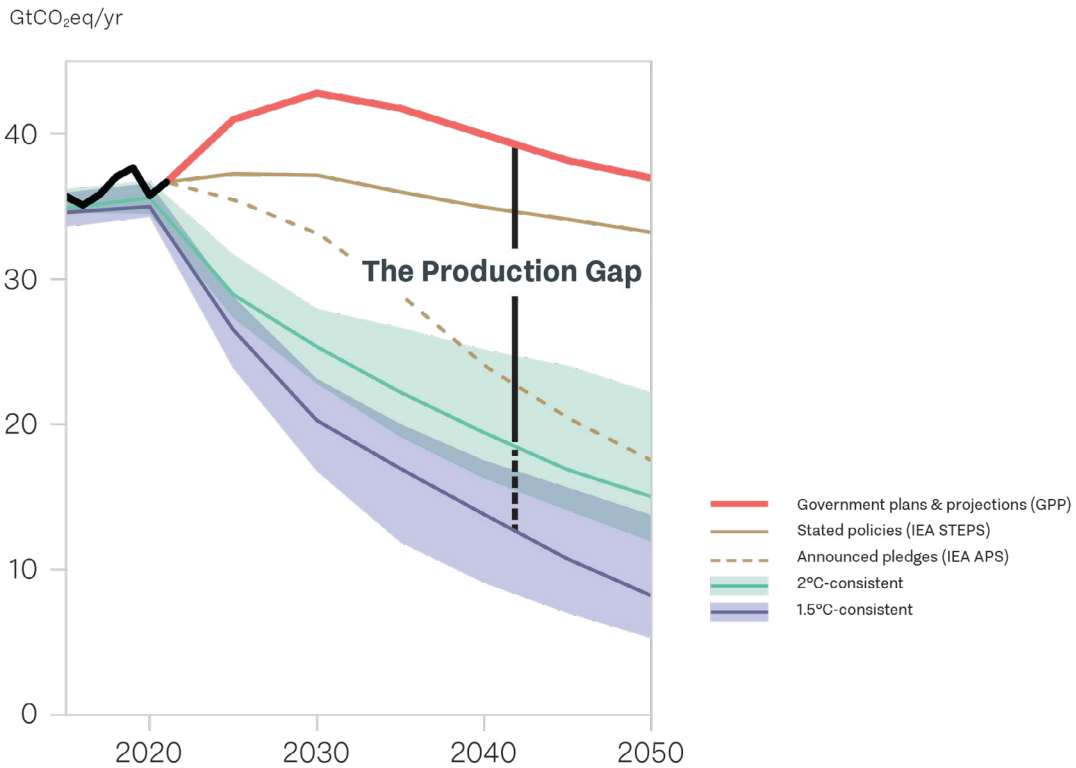
In this dire new normal, maintaining or improving the material welfare of people worldwide will demand the efficient and sustainable harnessing of resources from across the globe. Countries will need to hang together, or they will hang separately. Moreover, for most countries, welfare enhancing GDP growth⁶ will depend in part on export performance and openness to trade.⁷ Between 1950 and 2022, gains from trade for the US amounted to \$2.6 trillion a 10 percent increase in GDP (Hufbauer and Hogan 2023). For developing economies, trade has had a large hand in reducing poverty since the early 1980s (Figure 1). In fact, no country has scaled the income ladder without policy actions promoting trade.⁸ Moreover, growth that is export-led remains the only viable option for smaller economies.⁹ Looking ahead, a retreat from globalization, which has promoted trade and FDI would be counterproductive for all. No country however large, will benefit from the pursuit of greater autarky and for the majority, even a moderate degree of self-sufficiency would entail sacrificing decades of material progress.¹⁰ A fracturing of the trading system and a turning inward, would also redound against efforts to mitigate and/or adapt to climate change (Figure 2).¹¹ As the grip of the new normal tightens, it will be to the advantage of all to work towards a more closely integrated global economy.¹²

Figure 1. World trade helped reduce extreme poverty by three fourths since the early 1990s



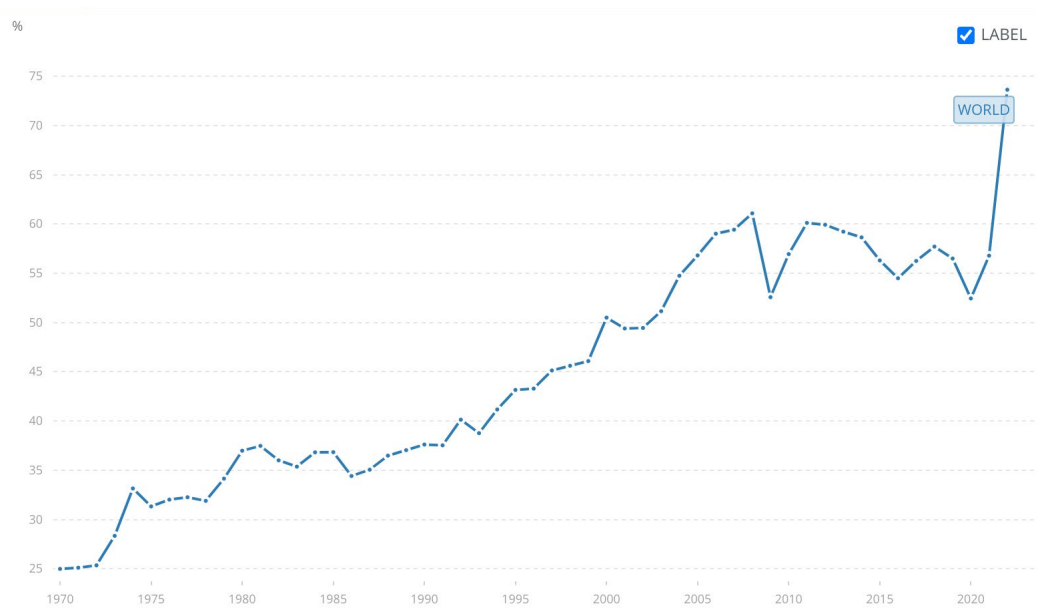
Source: WTO (2023) https://www.wto.org/english/res_e/booksp_e/wtr23_e/wtr23_ch0c_e.pdf

Figure 2. Projected global fossil fuel production and excess over 1.5°C/2°C climate goals



Source: UN (2023) <https://productiongap.org/2023report/#2023downloads>

Figure 3. World trade as a percent of GDP

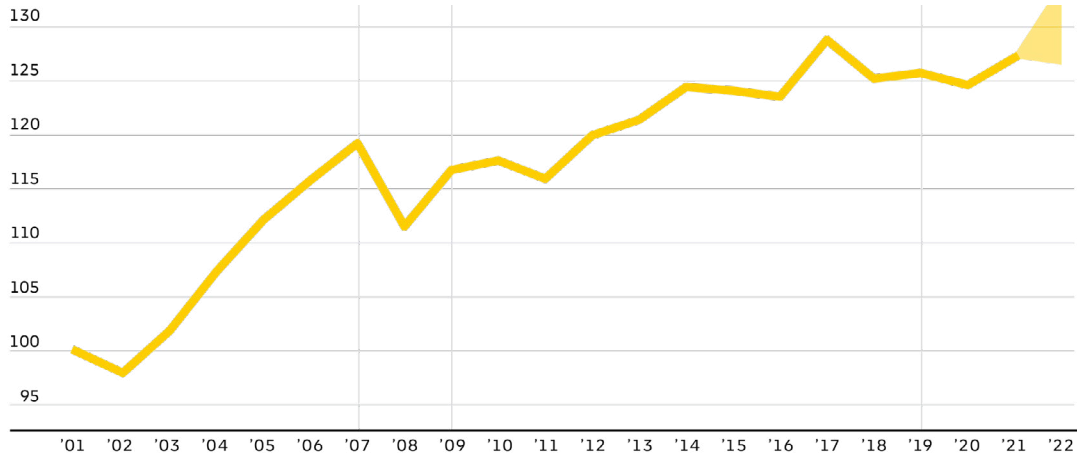


Source: WDI (2023) <https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS>

The slowdown in the growth of the value of trade and its ratio to GDP following the Financial Crisis of 2009, led observers to believe that the period of the so-called hyper globalization was ending (Figure 3).¹³ Ever since, the determinants of globalization have been obsessively scrutinized to identify the emergence of a trend.¹⁴ Historians worry that the current globalization wave might suffer the fate of earlier episodes and precipitate a prolonged global economic downturn. Although the value of world trade as a percent of total GDP peaked in 2008 (61 percent) and has oscillated between 52 percent and 57 percent since, other indicators suggest that globalization albeit slowing,¹⁵ recovered from the Financial Crisis and has weathered the buffeting inflicted by the Covid 19 pandemic. The DHL Connectedness Index (2022)¹⁶ based on 4 million data points tracking the movement of trade, capital, information, and people, experienced a slight decline in 2020, but then rebounded strongly in 2021 and is projected to continue rising—barring the appearance of a highly disruptive event (Figure 4).

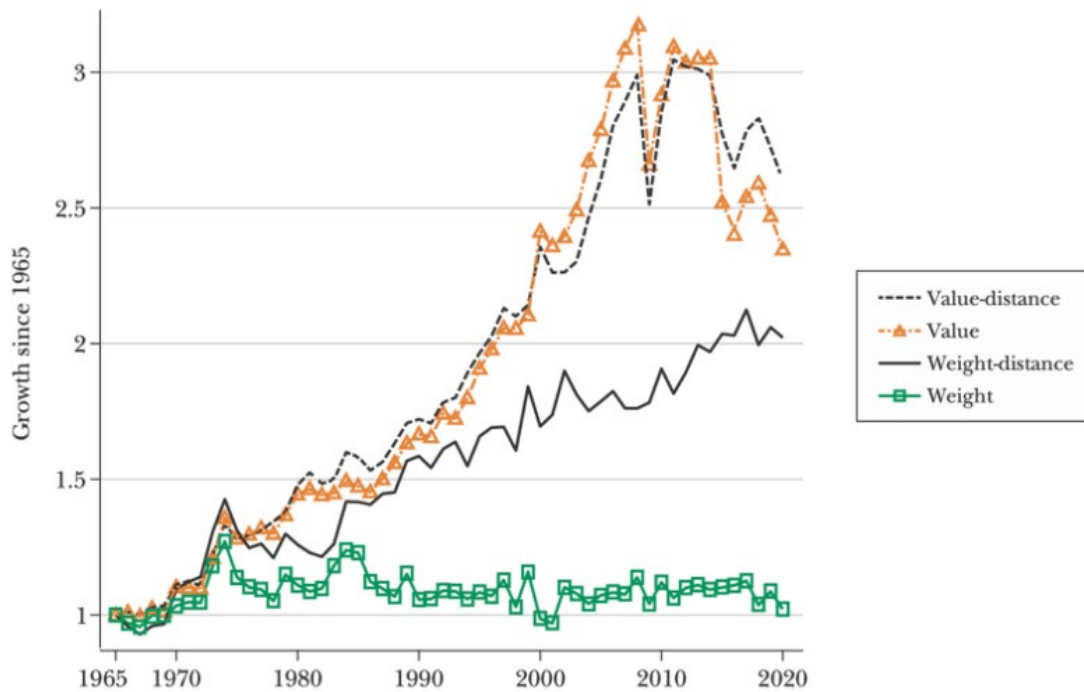
The DHL Index is rendered more credible by the findings of a recent study by Ganapati and Wong (2023). They show that when global trade is measured by tonnage—rather than by value—and by the distance goods are transported, globalization according to this metric has risen steadily. The tonnage shipped has remained close to 0.24 to 0.26 shipped tons per \$1,000 of real-world GDP but the distances the goods travel has increased. In other words, growth in the normalized weight measure of trade continues to rise steadily from the turn of the century through 2020 (Figure 5). These findings suggest that trade globalization could continue albeit more slowly and in the process buoy global growth prospects.

Figure 4. DHL global connectedness index 2001–2022



Source: DHL (2022) <https://www.dhl.com/content/dam/dhl/global/delivered/documents/pdf/dhl-global-connectedness-index-2022-complete-report.pdf>

Figure 5. Growth of trade and transport use 1965–2020



Source: Ganapati and Wong (2023)¹⁷

The sinews of globalization: GVCs

Global value chains (GVCs) have become the machinery of globalization.¹⁸ They have proliferated since the 1980s and are largely responsible for many of the benefits bestowed by globalization. They have generated most of the 13 billion supply links that connect 300 million firms that participate in international trade (Pichler et al 2023).¹⁹ Initiated by the liberalization of trade,²⁰ and accelerated by the declining cost of telecommunications and transport, globalization widened in the 1990s to encompass not just trade of intermediate and final products but also international flows of capital, technology, ideas, and people more fully (PIIE 2022). In this context, leading MNCs found it increasingly profitable to disintegrate the production process and to outsource some stages to other firms thereby reaping efficiency and productivity gains. As of 2021, GVCs intermediated up to 70 percent of trade-based movement of goods and services.²¹ They have served as conduits for FDI, innovation and the transfer of managerial and technical skills and tacit knowledge to their widely dispersed partners (Hauge 2019). By facilitating exports, GVCs have enabled developing countries to industrialize, achieve higher growth rates and to substantially reduce poverty. Undoubtedly, globalization has been disadvantageous for some in developed and developing countries alike. Arguably, the gainers outnumber the losers but the outcry from the losers is affecting the political calculus and must be reckoned with for global integration to be sustained (Bordo 2002; Ulgen and Inan 2022a).

The Covid 19 pandemic highlighted the key role of GVCs in expediting the production and dissemination of vaccines by marshaling scientific knowledge, intermediate inputs, production facilities, and logistics. But with economic policies taking a more nationalistic and protectionist turn over the past decade, trade conflicts between major economies sharpening, income inequality a rising concern, and sociocultural opposition to immigration becoming more acute, there is a perception in some quarters that going forward, 'slowbalization' if not deglobalization is in the cards (Walters 2021). This is evidenced by slackening rates of GVC participation rates and fragmentation of value chains.²²

In this paper, I argue that a retreat from globalization broadly defined, and disruption of the GVC machinery would have negative sum outcomes for all participants. In the troubling new normal that is currently unfolding, global integration aided by more streamlined GVCs will safeguard the gains to date and allow the global system to adequately cope with both the known challenges and others that remain unknown—including through the provision of global public goods.²³ Thus, the imperative for the leading economic powers is to minimize the threats to globalization and check the unraveling of GVCs. In this endeavor, the economic advantages of globalization will be pitted against strong political currents breeding distrust among nations and making it harder to agree on policies necessary for economic flourishing in a planetary environment the viability of which is no longer assured.

The remainder of the paper is divided into six sections. The second sketches the trends and developments that are transforming the global environment. Section 3 examines the evolving complexity of products and services, the resulting specialization, and the piecing together into a coherent whole of a sprawling, tendrillous, production system by GVCs. Section 4 discusses the forces that threaten to undermine a system that has contributed immeasurably to global material prosperity although the downsides cannot be ignored and are among the factors responsible for the pressure to deglobalize. Section 5 reviews the costs of deglobalization and an unraveling of GVCs. Section 6 explores the ways by which globalization can be stabilized and GVCs rendered more robust through restructuring and sufficiently ‘derisked’ with the help of strategic industrial policies to make them consonant with geopolitical realities. Section 7 concludes with a summary of the issues before policymakers, reiterates the desirability of sustaining GVC enabled globalization and notes that the instruments to tackle the downsides of globalization need to be forcefully deployed to contain the backlash.²⁴ Not only would countries sacrifice hard won prosperity, deglobalization would also imperil a fragile planetary ecosystem the survival of which calls for collective effort and burden sharing.

2. Global prosperity under threat

There have been few moments in world history when there was not a cloud in sight. From early in the twentieth century, a succession of threats including existential ones emerged and then as with the Cold War, they faded. Two destructive world wars, interspersed with a massive flu pandemic and the Great Depression, were followed by more than sixty years of unprecedented and widely shared economic progress. Then came the Financial Crisis of 2008, which brought back memories of the economic hardship endured in the 1930s, and a limping recovery during the subsequent decade was briefly stalled by the Covid pandemic that erupted in 2020.

History suggests that the global system can absorb major shocks from epidemics, wars, and oil embargos (although financial crises and crises that are global in extent can have longer lasting effects on potential growth),²⁵ bounce back within a matter of years, and continue to forge ahead. The flu pandemic of 1918-20, which was responsible for at least 50 million fatalities across the world is a distant memory, which was briefly resurrected and mined for “lessons” when the Covid 19 struck and then returned to the dustbin of history (Beach et al 2020; Barro et al 2020). The Covid pandemic, which has claimed almost 7 million lives²⁶ and continues to sputter as new variants of the virus emerge, is different from earlier shocks. It has heightened the awareness of multiple vulnerabilities, which cumulatively have the making of continuing gale unlike anything that world has experienced in the past. The disruption and shortages experienced in 2020, could recur in the absence of efforts to shore up supply chains and build enough redundancy—slack—into the system.

Pollution and infectious disease

The clouds on the near and the more distant horizon appear darker for several reasons. First, the consumption of fossil fuels, will worsen a slow burning health crisis. Already 99 percent of the world's population is breathing air that exceeds the WHO's air quality guidelines with seven million people dying prematurely each year from a variety of cancers, cardiovascular and neurological diseases.²⁷ Deryugina and Reif (2023) point to both the short-term effects of pollution on mortality and longer-term ageing effects of chronic exposure that compound the consequences of short-term exposure (Clean Air Fund 2023). The release of SO₂ and particulate matter by coal fired plants in the US is estimated to have caused 460,000 deaths of those over the age of 65 between 1999 and 2020, especially in the Eastern part of the country where SO₂ emissions were higher as is population density.

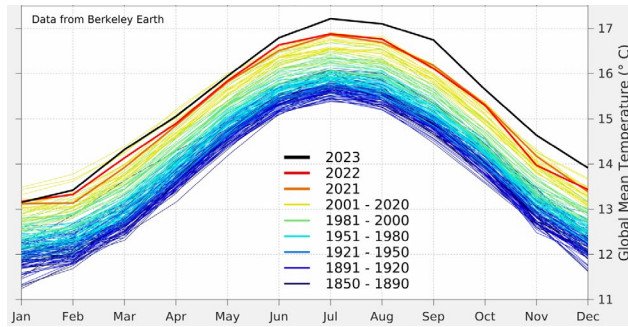
Furthermore, pandemic scale outbreaks of infectious diseases caused by pathogens with animal reservoirs (SARS, MERS, Marburg, Ebola, Nipah, West Nile, Lassa fever, Lyme disease)²⁸ could become more frequent because of greater contact between humans and animals or rodents (Marani et al 2021; Baker et al 2021; CGD 2021). Climate change and urbanization are creating environmental conditions that expose more people to infection, widen the range and increase the density of certain disease vectors (mainly arthropods).²⁹ Bioterrorism rendered more lethal by advances in synthetic biology and gene editing techniques makes the risk from this source more acute.³⁰ And greater global integration facilitates the worldwide diffusion of a localized disease outbreak within weeks.

Climate change

Second, with every passing day the acceleration of climate change is becoming more apparent.³¹ Rising temperatures on land and in the oceans, which set new records in 2023, are surfacing in economic statistics (Figure 6a&b). The economic damage inflicted between 1970 and 2021 by floods, droughts, hurricanes,³² and heatwaves runs into the billions for Africa (\$43 billion), South America (\$115.2 billion), and into the trillions for Asia (\$1.4 trillion), and North America, the Caribbean and Central America (\$2 trillion).³³ Thunderstorms caused more than \$55 billion in insured damage in the US during the first 11 months of 2023 much of it the result of hail.³⁴ An earlier survey by Dell, Jones, and Olken (2014)³⁵ of the literature on climate change and economic performance found that rising temperatures and severe weather adversely affected GDP growth and per capita incomes. Findings that have accumulated during the past decade have reinforced earlier results. Industrial and agricultural output and investment are all depressed with low-income countries suffering the most (Burke et al 2023; Yusuf 2021; Acevedo et al 2020). Higher temperatures strongly impinge upon labor and land productivity, reducing both.³⁶ In some of the world's most densely populated regions in East and South Asia (see Figure 7), temperatures during the peak summer months have been rising and are already approaching wet bulb levels that are at the limit of human tolerance. Daytime temperatures have exceeded 50°C in South Asia and the Middle East. Central America, parts of the

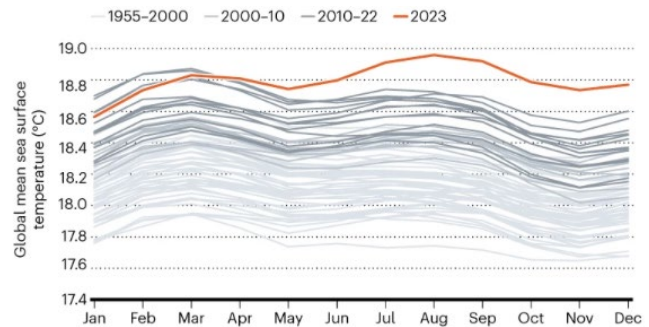
United States and Europe experienced life-threatening heat waves in 2023 (Wong 2023).³⁷ Elevated temperatures and associated desiccation are responsible for an increase in wildfires, their spread and destructiveness. And because warm air harbors more moisture, storms are fiercer, dump far more rain in a short period of time and can cause devastating floods.³⁸

Figure 6a. Earth’s average temperature: 1850–2023



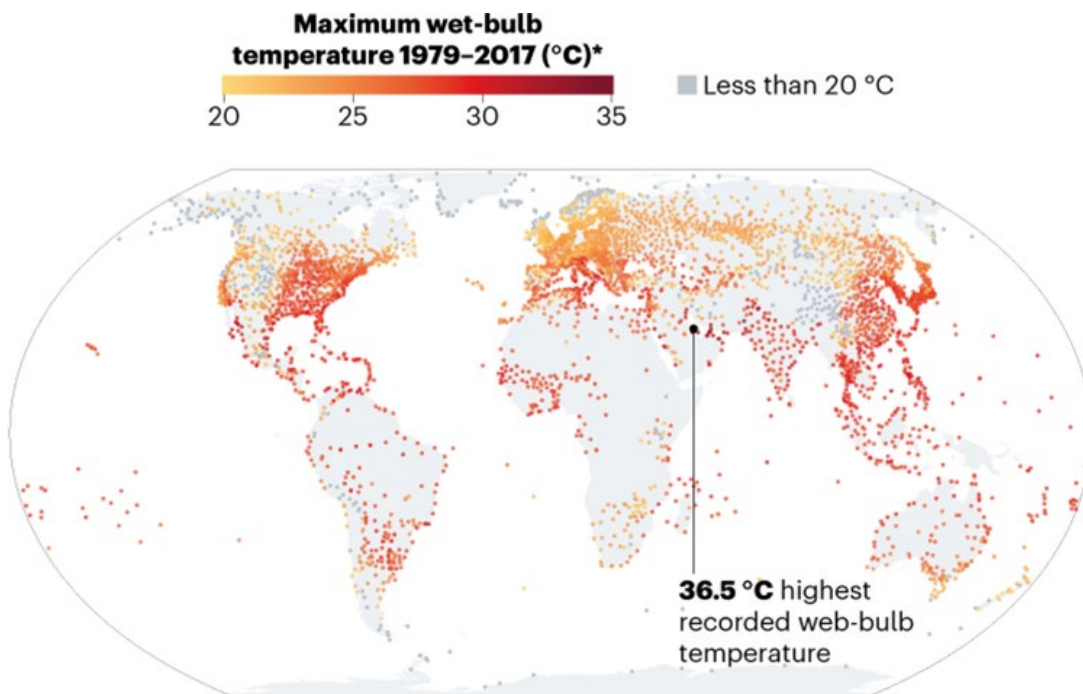
Source: Berkeley Earth (2024). <https://berkeleyearth.org/global-temperature-report-for-2023/>

Figure 6b. Ocean temperatures on the rise



Source: You (2024)

Figure 7. Distribution rising temperatures worldwide



*99.9th percentile of observed daily maximum for 1979–2017.

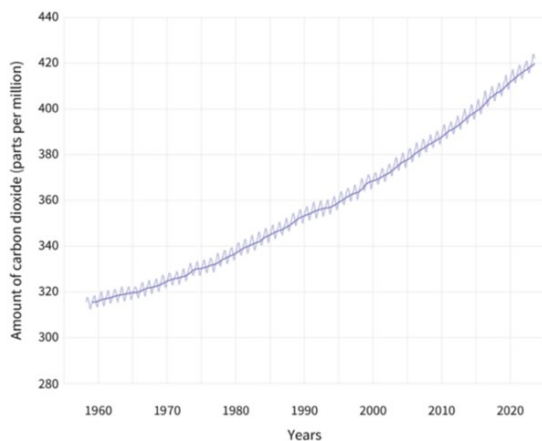
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Source: Wong (2023). <https://www.nature.com/articles/d41586-023-02482-z>

Sanderson (2023). Average temperatures reaching and breaching 1.5°C are more likely. On two days in November 2023, the average global temperature was 2°C more than the 1850–1900 baseline. Globally November and December were the warmest ever recorded. And on half the days in 2023, the average temperature was 1.5°C higher than the preindustrial baseline. Financial Times (20, January 10th). <https://www.ft.com/content/fafaf4cc-4f93-46fd-ab94-2f90165cef9f>

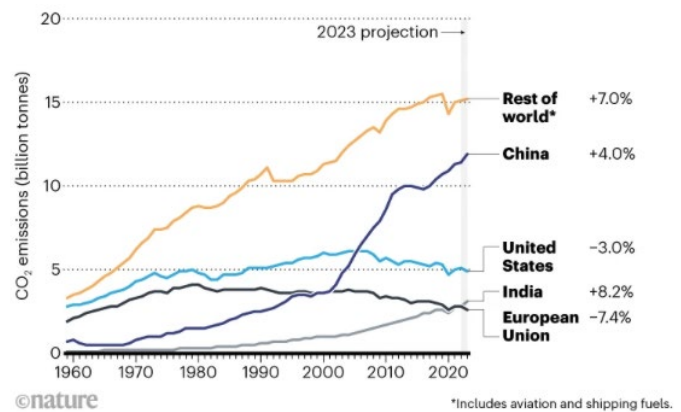
As noted above, a warming climate is changing the epidemiological environment for the worse. Higher temperatures are at the root of multiple threats and the trend is worrisome. Because the greenhouse gases (GHGs) pumped into the atmosphere (e.g. nitrous oxide, methane) will persist for up to a hundred years and in the case of CO₂, for thousands of years, temperatures could exceed pre-industrial levels by 2°C within the next two decades. Absent extraordinary efforts to curb GHGs,³⁹ carbon emissions will continue inching upwards through the second half of the century.⁴⁰ The atmospheric concentration of CO₂ was 318 ppm in 1960 (Figure 8a). By May 2023, it had climbed to 424 ppm. Neither warnings by scientists nor pledges by governments and commitments by corporations are bending the curve. Although CO₂ emissions from some regions have declined, they have soared from parts of Asia (Figure 8b). Oil majors such as Exxon and Chevron dismiss the likelihood of peak oil and are betting that the demand for petroleum will remain strong through the century.⁴¹ Hence much workaround involving GVCs, and international supply chains (themselves a cause of rising carbon emissions) will be necessary to sustain economic well being and living conditions for most of the world’s population in the face of the furies unleashed by a warming climate.

Figure 8a. Carbon concentration in the atmosphere



Source: NOAA (2023) <https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide>

Figure 8b. Rising CO₂ emissions



Source: Nature (2023) https://www.nature.com/articles/d41586-023-03849-y?utm_source=Live+Audience&utm_campaign=3627f7b91e-briefing-dy-20231206&utm_medium=email&utm_term=0_b27a691814-3627f7b91e-50827024

Geo-political tensions and mineral supplies

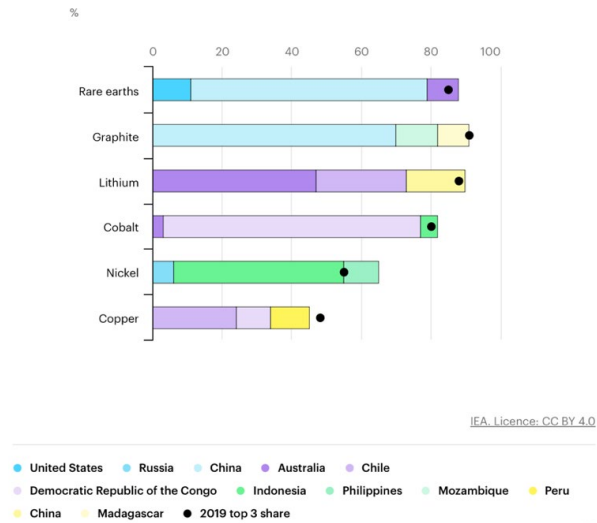
A third reason why the robustness of GVCs is acquiring greater salience stems from geopolitical discord. As tensions between the US and China have increased, and bilateral trade has been subjected to rising tariffs plus other restrictions on the trade in certain commodities, firms are having to source some of their products from countries other than China. With the weaponization of trade showing no signs of abating, dependence on China for a wide assortment of manufactures including critical refined minerals needed to produce semiconductors, solar panels, storage batteries and other items, is a mounting concern as well for the EU, Japan, and Korea. That electronic devices embedded in telecom equipment, EVs, laptops and even gantry cranes might be used for the purposes of espionage and transfer information to unfriendly parties has begun compelling companies, under pressure from governments, to reassess the vulnerability of their supply chains and to source sensitive products from trusted suppliers.⁴² An analysis of 5,384 products by the ADB (2023) identified 1,075 as potential bottlenecks all of which had increasing their share in total trade by value.

China's dominant role in so many GVCs complicates the reengineering of chains to exclude Chinese suppliers, because substitute sources of supply are limited and building capacity elsewhere can be a slow and expensive process (Song and Zhou 2023).⁴³ Not only does China rely less on imported inputs—which partially insulates it from an interruption of imports—it also is an important source of inputs for exports from other countries (Molnar 2019; Herrero 2019).⁴⁴

As countries seek to derive more of their energy from renewable sources and the reliance on electricity grows,⁴⁵ the demand for a variety of minerals already on the rise, will spiral upwards.⁴⁶ The importance of mining is frequently glossed over, and mining is not attracting the needed investment. As one observer remarked, the market capitalization of the top fifty mining companies is less than that of Apple.

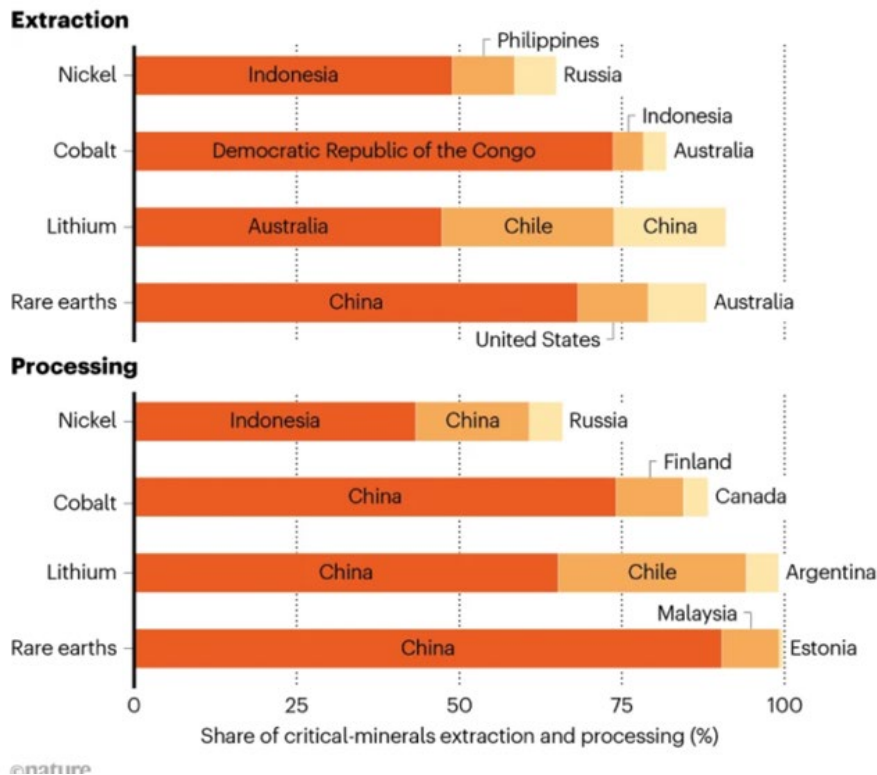
An increasing global population coupled with rising incomes, will also substantially enlarge the demand for foodstuffs. This has major implications for GVCs responsible for the mining, transport, and processing of primary commodities.⁴⁷ While the production of minerals and edible products has not peaked contrary to periodic warnings, there is greater awareness that the bulk of key minerals are found in a few locations—sand with the desired content of quartz⁴⁸—copper, cobalt, nickel, manganese, rare earths, uranium,⁴⁹ etc.—and much of the refining is also highly concentrated (Figures 9&10). For example, two thirds of the rare earths are mined in China, which is also responsible for 85 percent of the refining. Copper, which is key to the electrification of economies, is another case in point (Figure 11).⁵⁰ Similarly, many if not most countries depend on imports to meet a fraction of their food requirements.

Figure 9. Share of top three countries in mining of selected minerals⁵¹



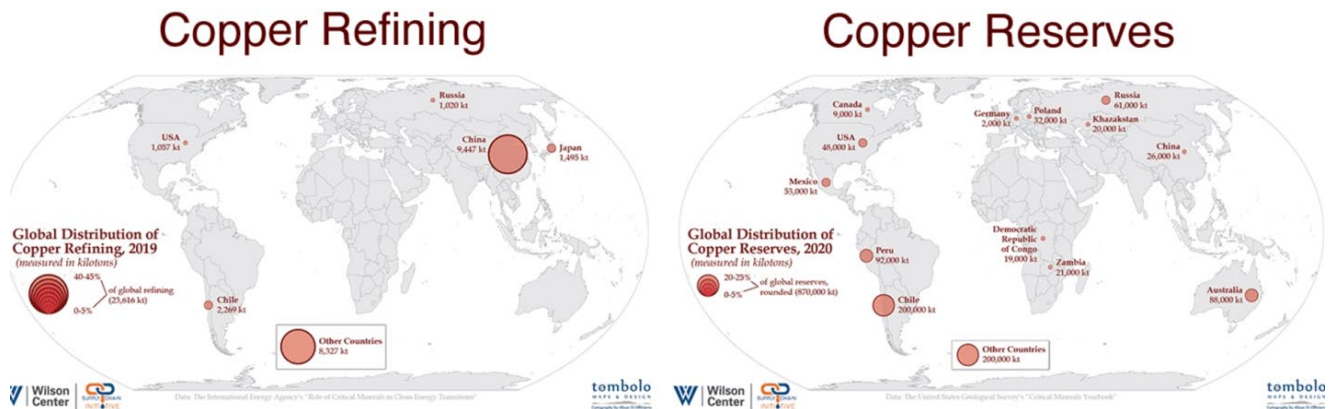
Source: IEA (2023) <https://www.iea.org/topics/critical-minerals>

Figure 10. Critical mineral sources and their processing



Source: Nature (2023) <https://www.nature.com/articles/d41586-023-02330-0>

Figure 11. Sources of copper and where it is refined



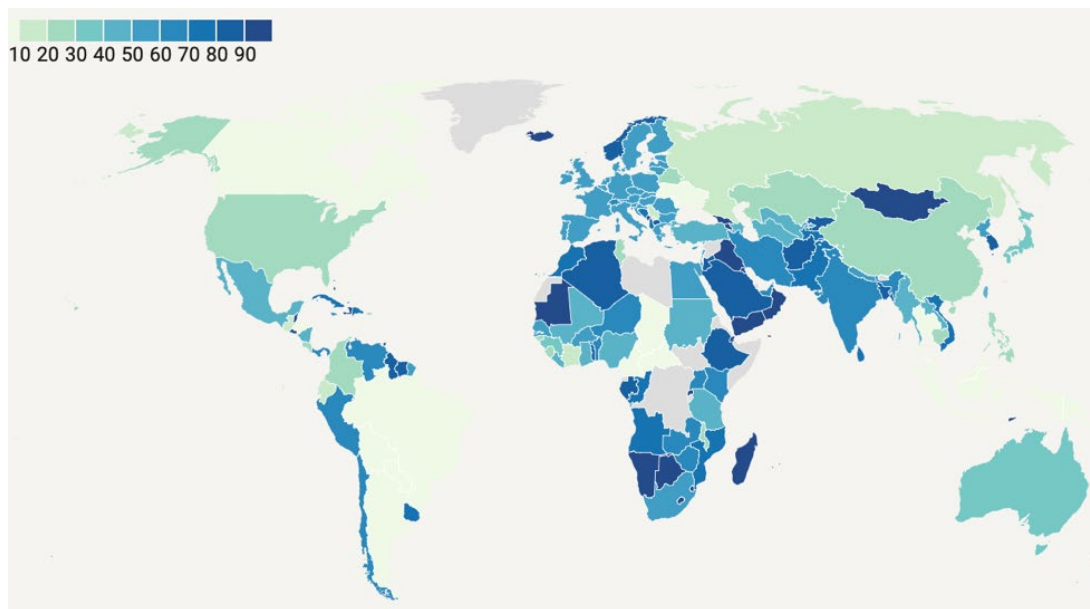
Source: Wilson Center (2022). <https://www.wilsoncenter.org/article/critical-mineral-maps>

Food (in)security

The Covid 19 pandemic, which disrupted the food supply system, was a wake-up call. The pandemic led to labor shortages, the shuttering of manufacturing and processing facilities, border closures, and transportation bottlenecks among others. Together they contributed to significant fluctuations in supplies and spiking prices. After a hiatus that lasted for several months, supply chains began to recover, aided by digital technologies, by tapping alternative sources of supply and mechanisms for delivering products to consumers (Reardon et al 2022).⁵² The GVCs weathered the storm but the disruption was costly for firms across the supply chain and inflicted considerable hardship on consumers at the receiving end.

The war between Ukraine and Russia again drew attention to the susceptibility of GVCs to shocks and how finely balanced the system is. It revealed the importance of a handful of countries, Ukraine, and Russia among them in the global supply chain for cereals. Germany, Italy, France, Turkey, Russia, the United States and Canada—account for more than one half of the global supply of wheat by volume. And the European countries have limited production capacities because of land area constraints (Raj et al 2022).⁵³ Excluding rice, global trade of cereals amounts to a fifth of total production, which under normal conditions, is enough to feed the world’s population. But because many countries are unable to meet their needs, trade serves to balance supply with demand (Strubenhoff 2022).⁵⁴ China was a net exporter of food until soon after the turn of the century. It has since become the world’s largest importer accounting for 10 percent of agricultural goods that are traded internationally and 5 percent of global agricultural output.⁵⁵ Two thirds of the sorghum used to produce China’s grain alcohol (baijiu) is imported from the US. China’s imports are responsible for a 7 percent increase in the global cropped acreage between 1995 and 2020 (Hansen and Wingender 2023).

Figure 12. Share of imported oils in total consumption

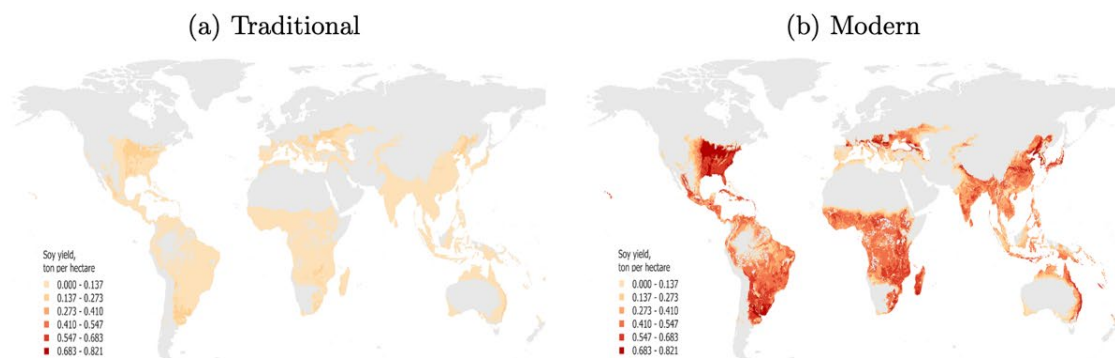


Source: Glauber et al (2022)

Cereals were not the only item that was affected. The Ukraine war also exposed the vulnerability of the market for edible oils because supplies of sunflower oil from Ukraine were interrupted (52 percent of the traded volume). As prices of edible oils rose, it deepened awareness of how dependent many countries are on the import of oils, the second most important food item after cereals (Glauber et al 2022; Figure 12).⁵⁶ The value chains of other items such as coffee, cocoa⁵⁷ and citrus can be disrupted by freak weather events and disease outbreaks that are becoming more common. Sixty percent of all wild coffee species are already threatened by climate change, which is also disrupting the supply of arabica coffee. By 2050, it is feared that fifty percent of the land devoted to growing coffee especially arabicas will become unusable.⁵⁸ Covid 19 showed that problems could arise at the processing and distribution stages as well. When a major supplier, processor or distributor is affected, compensating for the shortfall becomes an immediate challenge.⁵⁹ The greater the concentration at any waypoint in the supply chain, the greater the challenge.

The various inputs that go into the production of foodstuffs are integral to the value chain. Modern agriculture has become an intensive user of intermediate inputs (fertilizer, designer seeds, weedicides, fungicides etc.) capital, software, and skills. This has increased farm productivity (e.g., of soybeans, Figure 13) and is responsible for the abundance of agricultural products. At the same time, this input and tech heavy supply chain has become highly globalized. The traded share of inputs rises with GDP per capita. Farrokhi and Pelegrina (2021) estimate that “on average across countries, two-thirds of every dollar spent on the use of agricultural inputs is paid to foreign suppliers”. The war between Ukraine and Russia by interrupting the supply of fertilizer,⁶⁰ steepened price inflation, which had surfaced in 2020,⁶¹ constraining utilization especially in low- and middle-income countries (Figure 14).⁶²

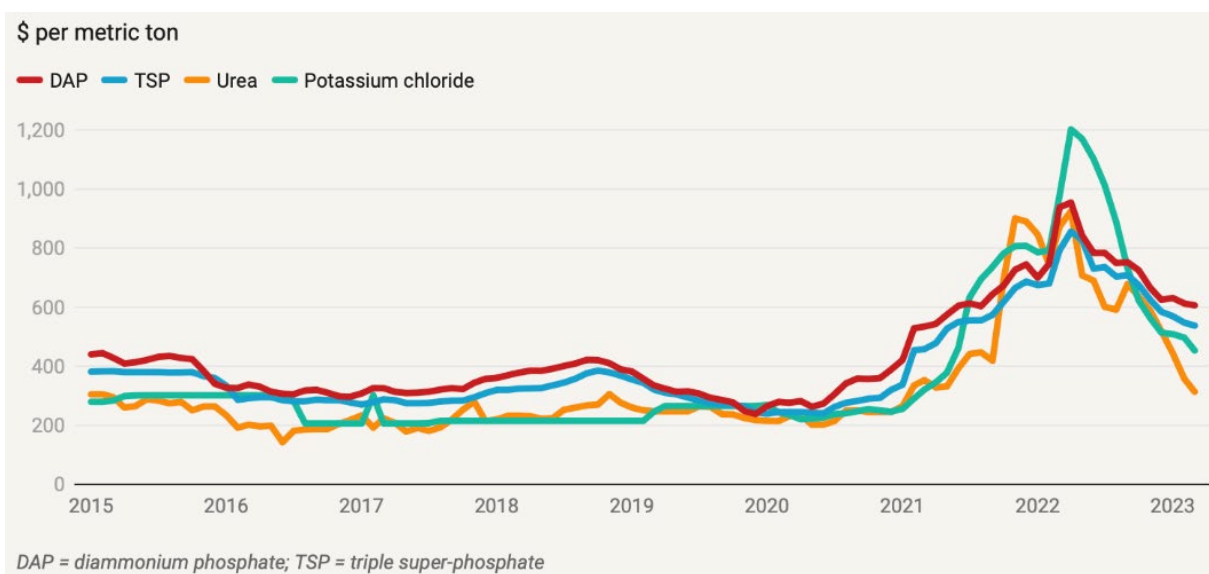
Figure 13. Potential yield of soybean under traditional and modern production regimes



Notes: This figure shows the spatial distribution of potential yields of soybean based on FAO-GAEZ data under traditional (labor-intensive) and modern (input-intensive) technology.

Source: Farrokhi and Pelegrina (2021)

Figure 14. Fertilizer prices



Source: Hebebrand and Glauber 2023. <https://www.ifpri.org/blog/russia-ukraine-war-after-year-impacts-fertilizer-production-prices-and-trade-flows>

Transportation bottlenecks

The Covid pandemic brought the fragility of transport networks to the forefront. Lockdowns, border closures and shortages of workers (the labor force in some ports was halved by disease), vessel space, containers, and warehouse space plus congestion at ports all led to long delays and skyrocketing shipping costs (IFC 2021). Between November 2019 and February 2022, the average global cost of transporting a container climbed from \$1,362 to \$9,628. The disruption of the trucking industry also impacted the distribution of goods that arrived at ports and airports.

The vulnerability of the global transportation system was underscored by an accident at a key chokepoint—the Suez Canal—through which flows 12 percent of global trade worth \$1 trillion and 30 percent of container traffic. In March 2021, a large container vessel (Ever Given) rammed into the side of the Canal at its narrowest point blocking all traffic through the waterway. For six days the blockage halted the daily passage of goods worth \$10 billion with ripple effects felt far and wide.⁶³

In 2023, the shipping industry came face to face with problems interrupting traffic at a second major chokepoint, the Panama Canal, which handles 5 percent of seaborne trade. Severe drought in the Canal region has depleted the water stored in Lake Gatun and other reservoirs that is used to raise ships transiting through the Canal's locks.⁶⁴ Therefore, fewer than 25 ships used the Canal on an average day with the number likely to drop further in 2024 to less than 40 percent of normal rates.⁶⁵ While the occurrence of El Nino may have exacerbated the problem, the worst in 70 years, climate change and the deforestation of the Amazon are also contributing to erratic rainfall in the region.⁶⁶

In addition, as of 2024, the shipping industry is also having to deal with attacks by pirates and Houthis in the Red Sea and the Gulf of Aden.⁶⁷ This adds to the industry's woes, with insurance charges on the rise and shippers having to shoulder the costs of rerouting vessels. Although the excess capacity in the shipping industry, has dampened the rise in ocean freight charges.

Each of these incidents concentrated in a three-year period have drawn attention to another fragile link in the value chains straddling the world. There are threats emanating from multiple sources. An accident, a drought, a regional conflict, the sudden stoppage of supplies of key materials can be destabilizing with ramifications that spread across the world. To minimize the disruption that can be caused by known unknowns and the black swan events, countries will need to work together to sustain a global equilibrium and the smooth functioning of GVCs.

3. GVCs are complex, fragmentary and with long tails

Digging deeper into mineral supply chains uncovers additional chokepoints deserving attention. The supply of sand with a silicon content in the 95 percent range used for making polysilicon the basis for solar panels, microchips and optical fiber, is found in relatively few places. Crucibles in which wafer quality ultra-pure silicon is melted require a specific type of quartz almost all of which, is sourced from a mine in North Carolina operated by Sibelco a Belgian company (Conway 2023). And the list goes on. The world is not at risk of running out of critical mineral resources at current rates of exploitation and recovery⁶⁸ however, the cost of mining certain minerals such as copper (in Chile) have been rising as the ores being processed are of poorer quality with diminishing amounts of mineral content (as little as 0.6 percent in the vast Chilean Chuquicamata mine. Conway 2023; Henckens 2021). Mining is only the start of the journey a mineral enters. This is followed by processing into different grades and shapes, which takes place in facilities located in different countries. Hence a substance can make several stops from extraction to end use as it wends its way along the value chain.

For example, quartz ore (SiO₂) of the highest quality mined in North Carolina (USA) is processed in Norway from where it is distributed to a handful of manufacturers in Japan, the US, France, Germany, and China.⁶⁹ Shin-etsu of Japan leads the field with its proprietary technology for making the most advanced single silicon crystal pulling crucibles.⁷⁰ These are paired with furnaces such as the ones produced by Linton Crystal Technologies, an American company. The supply chain for the materials and equipment needed by the microchip industry narrows as one probes deeper. The semiconductor supply chain is precariously balanced.

Semiconductors

A closer look at the GVCs for other products demonstrates more strikingly the complexity and dispersion of value chains of everything from semiconductors to diapers. A few examples can suffice, starting with semiconductors that threaten to dislodge oil as the economic lifeblood.⁷¹ Semiconductors exemplify the role of GVCs in knitting together tens of thousands of suppliers scattered across two dozen countries and enabling the production of some of the most complex items ever created (Yusuf 2022; ADB 2023).⁷² The inputs that that go into the fabrication of a semiconductor crisscross 70 national boundaries before they reach the final user.

The process begins with the Electronic Design Automation (EDA) software that creates the fiendishly complicated template for a semiconductor. Four companies, three American, control 70 percent of the world market.⁷³ Next comes the core IP that is the chip's brain, which determines what it delivers. Much of this is the preserve of firms based in the US such as CEVA, Rambus, SST, and Japanese owned ARM. Taiwanese and Chinese firms are getting into the act however, this end of the value chain

remains largely in North America and the UK (home of ARM). The manufacture of semiconductors calls for a wide assortment of both raw and manufactured items, such as silicon wafers,⁷⁴ lithography systems, photomasks, and photoresists, etching, cleaning and deposition tools (physical and chemical), along with certain chemicals and gases,⁷⁵ inspection and metrology equipment, each of which is the preserve of one or a few specialized suppliers in the US, Japan, the Netherlands, South Korea, China, Germany, and Taiwan.

Semiconductor manufacturing equipment is another major item with US and Japanese companies taking the lead in etching, fabrication, and inspection/metrology. The Big Three producers of etching equipment are Applied Materials, Lam Research, and Tokyo Electron.⁷⁶ NAURA and AMEC are two Chinese firms competing with foreign suppliers. Process control equipment, which determines yield rates of fabrication is the preserve of firms such as KLA Tencor and Advantest. Because of high entry barriers, Chinese firms are largely absent.

Suppliers of microlithography machines using photolithography, electron beam lithography, nanoimprinting lithography include ASML based in the Netherlands, Japanese firms Nikon, Canon, NuFlare, and Ushio, Finisar in the US, and a couple of European firms (EV Group, IDE). Three Chinese firms are also in the running: China Shanghai Micro-Electronics Equipment Group (SMEE); Dongfang Jingyuan Electron; and Semiconductor Manufacturing International Corp (SMIC).⁷⁷ SMEE has successfully developed immersion deep ultraviolet (DUV) lithography but has not apparently advanced beyond lab-based demonstration equipment. This is one critical area in which China lags.

Only a single firm, ASML currently produces EUV (extreme ultraviolet) photolithography machines capable of generating beams with wavelengths of 7nm and less.⁷⁸ However, Canon is now offering an alternative technology (invented in 1996), nano-imprint lithography (NIL), which it claims can deliver the desired degree of miniaturization at lower cost, and achieve the throughput of photolithography machines while consuming less power because it does not require light with a specific wavelength. If the Canon offering does prove to be commercially viable and can be used to produce chips with 2nm circuits, ASML will face competition down the road although in the near term, the leading manufacturers will continue relying on the proven technologies. By enabling inexpensive production of patterns of 15nm or smaller, NIL is poised to begin making inroads in the flash memory segment of the industry and edging into the logic chip segment possibly a decade from now.⁷⁹

The major corporations source numerous parts and components from hundreds of suppliers.⁸⁰ ASML has 5,000 suppliers of which 700 are product related and 200 are providers of critical components. ASML's subcontractors are spread over the Netherlands, Germany, the US⁸¹ and Japan. And ASML is by no means atypical. All firms in the microlithography industry e.g., Nikon and Canon, rely upon specialized suppliers to build their machines some located close at hand, others a continent away. To create an ASML (currently the most valuable technology firm in Europe) and internalize much of its

supply chain, a feat China is attempting, is an extraordinarily demanding and expensive task. “With [its long tail] of suppliers of everything from software to tin and tungsten and strategic partnerships with companies like Carl Zeiss AG, which makes its critical multilayer mirrors, ASML runs a global ecosystem ... A lot of ASML’s technology is not on blueprints, it’s in the heads of people. [To replicate the company] you don’t need just the blueprints; you need everything surrounding it and the entire supply chain. You must build an alternative Zeiss etc. That is a colossal task. You’re not talking about months or years. You’re talking about a decade or more.”⁸²

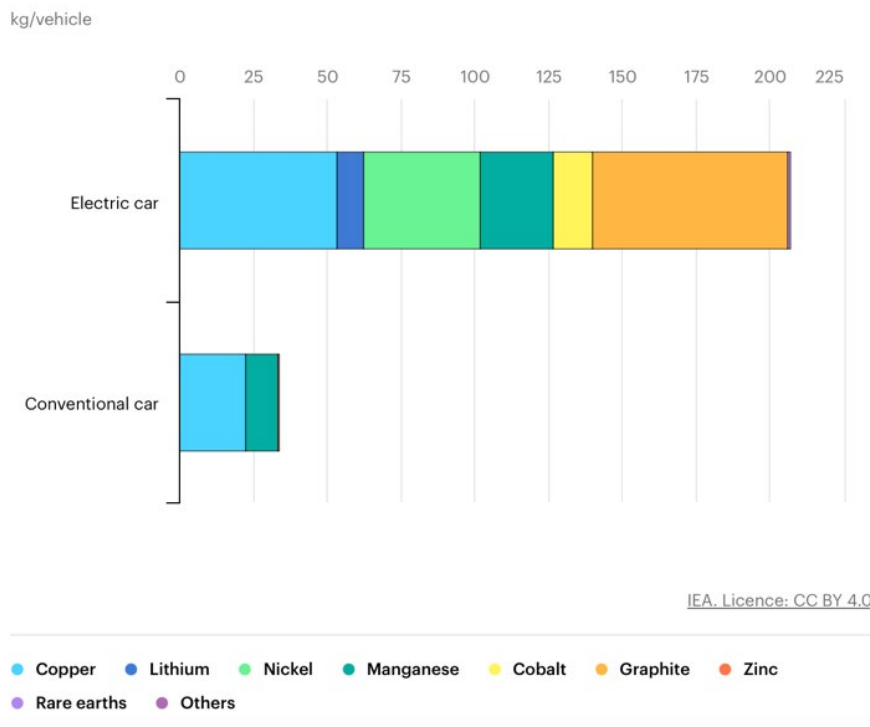
Automobile supply chains

The value chain for an ICE (internal combustion engine) car can be mind boggling. The average vehicle has 30,000 parts, which assemblers source from thousands of suppliers. Although a company such as Ford buys subassemblies from 1,800 suppliers they in turn depend on a tiered system of suppliers, which can be five deep distributed far and wide.⁸³ Sheffi (2023) describes how a car’s catalytic convertor is put together. The assembly is conducted in Mexico using a metal shell manufactured in Germany, which envelops the convertor, the internal ceramic honeycomb substrate coated with a precious metal catalyst. The substrate is manufactured in Guangzhou, the catalyst comes from Japan, and it is applied by a firm in North Carolina. The substrate itself is made of several materials including cordierite, mullite, alumina, and other minerals. It takes three months from the time that the substrate is completed by the Chinese company before it is installed in a vehicle. Enroute, it acquires a few additional parts needed to arrive at a fully functional component.

Although an EV (electric vehicle) has fewer parts—about 12,000 in total with the engine containing 20 parts or less vs. 113–200 in an ICE vehicle—the supply chain is as convoluted and sprawling with batteries that account for a quarter or more of the vehicle, at the core and are responsible for the still relatively high unit cost of the vehicles.⁸⁴ EVs have single speed transmissions and do not require superchargers to augment performance, but they are thickly loaded with electronics and these plus the powertrain can account for half the value of the car. The mechanical simplicity of EVs is offset by mineral intensity. An EV embodies six times the mineral content of an ICE vehicle and more energy is needed to process the minerals used to make EV batteries (e.g., nickel, lithium etc.) than for conventional cars (copper, manganese. Figure 15).⁸⁵

China dominates the production of storage batteries for EVs especially the mining and refining of key materials. CATL and BYD the two largest Chinese manufacturers of batteries are at the forefront of technology development and accounted for 52 percent of the global market in 2023 followed by LG Energy, Panasonic, SK On and others.⁸⁶ The geographic concentration of suppliers is relatively high which increases the vulnerability of the supply chain.⁸⁷

Figure 15. Mineral used for EVs and conventional cars



Source: IEA (2021) <https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary>

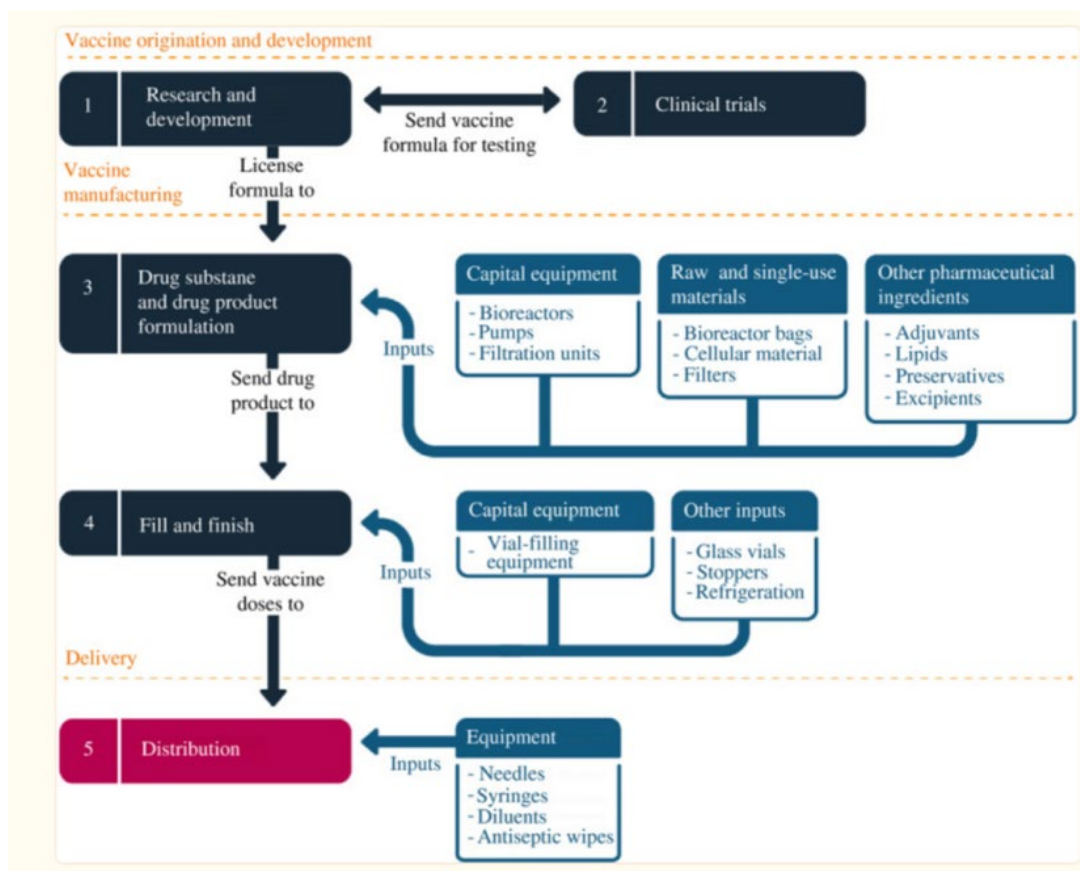
Vaccine and PPE supply chains

The Covid pandemic focused attention on the supply chain for mRNA and other vaccines and PPEs (personal protective equipment). To meet demand, suppliers had to be mobilized from far and wide, many in China, and equipment repurposed. Pfizer one of the two leading producers of the mRNA vaccine relied on 300 suppliers in the US, Europe, and East Asia and on 35 production facilities. In all, the suppliers and manufacturing facilities were spread across 100 geographic locations. Pfizer had to comb the globe to fulfil its requirements for reagents, specialized chemicals, borosilicate glass vials, syringes and other hardware, polymerases, a type of enzyme, that convert DNA to mRNA, ingredients used for making lipid nanoscopic bubbles to enclose the mRNA, and access to a rare substance called vaccinia capping enzyme (VCE), which helps keep the mRNA from degrading and prevents human cells from rejecting it. Fill and Finish facilities where vaccines were loaded into sterile containers had to be expanded and skilled workers found to operate them.⁸⁸

The logistics of storing and transporting mRNA vaccines to users were equally demanding as the vaccine had to be maintained at extreme subzero temperatures.⁸⁹ This called for reusable, insulated, thermal containers, which had to be manufactured in quantity in addition to electronic devices inserted in the boxes to monitor temperature and signal location. In addition, vaccine manufacturers built freezer farms and ensured that dry ice was available at appropriate waypoints (Sheffi 2021). That millions of doses were manufactured and delivered in record time is testimony to the creation and functioning of the supply chain, but it was a close-run thing. It was because the technology had been developed and suppliers as well as logistics providers could be assembled from around the world, that many tens of millions gained access to life saving vaccines.

Figure 16 depicts the vaccine value chain starting with decades of biochemistry and microbiology research, and continuing through trials, manufacture at scale, fill and finish and eventual distribution. A long journey that can take years and billions of dollars. To have completed the trials of the mRNA vaccine and begun distribution within months shows the working of the value chain at its best.

Figure 16. Stages of vaccine manufacturing



Source: Bown and Bollyky (2022) <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8447169/>

The Covid pandemic also revealed the inadequacy of stockpiles in most countries and a dependence for items such as facemasks, goggles, gloves, gowns, sanitizers, and respirators on a few suppliers. More than one half of facemasks were made in China. A high percentage of latex gloves were produced by Malaysia and Thailand. Raw material shortages and export controls hampered production and meeting the spiraling demand required retooling and repurposing factories to manufacture a different mix of products.⁹⁰ All manner of firms pitched in. For example, Barbour and Burberry the British fashion retailers began producing protective gowns and masks, while Louis Vuitton tasked its perfumeries to manufacture a hydro-alcoholic gel hand sanitizer (Best and Williams 2021). These innovations reshaped and extended supply chains and within months, critical constraints were eased, and backlogs worked down sufficiently for a degree of normalcy to be restored.

Figure 17 shows the global distribution of PPE production and the interdependence of countries for these vital items. As noted above, China is at the center of supply chains for masks, protective suits, and goggles. The production of surgical gowns is more equally divided between the US and China. Many European countries, China and the US were among the leading producers of respirators, and the surgical glove industry was concentrated in Southeast Asia and China (ADB 2020).

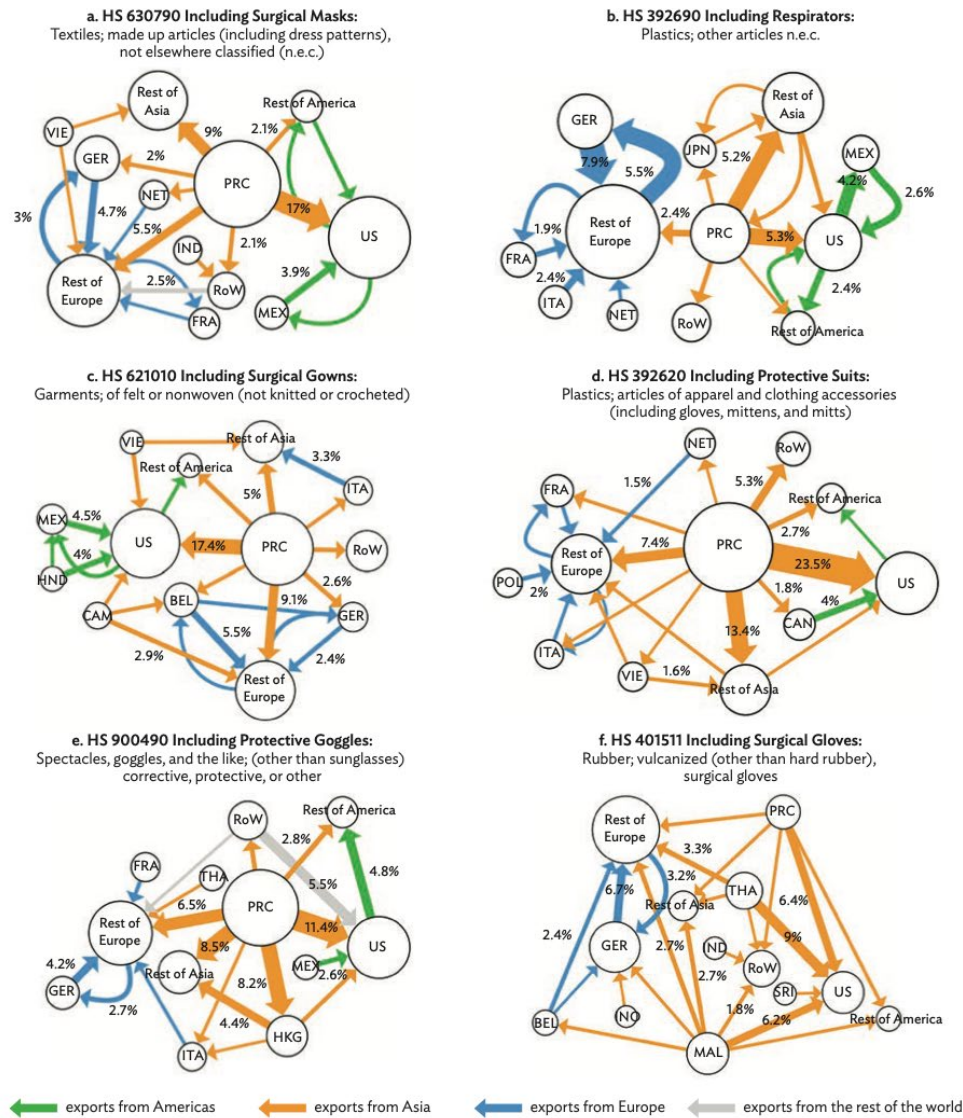
Other supply chains

The value chains for mundane items such as diapers and denim are no less complex and far flung. A diaper has fifty components including woven and non-woven material, elastic materials, hooks, fasteners, tapes, and glue. Companies making diapers in the US can source only some of these items from North America, the rest come from overseas (Sheffi 2023).

Likewise, the value chain for denim jeans might start with a designer in Paris or Milan and end at a retailer in New York but it traverses many countries in between. Cotton from Azerbaijan or Australia for example, may be spun, woven, and dyed in Japan using synthetic indigo,⁹¹ then shipped to Portugal or Cambodia or Bangladesh where it is cut, the ten different pieces assembled, sewed, and labelled.⁹² The buttons, zippers, rivets, and labels might come from China or other Asian countries. Once it is ready, the jeans might be trucked to Chittagong port and shipped to their destination (Snyder 2008).

The examples can be multiplied but the message that emerges is consistent. Unlike the times when a single vast factory such as Ford's Rouge River Plant manufactured the entire vehicle from basic raw material, most products depend upon parts, components, and services from several suppliers, which thanks to the Internet and advanced logistics, can be increasingly spread across the country and the world, especially services. Whereas value chains for certain products can be internalized within a large, diversified economy such as China, in most instances, countries depend upon GVCs to trade and to satisfy their requirements for both goods and services. It is difficult to imagine a world devoid of GVCs. It would mean turning the clock back by three to four decades with a significant diminution of income and material consumption standards.

Figure 17. PPE supply chains



BEL = Belgium; CAM = Cambodia; CAN = Canada; FRA = France; GER = Germany; HKG = Hong Kong, China; HND = Honduras; HS = Harmonized System; IND = India; INO = Indonesia; ITA = Italy; JPN = Japan; MAL = Malaysia; MEX = Mexico; NET = Netherlands; POL = Poland; PPE = personal protective equipment; PRC = People's Republic of China; RoW = rest of the world; SRI = Sri Lanka; THA = Thailand; US = United States; VIE = Viet Nam; n.e.c. = not elsewhere classified.

Notes: The size of the nodes represents the economy's total trade (exports plus imports) of the concerned commodity group. The thickness of the lines represents the value of the flow of goods between economies. Some lines show the share of exports to the total global exports of the commodity group. For clarity, only exports with high values are represented by the lines.

Source: ADB calculations using data from United Nations. Commodity Trade Database. <https://comtrade.un.org> (accessed 22 March 2020).

Source: ADB (2020)

4. GVCs (and globalization) imperiled

Rumblings against globalization had begun surfacing in the 1990s even as neoliberal policies gained ascendance (Scholte 2005; Rodrik 1997).⁹³ A similar backlash had surfaced in the late nineteenth century against the then ongoing globalization (O'Rourke and Williamson (1999)⁹⁴). And according to Dani Rodrik (2019), one of the voices cautioning against hyperglobalization, "Policymakers set the world on [a] path, requiring domestic economies to be put in the service of the world economy instead of the other way around. In trade, the transformation was signaled by the creation of the World Trade Organization, in 1995. The WTO not only made it harder for countries to shield themselves from international competition but also reached into policy areas that international trade rules had not previously touched: agriculture, services, intellectual property, industrial policy, and health and sanitary regulations ... In finance, the change was marked by a fundamental shift in governments' attitudes away from managing capital flows and toward liberalization Countries freed up vast quantities of short-term finance to slosh across borders in search of higher returns."

Globalization, crises, and policy reactions

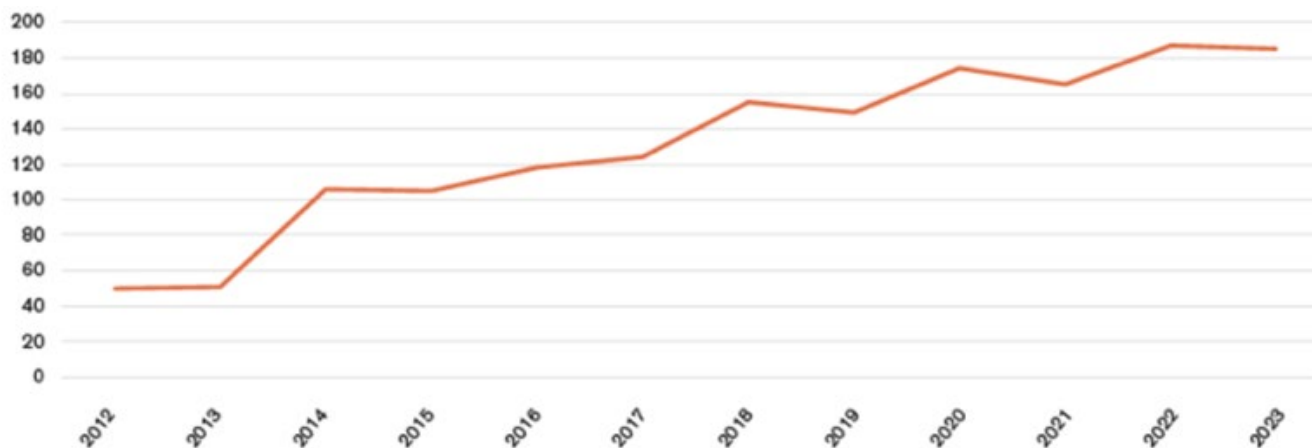
An early indication of the risks associated with accelerated globalization was the East Asian Crisis of 1997-98, which pummeled economies pursuing trade liberalization and export-led growth and integrating with GVCs.⁹⁵ Because the Crisis was regional, and the affected countries were able to make the needed adjustments as well as to regain their economic stride within a couple of years, GVC enabled globalization with China now in the forefront, resumed. This phase of globalization ended with the onset of the Financial Crisis in 2008-2009. The painful and lingering disruption caused by this powerful shock exposed the downsides of globalization and initiated the partial retreat from neoliberal policies in advanced economies.

The post Financial Crisis has brought into the open the pressures that had been building. The very success of GVCs accelerated industrialization in developing economies, China in the lead. With MNCs aggressively outsourcing production to emerging economies and integrating them into their value chains, several labor-intensive industries in the US and European countries were exposed to severe competition from imports and began losing ground (Pierce and Schott 2012). While light manufacturing was the initial victim, companies producing consumer durables, ferrous and non-ferrous metals, auto parts, machine tools, and electronic products saw their market shares battered by imports. Industrial hollowing was devastating for communities whose livelihood depended on the functioning of manufacturing establishments. Many of those laid off found it difficult to acquire new skills, relocate and start afresh⁹⁶ and their lifetime incomes were reduced. Their predicament was made worse—at least in the US—by a barebones social safety net (Autor, Dorn and Hanson 2016; 2021). Those lacking a four-year college degree, the majority of the US workforce, were among the hardest hit (Deaton 2023; 2023a). The loss of jobs providing stable incomes contributed to the breakdown of marriages, mental stress leading to self-harm,⁹⁷ and a rising distrust of political elites (Charles, Hurst, and Schwartz 2018; Graham and Pinto 2021). An erosion of property values in communities

where economic activity had entered a downward spiral, curtailed local property tax revenues and this impacted the supply of public services that were needed more than ever.

Imports were not the only reason why well-paid jobs particularly for those with a high school diploma or less, became harder to find. Automated machinery, industrial robots, software and the diffusion of capital and skill intensive technologies shoulder more of the responsibility for job-scarce growth especially affecting those lacking higher education and skills, and for the decline in the share of labor (Harrison 2024).⁹⁸ The winnowing process also affected certain routine mid-level white collar jobs. (Autor 2022; Kogan et al 2021; Acemoglu and Restrepo 2019; Restrepo 2023). However, it was imports that shouldered more of the blame because they were easier to target politically. The net result of this almost two decade long industrial upheaval was the rise of the 'great discontent' on the part of those who felt bypassed by the prosperity enjoyed by the top 10 percent and neglected by the ruling elites. In the US and more gradually in Europe, there was an upsurge of populism caused by trade related economic insecurity but also by other factors such as income inequality (Graham 2001; Autor et al 2022; Dippel et al 2015; Margalit 2019; Qureshi 2023).⁹⁹ This populist turn, aside from undermining liberal democracy, has begun to transform the global trading environment and GVCs. One tangible evidence of this is the upward creep of quantitative restrictions and tariff barriers over the past decade and renewed interest in industrial policies (Figures 18&19).¹⁰⁰ Among the most notable developments was the imposition in 2018 by the US of tariff duties on imports from China averaging 19.3 percent (covering two thirds of China's exports to the US).¹⁰¹ China retaliated with tariffs averaging 21.1 percent on imports from the US (covering 58 percent of US exports).¹⁰²

Figure 18. Quantitative restrictions are on an upward trend since 2012

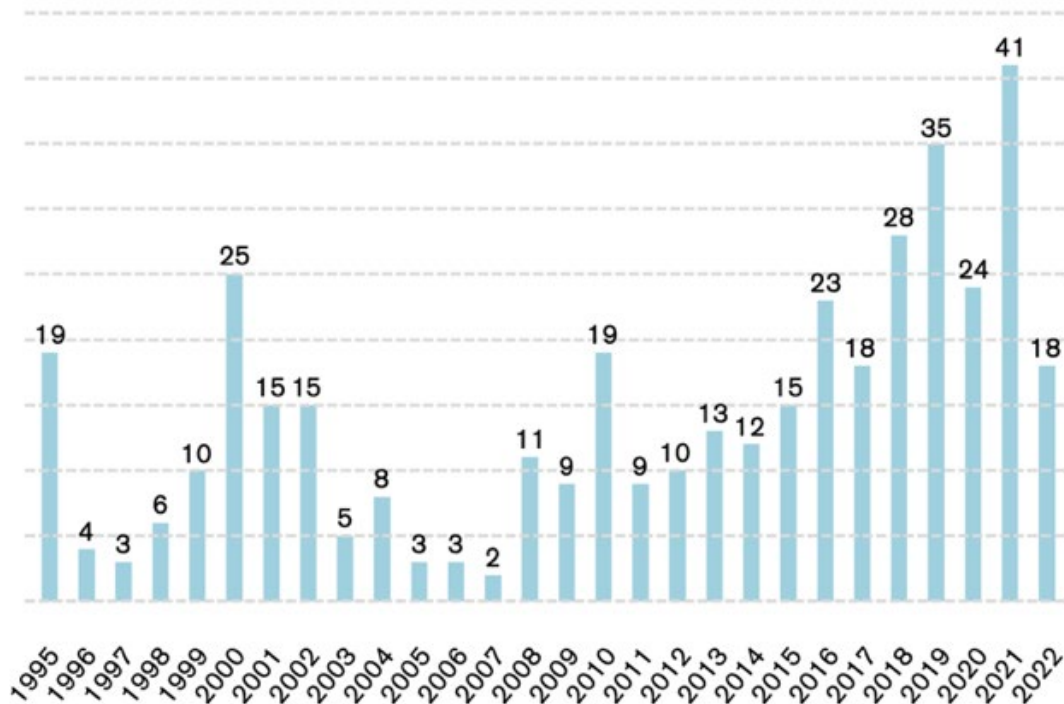


Notes: Figure C.1 shows the evolution of the number of quantitative restrictions in force justified by WTO members under Article XXI of the GATT 1994 from 2012 to 2022.

Source: WTO Quantitative Restrictions (QR) Database. Available at: <https://qr.wto.org/en#/home>.

Source: WTO. <https://qr.wto.org/en?ref=common-navbar#/home>

Figure 19. So also, are countervailing measures



Source: WTO (2023) https://www.wto.org/english/res_e/booksp_e/wtr23_e/wtr23_ch0c_e.pdf

The rise of protectionism, the adoption of ‘soft industrial policies’¹⁰³ and the weakening support for the rule based international order have immediate and longer-term implications for GVCs. Protectionism and the resurgence of industrial policies have been reinforced by supply chain vulnerabilities brought to light by the Covid pandemic and the Ukraine war.

Magnifiers of deglobalization tendencies

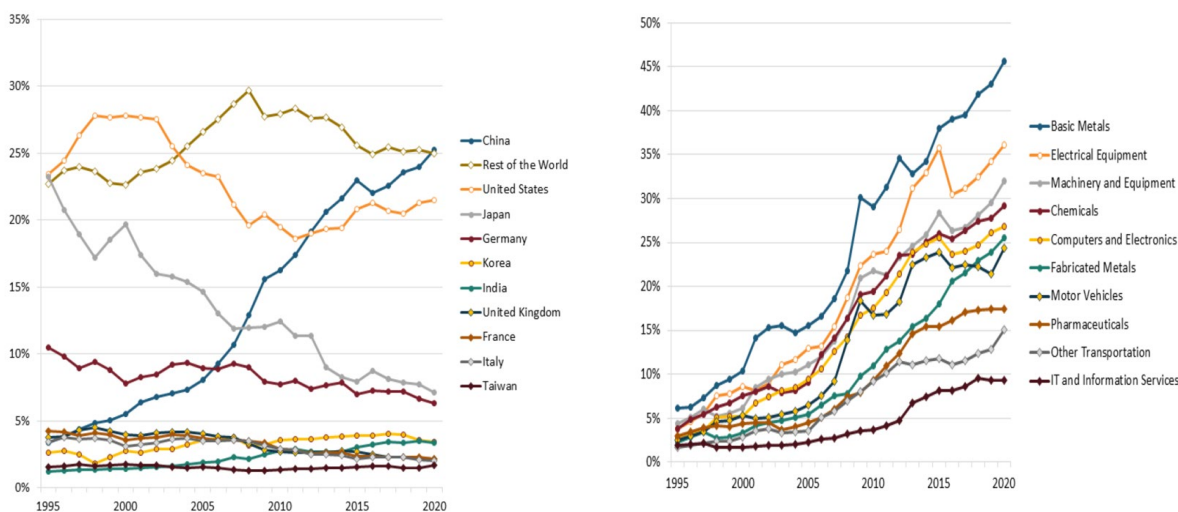
That these trends could persist is linked to a parallel development, which is the sharpening geostrategic rivalry between the US and China exacerbated by increasing tensions also between China and the EU, Korea, and Japan. The causes of the geostrategic rivalry are threefold. One is the emergence of China as the world’s preeminent manufacturing hub and a major source of imports into the US. In 2022, the US imported \$563 billion worth of goods from China and ran a bilateral trade deficit of \$367.4 billion. This import dependence and trade deficit is blamed for some of the industrial hollowing and ensuing localized pockets of unemployment.

A second cause is China’s growing political clout and the influence it is acquiring in Southeast Asia, parts of South Asia, the Mideast, SSA, and Latin America, and its “unlimited friendship” with Russia. Much of this influence derives from China’s Belt and Road Initiative, its FDI and lending by China’s

banks (with fewer strings attached), and the ability of China's construction firms to rapidly complete complex projects. The US and European countries fear that they are being eased out of their past spheres of influence and because of fiscal and other constraints,¹⁰⁴ cannot match the scale of China's activities. Moreover, in a world where liberal democracy is losing adherents by the day, China's authoritarian model is favored by many leaders and by disillusioned electorates that are persuaded to swap democracy for rule by a strongman.¹⁰⁵

A third cause is the worry that China is determined to overhaul the US industrially and to build military capabilities that are on par with those of the US.¹⁰⁶ Already, China's industrial output in seven of ten major strategic industries substantially exceeds that of the US. Figure 20 shows, China pulling ahead of the US as well as of other OECD countries in terms of total output and increasing its global share in each one of the ten industries.¹⁰⁷ Barring a major domestic crisis, whether financial or political, a Chinese economy that sustains growth rates of 4–5 percent per annum for a decade, will surpass the US's GDP.¹⁰⁸ Measured using the PPP metric, China's GDP exceeded that of the US in 2018 and the gap has widened since.¹⁰⁹ China's military already a formidable regional force (with a naval fleet almost twice the size of the US'), is on track to challenge the preeminence of the US within a matter of years. Its military-industrial complex churns out weaponry at rates far higher than what the US can muster (e.g. J20 Stealth aircraft).¹¹⁰ For example, the Bohai Shipyard at Huludao, which builds both civilian vessels and nuclear submarines, now has the annual capacity greater than all ships launched by the US since 2014. The launch of a "sailless" submarine and nuclear submarines with angled sails¹¹¹ and new propulsion systems indicates that China is not lagging technologically.

Figure 20. Shares of the US, China, and other countries in ten strategic industries 1995–2020



Source: Atkinson and Tufts (2023)

The risks associated with geostrategic tensions are exacerbated by the possibility that Xi Jinping might want to deliver on his promise to the Chinese people that “Resolving the Taiwan question and realizing China’s complete reunification is a historic mission and an unshakable commitment of the Communist Party of China.”¹¹² A takeover of Taiwan by military or other means would disrupt a crucial value chain because it is an epicenter of the chip making industry, and the producer of the most advanced chips for the likes of Apple, Amazon, Google, Nvidia, and Qualcomm. Taiwanese contract manufacturers principally TSMC, command a 68 percent share of the global market for semiconductors and 90 percent of the most advanced semiconductors (e.g. with smaller geometries and node sizes of 5nm, 3nm and now 2nm) are produced by TSMC alone (Sacks 2023). Taiwanese firms are also among the leading suppliers of printed circuit boards, advanced camera lenses, and OLED screens for i-Phones some manufactured by Taiwanese owned factories in China. Many observers are of the view that a forcible takeover is unlikely in the medium term, but because developments worldwide could change Xi’s calculations, ensuring the robustness of the semiconductor value chain has acquired a high priority.¹¹³

The realists among political scientists view economic relations between the US and China through the lens of zero-sum logic. From this standpoint, interdependence is not necessarily beneficial. Instead, it exposes both countries to trade sanctions by either party. The US has used export controls to limit the access of Chinese companies to advanced chips and chip manufacturing equipment.¹¹⁴ China in turn is exploiting its control over supply chains for critical materials (e.g., graphite,¹¹⁵ rare earths) and is quick to punish countries when political differences arise. Australian exports of coal, barley and wine were subjected to bans and import controls¹¹⁶ and China banned Canadian exports of canola oil and beef. A dispute over fishing led to a ban by China of rare earth exports to Japan. A trade dispute led to a prolonged suspension of China’s exports of urea to Korea.¹¹⁷ With weaponization of trade becoming more frequent, some restructuring of value chains is becoming unavoidable even as the advantages of GVCs are as apparent as ever (ADB 2023).

5. Trade wars, incipient decoupling, and derisking using strategic industrial policies

In light of geopolitical developments and vulnerabilities exposed by the Covid pandemic, a rebalancing of trade relations and a restructuring of supply chains, is seemingly unavoidable. This entails a restructuring and “derisking” of some GVCs,¹¹⁸ while sustaining the benefits conferred by globalization. How this will unfold is unclear because the decisive determinants will be political and not economic. Furthermore, to render the concept of derisking meaningful, companies will require strategic guidance buttressed by a host of incentives to offset the costs and accompanied by an industrial policy that builds needed manufacturing capacity in OECD countries.¹¹⁹

As noted by the WTO, “Security and geopolitical concerns have always been an important aspect of the multilateral trading system. The founding of the WTO’s predecessor, the General Agreement on Tariffs and Trade (GATT), was in part a response to the disastrous effects of two world wars and the first era of deglobalization in which bloc-based trade had started to dominate multilateral cooperation. As one pillar of the international system established in the aftermath of the Second World War, the GATT’s aim was to promote cooperation and address the underlying causes of the war in combination with the United Nations, the World Bank, and the International Monetary Fund (IMF).” The WTO in conjunction with other institutions largely lived up to their billing, but in the absence of some reengineering of the key institutions and a renewal of commitment by leading participants, multilateral trade and other forms of cooperation could continue eroding. If they do, an international system of governance laboriously constructed over decades that delivered solid economic results, could be rendered ineffectual at a time when it is most needed. (Linscott 2022).¹²⁰

Figure 21 that correlates trade openness with the probability of conflict indicates that the trade infrastructure that promoted globalization appears to have worked. From the 1970s onwards, as openness rose, the probability of conflicts diminished. Hence, abandoning an architecture, which may reduce the risk of conflict, under current circumstances, would be a mistake, rather the imperative is to fix the shortcomings that have come to light.

Figure 21. Greater openness was correlated with declining conflict



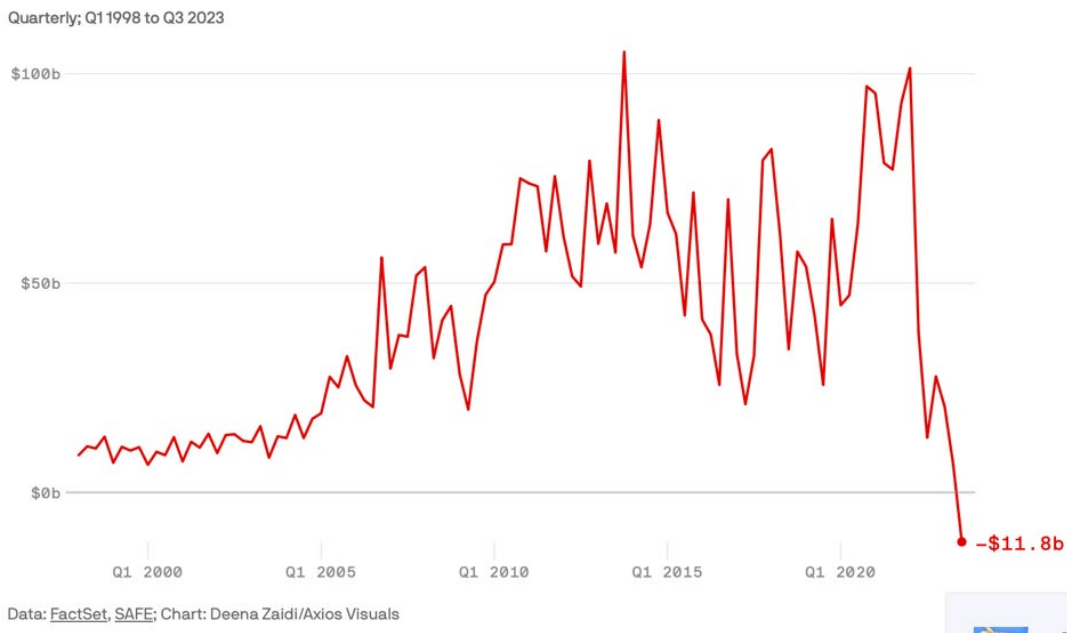
Notes: Trade openness is defined as the sum of world imports and exports divided by world GDP. Conflict probability is defined as the occurrence of militarized interstate disputes between two hostile parties, excluding threats to use force and lower levels of hostility, divided by the number of parties. **Source:** Feenstra, Inklaar and Timmer (2015) and Klasing and Milionis (2014) for trade openness, and Maoz et al. (2019) and Correlates of War Project (2017) (<https://correlatesofwar.org/>) for conflict probability.

Source: WTO (2023) https://www.wto.org/english/res_e/booksp_e/wtr23_e/wtr23_ch0c_e.pdf

A Cold War comparable to the one that simmered from the 1950s through the end of the 1980s is avoidable given the many stranded value chains that enmesh China with the US, the EU, and other Asian countries. By comparison, trade between the US and the USSR barely registered. It peaked at \$4.5 billion in 1979, which was less than 1 percent of total US trade. The two opposing parties during the Cold War, which ended with the dismantling of the Berlin Wall, had deliberately cultivated few economic linkages and the economic distance between them made it harder to achieve a rapprochement or paper over their geopolitical differences.

The ongoing trade war has been costly for both the US and China.¹²¹ Consumers and producers in the US paid a price, jobs were lost, there were political consequences, growth took a hit in both countries and the US trade deficit did not decline (Haas and Denmark 2020; Pettis 2021; Zhou 2023; Bolhuis et al. 2023).¹²² Much attention has been given to a decoupling of the two economies and its implications for other countries. Direct bilateral trade between the two countries has slowed and while most American firms operating in China intend to stay as do the Europeans and Japanese, they are cutting back on their investment and attempting to shift their supply chains away from China to the extent that they can in view of the options. The cutback in the release of economic and financial data by the Chinese authorities,¹²³ the laws announced by China restricting the flow of data out of the country coupled with severe punishments for those accused of espionage, have added to investor wariness (Arcesati and Groenewegen-Lau 2023).¹²⁴ FDI into China descended into negative territory in 2023 (Figure 22).¹²⁵ Technological decoupling is also ongoing.

Figure 22. FDI into China



Source: <https://www.axios.com/2023/11/07/china-economy-negative-foreign-investments>

Whether it is trade, FDI or technology, extensive decoupling would be costly for both countries. The expense of restructuring GVCs would be a major burden for MNCs large and small and many Chinese firms that depend on exports would be hard hit, as would be industries that rely on imports of equipment or technology. A fundamental shift in the characteristics of globalization, which made it more difficult for countries to work together in pursuit of economic greening, managing climate change, and other goals, would also have adverse long-term consequences even if the near-term adjustment costs are tolerable (Lardy and Huang 2023).¹²⁶

The new face of strategic industrial policy and international trade

A 'hard' decoupling aside from the administrative costs of policing such a development, would inflict major damage. An IMF study estimates that investment fragmentation would lower global GDP by one percent and that of China by two percent. The losses from trade fragmentation/decoupling could be as high as 7 percent of global GDP and technological decoupling could raise the cost to between 8 percent and 12 percent of GDP (Aiyer et al 2023).¹²⁷ According to the WTO (2023),¹²⁸ the world stands to suffer a 5.4 percent cut in real average incomes from a hard decoupling.

This dire scenario has not come to pass, and it is in the interests of all participants to avoid such an outcome by making suitable compromises. Too much is at stake. However, the perception of GVC vulnerabilities has led to renewed efforts to make GVCs more resilient without weakening their competitiveness and to double down on the efficient use of manufacturing capacity. It has initiated reshoring, nearshoring and friendshoring spurred by strategic industrial policies introduced by the leading developed economies and some from among the middle-income ones.¹²⁹ Analysis by Roth et al (2023) demonstrates the high concentration of US imports of critical technology items, with China responsible for five of seven global chokepoint commodities many of which are needed by the semiconductor industry. Meanwhile, China depends on imports of more than 400 items from the US and its allies with the semiconductor industry among the most exposed. Much of China's imports of silver powder needed for the manufacture of solar panels comes from Japan and it relies on Australia, Canada and the UK for nickel powder and flakes required for batteries and other electrical components.¹³⁰

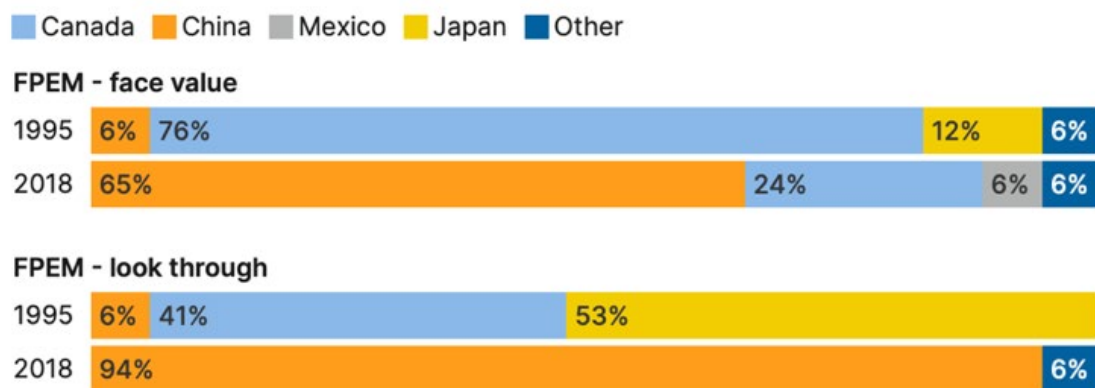
In response to rising concerns of governments, GVCs have begun sourcing more from countries other than China, and MNCs are backing these moves by redirecting their FDI.¹³¹ Because of some trade diversion, US exports to China fell as did China's exports to the US,¹³² however, exports to the rest of the world, rose. The big gainers were so-called bystander countries such as Vietnam, Mexico, Poland, Morocco, and Indonesia, which have attracted more FDI (including from China),¹³³ increased their exports to the US and have served as conduits for some of China's trade diverted through neighboring countries. Bystander countries with the latent revealed comparative advantage and the capital stock gained the most from trade diversion arising from near and friend shoring. They have begun attracting products not targeted by tariffs in addition to the ones that are targeted (colocation effect) and their exports to the rest of the world have risen alongside exports to the US and China

(Dang, Krishna, and Zhao 2023). Mexican firms integrated with GVCs have gained more than others especially those in the capital and technology intensive industries such as chemicals, computers, and automotive equipment (Utar et al. 2023).

However, countries belonging to the Indo-Pacific Economic Framework for Prosperity (IPEF) are integrating through trade with China, which has oriented more of its trade towards Asian countries (ADB 2023). Their sources of imports have become less diversified as have their export markets (Dahlman and Lovely 2023a). Even as the direct linkages between the US and China might be fraying, the indirect linkages between China and the US are expanding (Baldwin et al 2023; Figure 23).¹³⁴ And China remains the principal, regionally integrated, manufacturing hub and the dominant supplier of intermediate inputs (Figure 24).¹³⁵ Thus far, the decoupling from China is largely cosmetic.¹³⁶ Chinese trade to the US is being rerouted through other countries, a development that has lengthened GVCs making them more complex and carbon intensive, as new nodes are introduced (Oxford Economics 2024). Therefore, the distance between networked firms has increased but without any increase in network density which would signify greater diversification of suppliers (Qiu, Shin and Zhang 2023).¹³⁷ A Wall Street Journal (2023)¹³⁸ headline makes clear that “US companies find it hard to quit China”. Moreover, Chinese firms have sidestepped restrictions on the import of semiconductor manufacturing equipment by exploiting a number of loopholes.¹³⁹ Older fabs imported equipment, which was then transferred to leading edge ones; spare parts were routed through third parties (Fuller 2023).

Figure 23. Leading suppliers to US manufacturers 1995 and 2018

Share of U.S. manufacturing sectors for which the top supplier is China, Japan, Canada, Mexico, or Other.



Source: Source: Authors' elaboration based on 2021 OECD ICIO tables.

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Note: FPEM stands for Foreign Production Exposure: Import Side (See Baldwin, Freeman and Theodorakopoulos 2022). "Look through" takes account of the direct and indirect origin of imported intermediates.

Source: Baldwin et al. (2023) <https://www.brookings.edu/articles/hidden-exposure-measuring-us-supply-chain-reliance/>

Figure 24. Trade of IPEF countries becoming more integrated with China

China's share of manufactured imports and exports, percent, 2010-21



Source: Dahlman and Lovely (2023) Note. Imports from China are in blue; exports to China in red.

6. Resilient GVCs for a multipolar world

A globalized system that continues to deliver advantages to all participants calls for collective effort on three fronts. First the leading trading countries—the US, China, Japan, and those comprising the EU—need to agree on the essential rules and understandings to keep the system from splintering into regional blocs. Second, countries must address the domestic problems caused by globalization that are at the root of voter dissatisfaction. And third, having experienced the disruption caused by the Covid pandemic and the Russia-Ukraine war, governments and MNCs need to address the revealed shortcomings of their GVCs. This is a matter of urgency because the geopolitical environment will continue to be freighted with uncertainty and the several risks noted earlier will expose GVCs to acute challenges.

The vulnerabilities to which GVCs are subject have been identified time and again¹⁴⁰—and the fixes are not unfamiliar (Sheffi 2015). They include the following:¹⁴¹

1. Increasing supply chain transparency and thickening network relationships across tiers of suppliers
2. diversifying sources of supply.
3. holding larger inventories—a greater focus on just-in-case eventualities rather than just-in-time efficiencies.
4. using technology to lessen product complexity and number of production steps.
5. reducing material intensity (e.g. via additive manufacturing) and recycling.
6. factoring in risks from transport and logistics bottlenecks.
7. and reshoring or nearshoring to reduce the geographic sprawl of some GVCs.

Companies with long and complex supply chains subcontract the production of components to specialized producers many of which are deep within the value chain with their financial and other conditions unknown to firms at higher tiers in the system. In such networks, individual firms will prepare for disruptions based on their own incentives and in most instances will not make the socially optimal investments to minimize risks of stoppages. Some of these firms are responsible for a minor but critical part and their failure can ripple through the entire value chain causing production to halt as happened recently when certain chips needed by automakers became unavailable. Hence increasing the transparency of the system by mapping the supply chain several tiers down, rating (with the help of multiple metrics) key suppliers, and assessing the vulnerabilities of distribution and transportation hubs, is a process that many lead companies have neglected. To avoid being caught by surprise in the future a sound, frequently refreshed understanding of the state of the value chain can minimize disruption and enable prompt remedial action when a supplier encounters difficulties or the entire system is exposed to a shock.¹⁴² Moreover, governments can use subsidies and taxes that can induce companies to make socially optimal investments. Grossman et al (2023) state that such instruments can improve the supply chain environment by ensuring that firms in adjacent tiers make ideal sizes of tier-to-tier transactions and either encourage or discourage investment in agility.

Diversifying sources of supply is a frequently cited means of building resilience. For certain light manufactures this is feasible, and GVCs do tap multiple sources for certain items. But creating a diversified supply chain with all the associated soft and hard infrastructures required to make it work, is an expensive proposition (Roth et al 2023). The ongoing lengthening of supply chains also leads to rising carbon emissions. The building of a broad local supply base in China for auto parts, electronic components such as high-density circuit boards, air pods, and active pharmaceutical ingredients (APIs) took almost two decades with a great deal of support from the central and local authorities. This was done in tandem with the training of a flexible workforce, massive investment in the transport and logistics infrastructure and building of regulatory capability.¹⁴³

Moreover, there are many electronic components, chemicals, and other items that only a few firms that have invested in the R&D and skilled workers, can produce (e.g. Chinese firms dominate the refining of rare earths and production of permanent magnets; Japanese firms are the principal suppliers of chemicals used by the semiconductor industry such as photoresists). The recent experience of the automobile, chipmaking and bio-pharma industries has clearly shown how rapidly the supply chain narrows for certain items (ADB 2023). For example, the tools needed for chemical deposition, photomasks/resists, etching, and photoresist stripping that chipmakers need are manufactured by a handful of companies such as Applied Material, Tokyo Electron, and LAM Research. While it would be prudent for auto assemblers and makers of smartphones to diversify their sources, there are limits to what is practicable. Therefore, close communication with the most critical suppliers in the various tiers of the supply chain is probably the only viable means of minimizing unpleasant surprises.

Holding additional inventories of parts and raw materials can contribute to supply chain robustness and firms have begun to stockpile raw material, chips, rare earths, and gases (neon, argon needed for lasers, etc.). This ties up cash and there is the risk that certain items will become obsolete or redundant. Augmenting stockpiles also goes against the grain of practices favoring just-in-time replenishment and lean inventories. But it must be weighed against the disruption caused by sudden shortages, rising prices, lost revenue, and the cost incurred of acquiring the needed items when a crisis hits. The Covid pandemic drove home lessons that have been learned in the past and then quickly forgotten. Whether companies will commit to enduring changes remains to be seen.

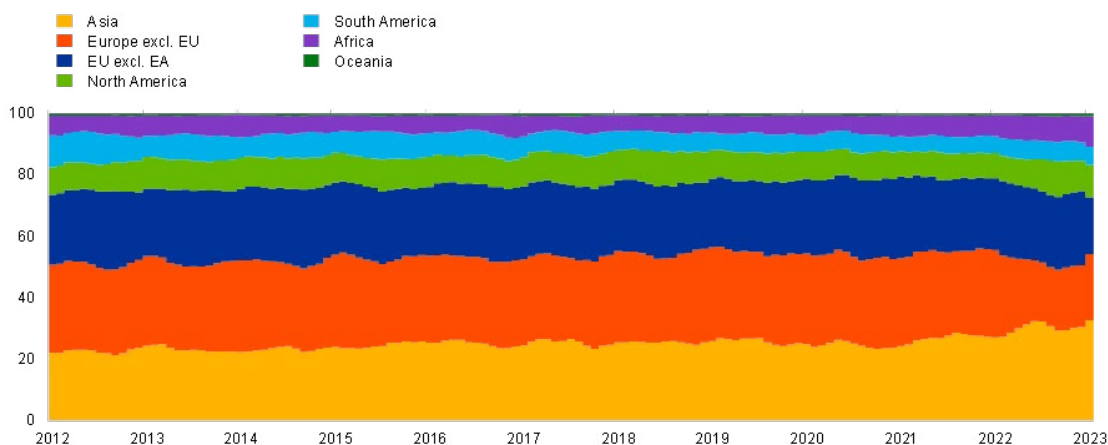
Using technology to make process innovations, which can lessen the complexity of the supply chain, improve the gathering and analysis of information on the health of the supply chain, and redesigning of products to simplify manufacturing and cut the number of parts (EVs are a big leap in this direction) is another way of rendering GVCs more robust. A less material intensive production system, substitution of more for less abundant raw materials (as is ongoing in the battery industry where firms are shaving the consumption of cobalt),¹⁴⁴ increasing use of additive manufacturing that minimizes waste, and greater emphasis on recycling materials, can all lessen value chain vulnerabilities.

However, there are limits to what is desirable and feasible. Reshoring, as the US and others are discovering runs into several obstacles. Costs are much higher, labor with the required skills is unavailable, and the manufacturing sector has lost capabilities that cannot be retrieved.¹⁴⁵ Furthermore, geographical diversification has advantages because it can cushion value chains against domestic or regionally localized shocks. A reduction in cross-border trade and FDI means that less innovation is shared, and countries do not take advantage of the specialized knowledge and expertise available elsewhere. In other words, globalization that harnesses the gains from international comparative advantage, trumps measures taken to enhance autarky even when internalizing the supply chain provides greater control over production processes. Chinese manufacturers of EVs with highly integrated production systems can undercut their foreign rivals

because a company such as BYD controls its entire supply chain and can procure inputs such as steel and rubber at prices that are not available to foreign competitors.¹⁴⁶ President Xi’s “whole nation approach” seeks to insulate China yet more through the import substitution of machineries, products, and components that China currently imports with a focus on mechanical and electrical products and high-tech items. As a result, China’s imports are growing more slowly than its exports.¹⁴⁷ The strategy is costly, but China seems ready to pay the price in the interests of greater security (de Soyres and Moore 2024; Setser 2023).

Nearshoring and friendshoring is a second-best response to the pressures on GVCs.¹⁴⁸ Deglobalization is averted albeit at a cost.¹⁴⁹ Some efficiency is sacrificed because of trade diversion in the interests of mitigating risks. This lengthens supply chains and raises costs as noted above (Oxford Economics 2024).¹⁵⁰ These processes are off to a slow start. The attempt at decoupling between the US and China has led to some nearshoring e.g., in Mexico¹⁵¹ and ‘friendshoring’ in Vietnam. Down the road other countries in LAC might benefit but it is early days.¹⁵² GVCs serving the EU have been slower to respond. Companies are attempting to diversify sources of supply and building inventories but not bringing production back home. Figure 25 shows that until the Covid pandemic struck, the share of intermediate goods imported from within the EU was increasing. Covid led to a reversal of this decade long trend with the EU importing 40 percent of intermediate and 65 percent of strategic goods (principally electronics) mainly from Asia where costs were lower and environmental rules less stringently enforced. Both the UK and Germany increased their imports of intermediate products from China between 2018 and 2022 (Oxford Economics 2024).

Figure 25. Imports by the EU of intermediate and strategic goods



Source: <https://www.ecb.europa.eu/press/blog/date/2023/html/ecb.blog230712~085871737a.en.html>

The situation remains fluid with no one having a good sense of where decoupling is heading or of knowing exactly what ‘derisking’ entails and how much is enough.¹⁵³ Companies are reacting to shifting political currents and other pressures and few if any can define a clear long-term strategy. However, industrialized countries appear to be firmly opposed to a further hollowing out of their industrial base.

7. Concluding remarks on issues and policies

Globalization and the value chains it spawned have been good for growth as well as for poverty reduction. By mobilizing resources, technologies, and skills from around the world, they have provided a buffer against shocks that can lead to interruption of supplies (Borin, Mancini and Taglioni 2021).¹⁵⁴ At least in the short-term, greater international connectedness can enhance resilience and speed up recovery when problems arise (Ghose and Montfaucon 2023).¹⁵⁵ Not everyone has benefitted equally from global integration and income disparities have brewed trouble for governments. However, there are ways countries can compensate the losers—those who felt left behind¹⁵⁶—and win their political support.¹⁵⁷ More effective implementation of these measures and creative utilization of strategic industrial policies are arguably the way to achieve domestic goals under current geopolitical circumstances (Evenett et al 2024 have tallied the number of industrial policies introduced in 2023 alone). As governments are discovering, this is easier said than done.

Going forward, only collective action at the global level will generate the needed public goods and support the desired level of economic activity.¹⁵⁸ But the future of globalization—and GVCs—is uncertain because geostrategic tensions remain high, and the perception of risks is evolving especially with respect to climate change. Technological advances offer longer term solutions but no quick fixes. Those at the frontier require testing, refining, debugging and the ones that prove to be commercially viable would need to be scaled up with large infusions of investment. Countries that are the global pacesetters confront serious domestic political and economic challenges. International institutions have lost credibility, financial clout and trust.¹⁵⁹ There is a dearth of leadership with politicians in major countries stoking nationalist sentiments—and blaming globalization—to win support and as happened in the 1930s, this could spur protectionism, slow technological progress, and tip the world economy from slowbalization into deglobalization (Suesse 2023; Colantone and Stanig 2017).

Dani Rodrik (2023) sums up the predicament of the few leaders still attempting to square some vital circles. “Policymakers [are] struggl[ing] to articulate an appropriate balance between global and local solutions. How much should international trade in goods and service be curbed or facilitated? How can the global climate change challenge be met by competing, sometimes hostile nations?¹⁶⁰ How is migration to be managed and its push factors adequately addressed? How are wars and conflict to be managed? To what extent should responses to health emergencies be dealt with by international organizations? ... The future path of the world economy will depend on how

these competing policy frameworks play out on their own and against each other ... Enabling the national-security establishments of the world's major powers to hijack the economic narrative would endanger global stability. The result could be an increasingly dangerous world in which the ever-present threat of a military conflict between the US and China compels smaller countries to take sides in a fight that does not advance their own interests."

A series of domestic missteps, the mishandling of international relations and further weakening of international institutions could spell the end of globalization in its current form and of the globe spanning GVCs. Growth would go into reverse, some of the gains from globalization would be voided and the search for solutions to existential threats put on hold or largely extinguished.

A return of political sanity and common sense plus increased scientific literacy could yet save the day. An attempt by Presidents Biden and Xi in November 2023 to try and normalize relations, to begin resolving differences and opening channels of communication, is a hopeful development.¹⁶¹ The transitioning away from fossil fuels and inefficient fossil fuel subsidies negotiated by COP 28 participants is another small positive step.¹⁶² Many more constructive multilateral initiatives are needed that credibly address current threats and at least the known unknowns around the corner. In Carl Sagan's words, "We must preserve and cherish the pale blue dot [because] in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves."¹⁶³

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Endnotes

- 1 The Institute of Strategic Studies (2023) counted 183 conflicts in 2023, the highest number in three decades. Moreover, the intensity of conflicts has risen with fatalities increasing by 14 percent.
- 2 This was flagged by Diamond (2015).
- 3 The Managing Director of the IMF worries that crises are being piled on crises. Blanchard (2023) makes clear that fiscal adjustment possibly with the introduction of carbon taxes will be required alongside an increase in green spending. In many countries, the primary deficit may climb before it can be capped and gradually reduced. <https://www.imf.org/en/News/Articles/2022/04/14/sp041422-curtain-raiser-sm2022> <https://www.imf.org/en/Blogs/Articles/2023/09/13/global-debt-is-returning-to-its-rising-trend>
- 4 Potential growth rates of many countries will also be dragged down, in some instances by declining populations. Celik et al. (2023).
- 5 Polycrisis was a term coined in the 1970s by Edgar Morin and subsequently forgotten. It was exhumed by Adam Tooze to characterize the interaction between the Covid pandemic, the war between Russia and Ukraine, climate change, rising energy prices, and the cost of living. <https://www.weforum.org/agenda/2023/03/polycrisis-adam-tooze-historian-explains/>. Countries will have to learn to cope with and make decisions under conditions of “radical uncertainty.” Kay and King (2020). To paraphrase Tolstoy, “No country is ready for crises which everyone expects.”
- 6 The WEF’s Future of Growth report (2024) offers a multidimensional approach to evaluating the quality of growth based on its innovativeness, inclusiveness, sustainability, and resilience.
- 7 Lindert and Williamson (2001) observe. “[T]here are no examples of countries that have risen in the ranks of global living standards while being less open to trade and capital in the 1990s than in the 1960s. “There are no anti-global victories to report for the postwar developing world.” The importance of agricultural trade is spelled out by Anderson (2023).
- 8 A survey of the literature by Irwin (2019) presents supporting evidence. <https://www.oecd.org/trade/understanding-the-global-trading-system/why-open-markets-matter/>; Bordo and Rousseau (2011) find that the impact of trade on growth is most apparent in the post-World War 2 period. Crafts (2000) examines the contribution of globalization to growth and welfare over the course of the 20th century.
- 9 Although exports and imports account for only 12-14 percent of US GDP, they materially contribute to industrial functioning, structural change, innovation, and efficiency gains and to welfare by providing the population with a wider array of goods at affordable prices.
- 10 Since 2018, China has redoubled its efforts to lessen its dependence on external suppliers of manufactured products and declining imports suggest that supply chains for machineries and other products are being internalized. Setser (2023); de Soyres and Moore (2024).
- 11 Rising temperatures are becoming baked in given the continuing investment by China, India and others in coal fired power plants. Recent moves by the major oil companies to expand their operations and their expectations that demand for petroleum will remain strong through mid-century at the least, are well in excess of what is needed to prevent average temperatures

from exceeding 1.5°C. Financial Times (2023) <https://www.ft.com/content/f389210f-ea4d-492d-b562-62aadd6ddc42>; Financial Times (2023) <https://www.ft.com/content/f25f315f-2551-4517-a7a2-2d9418001756>; <https://www.instituteforenergyresearch.org/fossil-fuels/coal/china-and-india-burn-record-amounts-of-coal/>; A UN report (2023) states that the twenty leading energy producing countries intend to increase their extraction of fossil fuels through 2050. The production of coal is projected to rise until 2030 and that of oil and gas through 2050. “Global levels of coal, oil, and gas estimated under the government plans and projections pathways would be 460%, 29%, and 82% higher than [what would be consistent] under the respective 1.5°C-consistent pathways.” UN (2023) <https://productiongap.org/2023report/#2023downloads>; India, which is the third largest emitter of greenhouse gases (GHGs) and the second largest producer of coal, plans to triple the output of coal from underground mines. Financial Times (2023). <https://www.ft.com/content/ea2595a-ecce-4f5e-a4c1-63c99293563d>; Nigel Grant a contributor to the report, remarked. “Despite their climate promises, governments plan on ploughing yet more money into a dirty, dying industry. On top of economic insanity, it is a climate disaster of our own making.” Fossil fuels are not the only culprits. Getting food from the farm to the table is responsible for a third of all GHGs with about one half of these emissions resulting from losses along the supply chain and from wastage. The way farming is conducted, the excess usage of NO₂ generating ammonia based fertilizer and land clearing, are also to blame. (Wong 2023b; Crippa et al 2021). <https://www.carbonbrief.org/food-systems-responsible-for-one-third-of-human-caused-emissions/>; <https://www.un.org/en/climatechange/science/climate-issues/food>; For a succinct analysis of the risks arising from climate change and the desirability of investing systematically in climate resilience, see Thomas (2023).

- 12 Based on an empirical study using input-output data from 155 countries for the period 1995-2015, Lim and Bellemare (2021) conclude that trade liberalization and participation in GVCs was a driver of structural change. Such participation can enable the average largely primary sector-based economy to leapfrog the manufacturing sector and become primarily service-based.
- 13 Hyperglobalization refers to the rapid integration of economies via trade following the elimination of barriers impeding the flow of goods capital ideas and people. In this paper, I am primarily concerned with integration through trade and secondarily through flows of capital. Rodrik (2011); Subramanian and Kessler (2013).
- 14 Globalization both the earlier round in the latter one fourth of the nineteenth century and the one that is ongoing, have received much scholarly attention both favorable and unfavorable. See Wolf (2004). Also, by the same author Wolf (2014) <https://www.imf.org/external/pubs/ft/fandd/2014/09/wolf.htm>; James (2001); Rodrik (2018). James (2023) notes, “The longtime critics of globalization are having another moment, claiming supply chain shortages, high inflation, and increasing migration are products of an overly globalized world. [But he claims that] Today’s globalization dynamic has the potential to create a revolution of system optimization, making the result of prior technical change cheaper and more accessible. In that sense, it is globalization that constitutes the real Inflation Reduction Act.”

- 15 Goldberg and Reed (2023) perceive a “shifting landscape”, which could further slow or reverse globalization. Paul (2023) envisions a form of truncated globalization with more state regulation and control.
- 16 Of interest as well is James (2021). IMF (2008) <https://www.imf.org/external/np/exr/ib/2008/053008.htm>
- 17 Figure 5 highlights three developments. “First, when trade is measured by value, the growth of normalized transport usage in dollar-distance (gray dashed line) echoes the growth of trade value as share of global output (orange triangles)—more than tripling by 2007 relative to 1965, before decreasing after the Great Recession. From 1965 to 2020, trade has increased by 2.5 times. In value, goods are being shipped more to both nearby and distant locations. Second, when trade is measured by weight, the growth of normalized transport usage in weight-distance (black solid line) is quite different from with the growth of trade weight as a share of global output (green squares) ... Transport usage in weight-distance steadily increases at a slower rate and more than doubles by 2020 (compared to the dollar-distance measure). However, as a share of the global economy, the aggregate amount of tonnage shipped has stayed relatively constant from 1965 to 2020 at around 0.24 to 0.26 shipped tons per \$1,000 of real-world GDP. Relative to the global economy, nations are not trading significantly more goods by weight. However, when nations do trade these goods, they are transported over increasingly further distances. Third, the growth in normalized trade statistics using ton-kilometer and dollar-kilometer parallel each other until 1990. After 1990, the growth in the normalized value measure accelerates through 2007 and then subsequently collapses. Meanwhile, growth in the normalized weight measure of trade continues to rise steadily throughout this period, largely unaffected by the 2008 recession ... While the collapse of the conventional measure of trade by value following the Great Recession is clearly visible in Figure 7, the measure of transportation usage by weight and distance barely changes.” Ganapati and Wong (2023).
- 18 Several reports prepared by IFIs examine the emergence and working of GVCs in detail e.g., World Bank (2020). ADB (2023) explores the implications for GVCs of the pandemic and trade frictions. They are complemented by literature surveys, see Antras (2022); Kano et al. (2020); and numerous publications on the topic issued by the Duke Center for International Development. <https://dcid.sanford.duke.edu/research/global-value-chains/>; Gereffi (2021).
- 19 The GVC encompasses the full range of value adding activities responsible for bringing a product to the end user. A supply chain takes account of the products, materials, and funds that go into the making of a product involving many different suppliers. <https://www.investopedia.com/ask/answers/043015/what-difference-between-value-chain-and-supply-chain.asp>
- 20 Trade liberalization was initiated by GATT in 1947. This led to eight rounds of multilateral trade negotiations plus regional trade agreements all of which contributed to a surge in the growth of trade.
- 21 The trade-based rate measures accounts for the portion of exports whose underlying value crosses two or more international borders prior to final consumption. An alternative production-based measures captures the share of GDP that goes into the export of

- intermediates. ADB/WTO (2021); Congressional Research Service (2020). <https://www.oecd.org/trade/topics/global-value-chains-and-trade/>
- 22 Timmer et al. (2021) compute a supply chain fragmentation ratio and use it to show that fragmentation began going down after 2010 and this was responsible for a third of the decline in global trade elasticity in the following years; Economist (2019a); ADB/WTO (2021); <https://www.imf.org/en/Blogs/Articles/2023/02/08/charting-globalizations-turn-to-slowbalization-after-global-financial-crisis#:~:text=The%20%20%20Slowbalization%20that%20followed%20the,trade%20amid%20rising%20geopolitical%20tensions.>
- 23 The need for global public goods is greater than ever and collective effort is essential. This is a large topic that has received extensive coverage. See Buchholz and Sandler (2021); Chin (2021).
- 24 An earlier round of globalization was halted early in the 20th century by the onset of the Great Depression and the rise of nationalistic regimes during the politically turbulent interwar years. Both led to a turning inwards of the leading industrial economies.
- 25 Fuentes and Moder (2020); A review by Eichengreen, Park and Shin (2021) of crises in several countries concludes: “It takes real GDP per capita a little over four years to recover the prior peak. Recoveries [are growing] longer, from less than three years on average in the 1950s to close to 4 ½ years starting in the 1970s (a 50% increase).⁶ However, this pattern is far from monotonic: recovery duration is longest in the 1980s (with the lost decade in Latin America) and 2000s (with the onset of the Global Financial Crisis). Over the entire sample and all countries, it takes three years for employment to recover to the previous peak, one year faster than for per capita GDP. It takes per capita GDP and employment longer to recover in global recession cases (there were no global recessions in the high-growth 1950s and 1960s according to this measure); Reinhart and Rogoff (2014).
- 26 <https://covid19.who.int>
- 27 WHO (2022) <https://www.who.int/news/item/04-04-2022-billions-of-people-still-breathe-unhealthy-air-new-who-data>
- 28 Most infectious diseases originate from animals. Rahman et al (2020).
- 29 Because arthropods and other vectors are ectotherms, it is expected that vector abundance, survival and feeding activity will increase with rising temperatures, as will the rate of development of the pathogen within the vector. Rocklov and Dubrow (2020); Thomsom and Stanberry (2022); Baker et al (2021); As many as one half of all infectious diseases could become more widespread as temperatures rise. Mora et al (2022); Joi (2023).
- 30 <https://emergency.cdc.gov/agent/agentlist-category.asp>; Charlet (2018); Tournier et al (2019) observe. “The bioterrorist threat assessment should be regularly re-assessed because threats can evolve swiftly with viral disease eradications and emergence of new pathogens, including those related to synthetic biology. Moreover, our modern societies are now much more sensitive to unexpected events, with a high media exposure, reflecting the emerging role of social networks. Any low-cost bioterrorist attack, even with a minor clinical impact due to a poorly pathogenic agent, can provoke a global deflagration with an immediate and long-lasting fear cost at the social level.” Suleyman and Bhaskar (2023) worry that synthetic biology and AI

have the makings of fragility amplifiers and in the wrong hands could have profound global consequences.

- 31 <https://www.nature.com/articles/d41586-022-00585-7>; IPCC (2021) <https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/>; <https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world/>
- 32 “It took Hurricane Maria just hours to erase decades of economic progress in Puerto Rico.” White House (2022). <https://www.whitehouse.gov/cea/written-materials/2022/09/01/the-rising-costs-of-extreme-weather-events/>
- 33 WMO (2023) <https://public.wmo.int/en/media/press-release/economic-costs-of-weather-related-disasters-soars-early-warnings-save-lives>
- 34 WSJ (2023) <https://www.wsj.com/articles/a-punishing-year-of-thunderstorms-has-led-to-record-breaking-losses-102bfb0d>
- 35 Burke et al (2023) estimate. “1 ton of CO₂ emitted in 1990 causes \$4 in global cumulative discounted damages by 2020 and an additional \$327 in discounted damages through 2100 (2% discount rate). These estimates of past and future damages from marginal emissions can be used to calculate L&D for a range of specific emitting activities: for instance, an individual taking one long-haul flight every year for the past decade will generate ~\$5500 in damages through 2100, the emissions associated with multiple oil majors between 1988-2015 have already caused \$50–200B of cumulative global economic damage by 2020, and CO₂ emissions in the US since 1990 have caused ~\$2T in global damage through 2020, with India (\$293B) and Brazil (\$167B) being harmed the most.” The National Climate Assessment released in November 2023 stated that the US experiences an extreme weather event that inflicts more than \$1 billion in damages once every three weeks with total annual costs now in the \$150 billion range. WSJ (2023) <https://www.wsj.com/science/environment/climate-change-us-economy-c9fbda96>; A review of the effect of climate change on the US economy by the Congressional Research Service (2022) states. “Climate change could negatively impact productivity and business investment, as rising temperatures and heat waves could result in lower output per worker. Declines in productivity and production could decrease businesses’ incentive to invest, particularly in a scenario in which physical capital is routinely damaged or destroyed [by] extreme weather events to a point where further investment becomes unattractive. [Climate change] is also expected to affect the overall economy through its impacts on specific sectors, such as housing, infrastructure, and agriculture. Nearly one-third of the U.S. housing stock could be at high risk of climate-change-induced hazards, and billions of dollars of property are vulnerable to complete destruction or being rendered unusable by flooding risk alone. Transportation infrastructure, which supports the production and movement of goods and services, could be damaged with climate change.”; See also the review by K. Abbass et al (2022). The consequences for agriculture are explored by Carter et al (2018).
- 36 Goodell (2023) offers a readable account of how heat affects livability, work, and agricultural output.

- 37 Wong (2023) notes that “A critical wet-bulb temperature for people is 35°C. At this threshold, a healthy person can survive for only around six hours, because no heat is lost from the body through sweating or radiation, leading to heat stroke in even the healthiest people. Wet-bulb temperatures are highest in subtropical, coastal locations in South Asia, the Middle East, and southwestern North America, where there is a potent mix of heat and humidity Weather-station data dating back to 1979 shows that wet-bulb temperatures in Pakistan and the Gulf have breached the 35 °C threshold for one or two hours at a time on several occasions, mostly since 2003.”; 2023 was the warmest year on record with both October and November shattering past records as well (Wong 2023a). <https://www.nasa.gov/news-release/nasa-analysis-confirms-2023-as-warmest-year-on-record/>
- 38 <https://apnews.com/article/china-beijing-rainfall-floods-1a8f968799bd539d11f3421010b8f2a9;> [https://www.reuters.com/world/us/new-york-subways-disrupted-more-heavy-rain-triggers-flooding-2023-09-29/#:~:text=NEW%20YORK%2C%20Sept%2029%20\(Reuters,some%20streets%20into%20small%20lakes.](https://www.reuters.com/world/us/new-york-subways-disrupted-more-heavy-rain-triggers-flooding-2023-09-29/#:~:text=NEW%20YORK%2C%20Sept%2029%20(Reuters,some%20streets%20into%20small%20lakes.)
- 39 Carbon capture and sequestration (CCS) technologies may play a role by helping to slow the accumulation clock or turn it back, but they are a long way from proving their worth. Energy and infrastructure costs and the difficulty of scaling up some of the direct air capture (DAC) techniques now in use or being trialed, are some of the hurdles. The cost of capturing a ton of CO₂ using current DAC technologies is much greater than with CCS. There are fifteen experimental CCS facilities operating in the US. Capturing and burying a few million tons will not suffice. CBO (2023) <https://www.cbo.gov/publication/59832>; <https://status23.globalccsinstitute.com>; WSJ (2023) <https://www.wsj.com/us-news/climate-environment/carbon-removal-credits-climate-startups-investments-4aa3ca70#>; <https://climate.mit.edu/explainers/carbon-capture>; <https://adagefficiency.com/energy-insights-vaclav-smil-on-carbon-capture-storage/> <https://news.stanford.edu/2019/10/25/study-casts-doubt-carbon-capture/>; FT (2023) <https://www.ft.com/content/c5abf5a1-9171-4f29-ae43-bc7c5ebc4df5>; According to Skuce (2016) “Whatever type of CCS technology that is used, [it would require] a huge carbon capture and sequestration industry that is about triple the size of the entire current fossil fuel industry. And [it would have to be done] fast—at a rate of about one new CCS plant completed every working day for the next 70 years, or from now until the year 2087.”
- 40 The carbon sinks that were helping to check the accumulation of carbon such as the oceans and tropical forests, are approaching saturation—and in the case of tropical forests—are now a net source of carbon emissions (the Amazon). <https://www.theguardian.com/environment/2021/jul/14/amazon-rainforest-now-emitting-more-co2-than-it-absorbs>; The Amazon region experienced unprecedented drought in 2023. The top 2,000 meters of the world’s oceans absorbed more heat during 2023 than ever before and the increase in temperatures is an additional indicator of the pace of warming and the danger it poses. (Figure 6b).
- 41 Financial Times (2023) <https://www.ft.com/content/7788e961-1784-4044-8437-2e6c32ead570>; New York Times (2023) <https://www.nytimes.com/2023/10/25/business/energy-environment/exxon-chevron-oil-mergers-peak.html>; Moreover, disinformation continues to feed climate

change denialism. Financial Times (January 16th, 2024) <https://www.ft.com/content/aa369295-1805-414c-af99-3c7596df0847>

- 42 As automobiles especially EVs become more closely connected with the digital infrastructure, their numerous sensors collect and transmit a large volume of data to auto companies and others who can share or sell the data. Hope (2023).
- 43 Song and Zhou (2023) observe, “Economic decoupling has detrimental impacts on the weakening global trading system, even with the emerging regional free trade arrangements, with long-term consequences to future cross-border flows of trade, investment, and technology. Such costs will far outweigh any benefits of decoupling.”
- 44 <https://www.bruegel.org/sites/default/files/wp-content/uploads/2019/11/Presentation-by-Margit-Molnar.pdf>; <https://www.bruegel.org/sites/default/files/wp-content/uploads/2019/11/Presentation-by-Alicia-Garcia-Herrero.pdf>
- 45 “Transitioning to electric technologies, which emit no emissions at the point of use, would transfer most emissions to the power sector. This would allow policymakers to focus on decarbonizing the electrical grid to reduce emissions, rather than focusing on myriad pathways like vehicle fuel efficiency requirements. Focusing on electrical grid decarbonization may be far more feasible than attempting to decarbonize each sector separately.” (RFF 2019) <https://www.rff.org/publications/explainers/electrification-101/>; The good news is that emissions from power generating facilities could begin to decline globally because renewable sources of energy and nuclear power will account for almost one half of all electricity produced in 2026. WSJ (January 25th 2024) <https://www.wsj.com/articles/global-emissions-from-electricity-set-to-fall-even-as-power-demand-climbs-181b5227#>; “Although industry consumes more energy than any other sector [only] about 20 percent—consisted of electricity. Most of the electricity is used to drive machines that move things, such as pumps, robotic arms, and conveyor belts. Thirty-five percent is energy used as feedstock, such as oil products from which plastics are produced. These oil products are not used for their energy content, but as a building block to produce other materials. Fuel consumption for energy accounts for almost 45 percent of energy consumption. This includes the generation of heat for processes such as drying, melting, and cracking ... Electrification of the fuel that industrial companies use for energy has several benefits. Generally, electrically driven equipment has lower maintenance costs, and, in the case of the industrial boiler, the investment cost of the electrical equipment is lower. And, if zero-carbon electricity is consumed, the greenhouse-gas emissions of the industrial site lower significantly ... Of all the fuel that industrial companies use for energy, we estimate that almost 50 percent could be replaced with electricity, using technologies available today.” (McKinsey 2020). <https://www.iea.org/energy-system/electricity>; <https://www.nationalgrid.com/stories/energy-explained/how-will-our-electricity-supply-change-future>
- 46 <https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals>; <https://www.wilsoncenter.org/article/critical-mineral-maps>; The transition to renewables and the other steps to carbon neutral economy will be costly and shouldering the costs will entail sacrifices. These costs are encountering opposition from taxpayers and workers. WSJ

- (2023). <https://www.wsj.com/business/autos/why-no-one-wants-to-pay-for-the-green-transition-aed6ba74>; Pisani-Ferry (2019). Notwithstanding some pushback, the capacity added in 2023 was 50 percent higher than in 2022 and investment in renewables is likely to remain strong in 2024 and beyond. <https://www2.deloitte.com/us/en/insights/industry/renewable-energy/renewable-energy-industry-outlook.html>; IES (2024). <https://www.iea.org/news/massive-expansion-of-renewable-power-opens-door-to-achieving-global-tripling-goal-set-at-cop28>
- 47 This includes demand for items such as rubber and cocoa the production of which is resulting in deforestation in Southeast Asia (e.g. Cambodia) and West Africa (Ghana, Nigeria, Cote d'Ivoire). Pearce (2023).
- 48 Both the shape of sand grains and its content determine its suitability for the various purposes to which it is put. Smooth grains of sand found in deserts cannot serve as inputs into construction materials, for the purpose of fracking or the manufacture of other products. Conway (2023); <https://www.unep.org/news-and-stories/story/problem-our-dwindling-sand-reserves>; <https://news.stanford.edu/2022/07/26/four-questions-eric-lambin-sand-shortage/>; Beiser (2019). Coastal sand mining is also depleting precious natural capital. <https://www.science.org/doi/10.1126/science.adj9593>
- 49 Australia, Kazakhstan, and Canada are the principal suppliers accounting for half of the total. However, in the face of rising demand and bottlenecks affecting supplies from Niger and Kazakhstan, buyers are feeling the pinch. WSJ (2023) <https://www.wsj.com/finance/commodities-futures/uranium-is-finally-running-hot-and-miners-cant-keep-up-e6a79367#>
- 50 The environmental (and human) impact of mining whether it is cobalt in the DRC, nickel in Indonesia or copper in PNG, can be severe and has given rise to protests from locals and others. The closure of the Panama's Cobre Panama mine in the face of protests, which accounted for 5 percent of Panama's GDP, reflects mounting concerns in many countries regarding damage wrought by mining. Kara (2023); Financial Times (2023). <https://www.ft.com/content/1d3e72fb-9c6d-48da-963d-31afd456850f>
- 51 Just three countries are responsible for 70 percent of the world's mined production. Diversification in response to price signals or geopolitics is a slow process. A new mine can take anywhere between 5 and 10 years to begin producing and processing facilities can also take years to come on stream. Nimbyism can be a major hurdle. Exploiting a large deposit of nickel in Minnesota confronts opposition from locals worrying about pollution. https://www.imf.org/en/Blogs/Articles/2023/10/03/geoeconomic-fragmentation-threatens-food-security-and-clean-energy-transition?utm_medium=email&utm_source=govdelivery; <https://www.cbsnews.com/minnesota/news/long-delayed-minnesota-copper-nickel-mining-project-wins-a-round-in-court-after-several-setbacks/>
- 52 <https://www.ifpri.org/blog/covid-19-and-resilience-innovations-food-supply-chains-two-years-later>
- 53 <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0269891>
- 54 Also see, Economist (2022) <https://www.economist.com/business/2022/05/07/the-war-in-ukraine-is-rocking-the-market-for-edible-oils>

- 55 China's food self-sufficiency rate fell from 94 percent in 2000 to 66 percent in 2020. <https://www.cfr.org/article/china-increasingly-relies-imported-food-thats-problem> Enhancing food security has emerged as a priority with the cultivation of GM crops such as soybeans viewed as a partial solution. Donnellon-May (2024)
- 56 <https://www.ifpri.org/blog/impact-ukraine-crisis-global-vegetable-oil-market>
- 57 A discussion of coffee and cocoa GVCs can be found in Sun and Yusuf (2023); and of coffee and garments in Boudreau et al. (2023).
- 58 Financial Times (2023) End of the coffee boom. <https://ig.ft.com/coffee/> This will hit countries such as Colombia, Brazil, Ethiopia, and Indonesia, possibly Vietnam although 95 percent of its production is of Robustas. <https://oec.world/en/profile/hs/coffee>
- 59 "The food manufacturing sector in the United States is both increasingly mechanized and highly concentrated. Consequently, labor risks in food manufacturing have changed over time with changes in industry structure. Labor risks were highlighted by the COVID-19 pandemic—particularly in the animal slaughtering and processing industry—where labor-driven disruptions resulted in temporary plant closures." Ramsey, Godwin, and Haley (2021); "The concentrated nature of the meat processing sectors in the United States implies that disruption of the processing capacity of any one plant, from accident, weather, worker illnesses from a pandemic, has the potential to lead to system-wide disruptions." Ma and Lusk (2021).
- 60 Russia and Belarus together account for 20 percent of the global trade of nitrogen, phosphate, and potassium fertilizers. Kee et al (2023). The heavy consumption of phosphate is depleting global supplies with growing dependence on mines in western Africa e.g. Bou Craa from where phosphate rock is transported by a 150 km conveyor belt to the Moroccan Ali Ben El Ayoun port on the Atlantic coast. https://e360.yale.edu/features/phosphate_a_critical_resource_misused_and_now_running_out; Phosphorous is a building block of all living things and talk of a peak phosphorous has begun surfacing. Porder (2023); ([https://www.theguardian.com/environment/2023/mar/12/scientists-warn-of-phosphogeddon-fertiliser-shortages-loom#:~:text=Traditional%20rock%20phosphate%20reserves%20are,phosphorus"%20in%20a%20few%20years](https://www.theguardian.com/environment/2023/mar/12/scientists-warn-of-phosphogeddon-fertiliser-shortages-loom#:~:text=Traditional%20rock%20phosphate%20reserves%20are,phosphorus)).
- 61 Fertilizer price inflation starting in 2020 can be traced to rising gas prices and higher transport costs. <https://asmith.ucdavis.edu/news/story-rising-fertilizer-prices>
- 62 Forty-five percent of the operating cost of US wheat and corn farmers is comprised of outlay on fertilizers. It is 23 percent for soybean farms. The price increase was consequential for farmers in developed countries as well. Kee et al (2023)
- 63 New York Times (2021) <https://www.nytimes.com/2021/07/17/world/middleeast/suez-canal-stuck-ship-ever-given.html>
- 64 New York Times (2023). <https://www.nytimes.com/2023/11/01/business/economy/panama-canal-drought-shipping.html>
- 65 Just 167 ships were able to cross the canal in the first week of December 2023 vs. 238 in December 2022. Financial Times (2023) <https://www.ft.com/content/416310ed-9ad0-4cf8-b7df-fd59ce79847b>. Water levels in the canal as of January 2024 were the lowest recorded in five years.

- 66 <https://earth.org/panama-canal-authority-cuts-ship-crossings-further-as-el-nino-induced-drought-intensifies/>
- 67 <https://www.reuters.com/world/middle-east/red-sea-attacks-ships-spark-safety-concerns-sailors-2023-11-29/>; <https://www.washingtoninstitute.org/policy-analysis/houthi-ship-attacks-are-affecting-red-sea-trade-routes>
- 68 Recovery of certain metals from alloys is difficult if not impossible. These include dysprosium, samarium, vanadium, niobium, tellurium, and gallium. Graedel et al (2022)
- 69 <https://thequartzcorp.cn/?lang=en>
- 70 Shin-etsu has a 29 percent share of the market for crucibles. <https://www.sqp.co.jp/e/products/crucible.html>
- 71 Semiconductors are ubiquitous. Thadani and Allen (2023) report. “In the United States, semiconductors account for only 0.3 percent of GDP, but they are an important production input to 12 percent of GDP. [The shortage experienced during peak Covid 19] shaved an estimated \$240 billion off U.S. GDP in 2021. The auto industry alone produced 7.7 million fewer cars in 2021 due to lack of chips. In other words, U.S. GDP was a full 1 percent lower than it would have otherwise been had the semiconductor shortage never occurred. For comparison, the average U.S. GDP annual growth rate over the past 10 years has been 2 percent.” <https://www.csis.org/analysis/mapping-semiconductor-supply-chain-critical-role-indo-pacific-region>
- 72 The proliferation of fabless chip designers dependent on chip foundry fabs mostly located in East Asia thickened the semiconductor GVC.
- 73 The four are Synopsis, Cadence, Mentor Graphics, and a subsidiary of Siemens based in the US. In 2021, the market was valued at \$8.27 billion.
- 74 In addition to Shin-etsu, other producers of 300 mm wafers include Sumco (Japan), GlobalWafers (United States), Siltronic (Germany), SK Siltron (South Korea), and Soitec (France). Chinese suppliers have yet to make substantial inroads in this market.
- 75 About one half of the neon gas used in the making of semiconductors comes from Ukraine (some also from Russia). “Neon gas is a byproduct of steel production, specifically from older steel mills that today are largely located in eastern Ukraine. The former Soviet Union (which included today’s Ukraine) had many of these large steel mills, which were outfitted with air separation equipment to capture rare waste gases [resulting from the fractional distillation of liquid air to produce oxygen], including neon, krypton, and xenon, for use in experimental high-powered laser weapons, missiles, and satellites. After the dissolution of the USSR in 1991, these older steel facilities were largely replaced with new infrastructure that had no gas-collection technology because the economics did not support it. In contrast, by continuing to operate old-style steel mills, Ukraine became the dominant supplier of these gases that are vital to the global semiconductor industry.” “Excimer laser technology in the deep ultraviolet, with a wavelength of just under 200 nanometers used in semiconductor manufacturing require gases such as argon and fluorine, with neon as a buffer gas.” The war with Russia resulted in the loss of this supply and forced chip producers to scramble in search of alternative sources of supply. <https://www.reuters.com/technology/exclusive-ukraine-halts-half-worlds-neon->

output-chips-clouding-outlook-2022-03-11/;https://sloanreview.mit.edu/article/russias-invasion-spells-more-trouble-for-semiconductor-supply/ ; https://www.engineering.com/story/will-the-neon-shortage-cripple-computer-chip-production

- 76 Among the products they export to China their largest customer are deposition and related tools, etching and cleaning tools, and process diagnostic equipment.
- 77 SMIC used imported DUV equipment to manufacture Huawei's Mate60 7nm chip. SMIC is now on the "entity list" and barred from importing ASML's DUV equipment.
- 78 <https://us.metoree.com/categories/semiconductor-exposure-system/>
- 79 "Unlike conventional lithography technology that uses light to expose circuit patterns. Circuits are formed using a simple principle that involves transferring a circuit pattern mask (mold) onto the coated resist (resin) on the surface of the wafer (a thin silicone plate) ... By using optimal moiré patterns as well as proprietary optical technologies and control technologies developed in collaboration with U.S.-based Canon Nanotechnologies, Inc. (CNT), NIL equipment can measure and correct for positional deviations between the mask and the wafer with nanometer-level accuracy." <https://global.canon/en/technology/nil-2023.html>
- 80 <https://asia.nikkei.com/Business/Tech/Semiconductors/ASML-says-decoupling-chip-supply-chain-is-practically-impossible>; <https://www.nytimes.com/2021/07/04/technology/tech-cold-war-chips.html>
- 81 <https://www.pcmag.com/news/asml-making-euv-components-in-connecticut>
- 82 <https://www.japantimes.co.jp/news/2023/04/28/business/tech/asml-center-us-china-chip-war/>; Economist (January 13th 2024a)
- 83 Baldwin et al. (2023) "General Motors (GM) had 856 tier-1 (i.e., direct) suppliers, but these 856 suppliers had suppliers themselves, so-called tier-2 suppliers, as did the tier-2 suppliers and so on. The research estimated that GM had a staggering 18,000 suppliers in tier-2 and below. Given that each of these 18,000 suppliers had its own roster of suppliers, an exhaustive cataloging of GM's suppliers would create a sequence that reaches what Buzz Lightyear would call "infinity and beyond." Apple's i-Phone involves 200 suppliers spread across 43 countries. (IFC 2021).
- 84 American manufacturers such as Ford, Rivian, Fisker, Lucid, and GM continue to make losses on their larger EVs such as the Mach E, the F150 Lightning and the Blazer. Price and charging infrastructure concerns plus higher interest rates have weakened the demand for EVs. WSJ. <https://www.wsj.com/business/autos/are-americans-falling-out-of-love-with-evs-2c7e6a1a>; WSJ (2023) <https://www.wsj.com/articles/lucid-electric-vehicle-losses-51035f63>
- 85 The geographic or supplier concentration of suppliers is high (Bain and Co 2023). IEA (2021) <https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary>; Battery production goes through the following steps: Mining of raw materials e.g., lithium, cobalt, manganese, nickel, and graphite. Processing and refining followed by the creating of cathode and anode battery materials, which are sold to producers of battery cells. The latter assemble the cells into modules and pack and sell them to automakers. Once the batteries have exhausted their original purpose, they can be reused e.g., EV batteries can be used for other storage purposes or recycled. <https://rmi.org/the-ev-battery-supply-chain-explained/>;

The EV battery supply chain is dispersed around the world – battery minerals travel an average of 50,000 miles from extraction to battery cell production. Straubel (2022).

- 86 <https://cnevpost.com/2023/05/04/global-ev-battery-market-share-q1/>
- 87 As observed by Villalobos et al (2022), China’s dominant role in the production and processing of rare earths (e.g., neodymium and dysprosium used to make permanent magnets), and of lithium-ion (Li-b) battery components and its significant share of the magnet manufacturing industry, increases the risk of supply disruption. Seventy two percent of permanent magnets and metal articles that can be magnetized are produced by Chinese enterprises. By curtailing supplies of rare earths, China could hold hostage downstream industries in the US and Europe, including the ones manufacturing wind turbines, EVs, motors of all sorts, i-Phones, MRI equipment and others. Neodymium ferrite boron magnets are the ones in greatest demand. Villalobos et al. (2022); Roth et al (2023); <https://www.grandviewresearch.com/industry-analysis/permanent-magnets-industry>; Riddle et al (2021) model the impact of supply disruptions including a temporary stoppage.
- 88 <https://www.scientificamerican.com/article/new-covid-vaccines-need-absurd-amounts-of-material-and-labor1/>
- 89 The Pfizer vaccine had to be stored at temperatures ranging from minus 112°F to minus 76°F; Moderna vaccines need to be stored at temperatures of between minus 58°F and 5°F. Sheffi (2021).
- 90 Skyrocketing demand for N95 masks resulted in a shortage of essential nonwoven polypropylene, a melt-blown fabric. Producers had to scramble to expand their production capacity as it can take up to six months to build a melt-blown fabric production line.
- 91 Both the production of synthetic indigo and the dyeing process are highly polluting. <https://www.smithsonianmag.com/innovation/have-scientists-found-greener-way-to-make-blue-jeans-180967902/>
- 92 <http://www.madehow.com/Volume-1/Blue-Jeans.html>
- 93 In an essay published in 2002, Amy Chua painted a dark picture of how democracy and marketization in a globalizing environment could fan ethnic tensions and lead to combustible political outcomes.
- 94 “Globalization can plant the seeds of its own destruction” through the integration of goods markets and by facilitating international migration.
- 95 Neoliberalism came under attack with some economists such as Joseph Stiglitz blaming the IFIs for compelling developing economies to adopt policies that were counterproductive. Stiglitz (2003).
- 96 Geographical mobility of the US workforce has declined with fewer people willing to leave their homes and communities. <https://www.philadelphiafed.org/the-economy/regional-economics/recent-trends-in-u-s-labor-mobility-not-so-fast>
- 97 Opioid addiction, suicide and alcoholism are some of the problems that have become more acute in the US.

- 98 Harrison (2024) analysis of millions of firm records from 1995 through 2019 shows that technological change was the principal cause of falling labor share followed by the rising market power of firms as concentration ratios rose, with globalization in third place.
- 99 Margalit (2019) argues that economic insecurity is overshadowed by other factors. The older and more conservative segments of the population are uncomfortable with the exposure to external influences and by the increase in immigration resulting from globalization. The displacement of traditional social values and cultural as well as demographic threats have magnified the fears.
- 100 In one form or the other, industrial policies have remained a part of the toolkit in Europe, the US, Japan and Korea. Siripurapu and Berman (2023).
- 101 The US CBO estimated that these tariffs reduced US GDP by 0.3% in 2020 and by increasing uncertainty, dampened investment. <https://www.cbo.gov/publication/55576>; non-tariff (NTMs) barriers imposed by both the US and China are equally if not more burdensome impediments. <https://research.stlouisfed.org/publications/economic-synopses/2023/04/28/us-barriers-to-international-trade-of-goods-tariffs-and-non-tariff-measures>; “About 50% of the overall decline in US exports to China between 2017 and 2019 was due to higher non-tariff trade barriers, and the other half due to higher tariffs. However, most of the welfare loss incurred by China from the trade war was due to non-tariff trade barriers.” <https://bfi.uchicago.edu/insight/research-summary/non-tariff-trade-barriers-in-the-u-s-china-trade-war/#:~:text=Specifically%2C%20trade%20barriers%20imposed%20in,decline%20due%20to%20higher%20tariffs>.
- 102 WTO (2023) https://www.wto.org/english/res_e/booksp_e/wtr23_e/wtr23_ch2_e.pdf
- 103 Rebuilding the industrial base will be an uphill battle but sustained policy support could restore the production of certain strategically important products in the US, Europe, and Japan. The US CHIPS and Science Act, passed in 2022, and the European Chips Act, approved in April, were in response to the sudden tightening of semiconductor supplies and seek to guarantee that chips made in the US and the EU will be available for domestic manufacturers. The reemergence of industrial policies is explored in Yusuf (2023); Rodriguez-Clares and Harrison (2010); Juhasz et al 2023). Evenett et al (2024) have constructed a database to track the introduction of new industrial policies (NIPs) worldwide starting in 2023. These include all “targeted government intervention aimed at developing or supporting specific domestic firms, industries or economic activities to achieve national economic or noneconomic objectives”. The instruments used include grants, loans, tax exemptions, state investment in private firms and the mobilizing of SOEs. Thus far 2,500 NIPs were counted in 2023. According to the authors, 71 percent of the NIPs were trade distorting affecting 22 percent of global trade.
- 104 Fiscal worries are a growing worry as debt burdens have ballooned in countries such as the UK, the US and Japan. See for example Financial Times (2023) Governing when there is no money left. <https://www.ft.com/content/8c6461c6-e976-4563-b277-bf61ae0a2c07>
- 105 Rachman (2022) and footnote 3. The retreat of democracy has been widely catalogued. Levitsky and Ziblatt (2023) examine the reasons why democratic institutions are on the skids in countries such as Peru, Thailand, and Hungary and delve into the reasons why a conservative

minority in the US, a constitutional democracy, can win the presidency, and at times dominate both houses in federal and state legislatures. V-Dem (2023) Democracy Report finds that all the democratic freedoms gained over 35 years have been erased and that 72 percent of the world's population lives in autocracies. https://www.v-dem.net/documents/29/V-dem_democracyreport2023_lowres.pdf; See also Freedom House (2018). <https://freedomhouse.org/report/freedom-world/2018/democracy-crisis>; <https://www.reuters.com/world/half-worlds-democracies-decline-intergovernmental-watchdog-2022-11-30/>; Carrothers and Press (2022); Williamson (2023).

106 A longtime observer of China, Kevin Rudd (2023), noted that “The stability of US-China relations is ultimately hinged on respective perceptions of a balance of power between China and the United States. From the Chinese lens, that balance of power over the last 20 years has been moving more decisively in China’s favor. [Because it has become more powerful, militarily, technologically, and economically], it is able to exercise agency in East Asia and the world.” It is now imagining a future state of multipolarity led by the East “eastward and west”. <https://www.dailyprincetonian.com/article/2023/03/kevin-rudd-book-spia-event-avoidable-war-princeton-university-panel-lecture-event>; China has mastered fifth generation fighter technology, it is a leader in drone swarm deployment, it has operationalized nuclear capable hypersonic glide vehicles, and it is developing nuclear submarines using pump jet propulsion comparable to that of the US’s Virginia class vessels.

107 The ten strategic industries in the ITIF’s Hamilton Index are: pharmaceuticals; electrical equipment; machinery and equipment; motor vehicle equipment; other transport equipment; computer, electronic, and optical products; information technology and information services; chemicals (not including pharmaceuticals); basic metals; and fabricated metals. In 2020, their combined output was valued at \$10.1 trillion—11.8 percent of global GDP. Atkinson and Tufts (2023).

108 China’s slowing growth rate, the rising domestic debt burden, the problems besetting the overextended real estate industry and lenders in the shadow banking sector, a declining population, and the trade war with the US is leading some observers to doubt that the Chinese economy will overtake the US. See Fernandez-Villaverde et al (2023); Petri (2023); Petri observes, “Decades of massive infrastructure and real estate investments have exhausted the backlog of high-productivity projects and are now dragging down the economy. China’s growth will not rebound enough to justify high investments; the economy is slowing for fundamental reasons including an aging population, less rural-to-urban migration, and the shift in demand toward services.” Wang (2023) projects a growth rate of 4.0–4.5 percent during the balance of the 2020s. Bloomberg (2023) <https://www.bloomberg.com/news/articles/2023-09-05/china-slowdown-means-it-may-never-overtake-us-economy-be-says?embedded-checkout=true>; Financial Times (2022). <https://www.ft.com/content/cff42bc4-f9e3-4f51-985a-86518934afbe>; WSJ (2023) <https://www.wsj.com/economy/why-xi-can-no-longer-brag-about-the-chinese-economy-3397e6f4>; WSJ (2023) <https://www.wsj.com/finance/chinas-economy-is-stuck-in-a-vicious-cycle-f6aa55b0#>; <https://www.reuters.com/world/china/chinese-state-firms-help-troubled-shadow-bank-does-little-address->

- investor-2023-09-18/; Fortune (2023) <https://fortune.com/2023/11/24/china-real-estate-zhongzhi-enterprise-group-shadow-bank-real-estate-crisis/>; The frequency of natural disasters is compounding other problems and hampering growth. <https://www.chinafile.com/conversation/could-chinas-very-hot-summer-revive-action-climate-change>
- 109 <https://chinapower.csis.org/tracker/china-gdp/>; <https://www.imf.org/external/datamapper/PPPSH@WEO/EU/CHN/USA>
- 110 <https://www.airandspaceforces.com/pentagon-china-upgrades-top-stealth-fighter/#:~:text=While%20the%20report%20didn%27t,of%2040%2D50%20per%20year.> <https://defence-blog.com/china-increases-j-20-stealth-fighter-jet-production/>
- 111 Reduces the risk of detection by enemy submarines using active sonar.
- 112 <https://www.cfr.org/blog/what-xi-jinpings-major-speech-means-taiwan;>
- 113 Heath (2023); Culver (2022) lists the factors that would signal China's intent to invade Taiwan; <https://foreignpolicy.com/2023/04/13/china-attack-taiwan-war-expert-poll-biden/>; <https://theweek.com/news/world-news/asia-pacific/954343/what-would-happen-china-attempt-invade-taiwan>
- 114 During the Trump presidency, Section 232 of the Trade Promotion Act was used to impose tariffs of steel and aluminum. A proposal has been put forward in the Senate to limit imports of garlic from China in the interests of "national security".
- 115 <https://www.ft.com/content/8af8c05c-8e54-40e9-9051-5a0b2b036c32>
- 116 <https://www.reuters.com/markets/commodities/live-dont-learn-lesson-chinas-failed-australia-trade-bans-russell-2023-08-07/#:~:text=The%20action%20against%20imports%20of,generate%20power%20and%20make%20steel.>
- 117 https://www.koreatimes.co.kr/www/biz/2023/12/602_364637.html
- 118 Gewirtz (2023) rightly states that the term derisking coined by the EU is ambiguous and its meaning uncertain.
- 119 Coordinating a derisking strategy between the members of the EU will pose a challenge. Initiatives such as the Critical Raw Materials Act and Net Zero Industrial Act will need to be complemented by others.
- 120 https://www.lemonde.fr/en/opinion/article/2022/12/28/the-decline-of-the-wto-a-threat-to-global-stability_6009406_23.html#; <https://www.cfr.org/backgroundunder/whats-next-wto>
- 121 The tariffs imposed by the US on imports did not benefit the protected industries while retaliatory tariffs hurt agricultural exports and employment in the farming sector. Autor et al (2024).
- 122 <https://www.brookings.edu/articles/more-pain-than-gain-how-the-us-china-trade-war-hurt-america/>; <https://carnegieendowment.org/chinafinancialmarkets/83746>; <https://thedocs.worldbank.org/en/doc/3e5537ac17a795823a3e3c46b12c0351-0050022023/related/54-The-US-China-Trade-War-and-Global-Value-Chains.pdf>; The trade policy changes cost the Republicans five seats in the 2018 mid-term elections. Blanchard et al 2019. Bolhuis et al (2023) estimate that a limited decoupling between the US and China and Russia could result in a 0.3 percent loss of global GDP while a splitting of the world into two blocs that do not trade

with each other could lead to a 2.3 percent decline. A survey of the empirical research on this topic by Fajgelbaum and Khandewal (2022) identifies a range of outcomes. “Fajgelbaum et al (2020) estimate losses of 0.04% of GDP from the 2018 tariffs only. Chang et al. (2021) replicate their methodology on 2018–2019 tariffs and find an aggregate welfare loss in China of 0.29%. Other analyses, including those by Balistreri et al. (2018), Caliendo and Parro (2022), and Charbonneau and Landry (2018) simulate general-equilibrium impacts using multi-country environments. Despite the many methodological differences with Fajgelbaum et al.’s (2020) work, the aggregate effects are similar and are consistently found to be small relative to GDP and negative for both the United States and China. For example, Caliendo and Parro (2022) find that the trade war tariffs lower US and Chinese welfare by 0.01% and 0.09%, respectively [in line with the] observed trade-to-GDP ratios. As a benchmark, Costinot and Rodriguez-Clare (2014) show that, in a standard parametrization of these frameworks, a 100% uniform tariff imposed by the United States reduces welfare by approximately 0.3%, whereas Baqee and Farhi (2021) compute that a 10% universal tariff shock would increase US and Chinese welfare by 0.09% and 0.16%, respectively. These welfare effects appear small relative to GDP, but the distortions due to tariffs are [not] small. Finkelstein and Hendren (2020) calculate that the US–China tariffs have a marginal value of public funds (MVPF), defined as the ratio of real income costs of a policy to its revenue benefit, ranging from -1.2 to -1.5. This implies that the tariffs are particularly costly relative to many other public policies.” <https://www.annualreviews.org/doi/full/10.1146/annurev-economics-051420-110410>

- 123 China National Knowledge Infrastructure is limiting the use of its data to universities located in China; foreign subscribers to information provided by Wind Information are unable to renew their subscriptions; Quantcube Technology has ceased publication of data on items such as urban pollution and job openings as has China’s Ministry of Human Resources and Social Security. And youth unemployment has been erased because the Statistics Bureau is no longer releasing this information. In other words, outside observers of the Chinese economy must increasingly rely on educated guesses.
- 124 Financial Times (2023) <https://www.ft.com/content/93bbc4ee-41ee-4552-9da0-d2cffaae0528>; The investigation. by Chinese authorities of American consulting firms, has also stoked concerns. New York Times (2023) <https://www.nytimes.com/2023/04/27/business/bain-china.html>
- 125 China recorded its first ever FDI deficit in the third quarter of 2023 amounting to \$11.8 billion. <https://www.reuters.com/world/china/chinas-first-deficit-foreign-investment-signals-wests-de-risking-pressure-2023-11-06/>; <https://www.bloomberg.com/news/articles/2023-08-07/china-foreign-investment-gauge-at-25-year-low-amid-high-tensions?embedded-checkout=true>; In response to declining FDI during the previous quarters, China announced 24 policy measures to attract FDI including in six areas so as to lift the quality of foreign investment commit to equal treatment of domestic and foreign businesses and making available financial and tax incentives to improve the business environment and to bolster investor confidence. Foreign companies are encouraged to set up R&D centers and to pursue

- research in biotech and pharmaceutical areas. <https://www.wilmerhale.com/insights/client-alerts/20230815-china-issues-policy-to-further-boost-foreign-investment>
- 126 <https://www.eastasiaforum.org/2023/07/07/is-us-china-decoupling-heading-in-a-dangerous-direction/>
- 127 <https://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2023/01/11/Geo-Economic-Fragmentation-and-the-Future-of-Multilateralism-527266>
- 128 Metivier et al (2023) https://www.wto.org/english/res_e/reser_e/ersd202302_e.pdf
- 129 Sposato (2023) describes the efforts underway in Japan to revive the semiconductor industry once a major force with 51 percent of semiconductor sales in 1988. A shortage of skilled workers is a major constraint as in the US. Currently, Japan makes less advanced chips of the 40 nm kind. To graduate to the mass production of 2nm chips as government supported Rapidus is attempting in collaboration with IBM, will be a considerable challenge.
- 130 Borin et al (2024) examine the dependence of Italian manufacturing firms on foreign sourced inputs, the scope for substitution from less risky sources, and the impact on production of shortages.
- 131 Trade tensions and rising costs of producing in China led to a 24 percent decline in the number of foreign firms with manufacturing facilities in China by early 2021. Storey (2023).
- 132 China's share of US imports has fallen from a peak of 21.6 percent in 2017 to 16.7 percent in 2022 and to 14.6 percent in the first half of 2023. Storey (2023).
- 133 "Statistically significant increases in bystander countries' exports in response to the tariffs occurred in 19 of the 48 countries in the data sample. One country reported a statistically significant decrease; there were no statistically significant impacts in the remaining 28 countries." Digest (2022) <https://www.nber.org/digest/202204/how-us-china-trade-war-affected-rest-world>; Bloomberg (2023) <https://www.bloomberg.com/news/newsletters/2023-11-02/supply-chain-latest-mexico-morocco-poland-vietnam-win-in-supply-shift?embedded-checkout=true#xj4y7vzkg>
- 134 For 90 percent of US manufacturing industries, China is the principal supplier. China has become more closely integrated with Korea and to a much lesser extent with the US between 1995 and 2018, and its integration with the Japanese economy has declined sharply.
- 135 India is in the running to replace China as a supplier of critical manufactures with companies such as Apple and Foxconn sourcing more of their electronic components and final products from factories located in India. However, the quality of Indian infrastructure and restrictive labor laws, which prevent companies from running 12-hour shifts, eat into operating margins. In 2023, Foxconn's operating margin in India was a negative 1 percent. WSJ (2023). <https://www.wsj.com/world/india/big-labor-is-a-big-barrier-to-apples-india-ambitions-26303f6b#>; WSJ (2023) <https://www.wsj.com/podcasts/tech-news-briefing/apple-ramps-up-iphone-production-in-india/71a13f93-ad89-495d-bfbf-310285ace611#:~:text=Now%20though%2C%20the%20company%20is,Apple%20is%20making%20the%20shift.>
- 136 Tellis (2023) maintains that extensive decoupling between the US and China is a stretch given the gains from trade that would be sacrificed.

- 137 Qiu, Shin, and Zhang (2023) analyze snapshots of GVCs in 2021 and 2023. They find that “For Asia, there is a relatively low share of links that extend outside Asia, suggesting that the integration of regional supply chains is tighter in Asia ... [There are] signs of some reshoring but also a greater incidence of longer supply chains. The share of direct (one-step) cross-country linkages in the total linkages declined between December 2021 and September 2023, indicating greater reshoring. Nevertheless, the overall share of cross-country linkages at longer distances shows no signs of a decrease. The share of cross-country linkages actually increased somewhat for connected firm pairs with a distance of 10, rising from 93.3% in December 2021 to 94.1% in September 2023 ... The lengthening of the distance between suppliers in China and customers in the United States suggests that firms from other jurisdictions have interposed themselves in the supply chains from China to the United States ... Asian firms from outside China have taken up a greater proportion of the value added in the supply chains to the United States.”
- 138 WSJ (2023) <https://www.wsj.com/world/china/u-s-companies-are-finding-it-hard-to-avoid-china-213997b7#>
- 139 Russian conglomerates such as Rostec in need of advanced semiconductors have built up a network of suppliers in Europe that enable the evasion of export controls and the smuggling in of vitally needed processors. Financial Times (2023, November 13th). The Russian buyer’s network. <https://www.ft.com/content/e70467d7-9df2-4a8c-9d0f-ddc61062b745>
- 140 To minimize costs and working capital and to increase shareholder value, GVCs according to Barry Lynn have been “built to break”.
- 141 Gopal (2023) catalogues the factors contributing to the fragility of GVCs and indicates how risks could be reduced and security enhanced, particularly with the help of talent and sound management. The ADB (2023a, p.12) lists policy interventions that complement the above: “A conducive business environment needs to maintain stable macroeconomic fundamentals, create a non-distortive regulatory environment, choose non-trade policies with minimal trade disruption, promote flexible yet fair labor markets, and be aware of the need for financial and social protection.”
- 142 In November 2023, the US signed an agreement with 13 countries in the Indo-Pacific that will improve the early detection of potential supply chain bottlenecks.
- 143 The absence of high-capacity ports that can handle the largest container vessels and of direct marine liner services, can constrain the transfer of production from China to other countries in the region.
- 144 <https://www.energy.gov/eere/vehicles/articles/reducing-reliance-cobalt-lithium-ion-batteries>
- 145 The struggle to ramp up the production of 155mm howitzer ammunition in 2023 by the US and European countries highlights the diminution of industrial capabilities.
- 146 Financial Times (2024) <https://www.ft.com/content/716c9b0b-d8cd-491a-a91b-d70c1e540797>; China is now the leading exporter of cars including EVs and hybrids many manufactured by foreign companies and joint ventures (jv) e.g. SAIC’s jv with Volkswagen and Xpeng. Mazzocco and Sebastian (2023). According to one estimate it costs 40 percent less to manufacture an EV in China relative to the US. <https://macropolo.org/cost-of-ev-industrial-policy-vs-adoption/?rp=e o>

- 147 Pre pandemic China's trade surplus on goods was about \$400 billion. It was close to \$900 billion in 2023.
- 148 Lovely (2023) spells out the costs and downsides of friendshoring, nearshoring and efforts to derisk GVCs by limiting exposure to China. Hard de-risking via reshoring or friendshoring would precipitate losses of GDP for Asia, China and the world with China taking the biggest hit followed by Asia. Technological decoupling would be costly for most countries with China suffering the most followed closely by the US and Germany. Losses scale with the degree of fragmentation and countries that end up trading with a single technology hub suffer the most. Cerdeiro et al (2023) Cerdeiro et al. (2023a)
- 149 For example, the US is incentivizing the mining of rare earths in Georgia. However, because the mix of rare earths contains radioactive uranium, it is first shipped to a facility in Utah that removes the radioactive isotope. The material is then sent to Estonia where the rare earths are separated and refined (Malaysia is an alternative destination) and transferred to Japan where they are used to make permanent magnets. All this in the interests of derisking a vital supply chain. WSJ (2023) <https://www.wsj.com/business/the-road-to-china-free-supply-chains-is-long-warning-legless-lizards-ahead-00c45f9b>
- 150 WSJ (2024). <https://www.wsj.com/economy/trade/derisking-china-reliant-supply-chains-is-creating-new-risks-b5f26440>
- 151 Mexico became the US's largest trading partner in 2023 and attracted a record volume of FDI with Monterrey a focus. If Mexico can improve infrastructure, security, and planning, it could capitalize further on the recently acquired momentum. Financial Times (2023). <https://www.ft.com/content/445a2ca2-931b-4556-b735-a9d70f5e7b44>
- 152 <https://www.iadb.org/en/news/nearshoring-can-add-annual-78-bln-exports-latin-america-and-caribbean>; Freund (2023).
- 153 Derisking must take account of considerations other than economic and commercial. Diplomatic and geostrategic elements must be factored in as well requiring political guidance alongside industrial policies that are comparable to ones that China offers companies. In the EU, members differ regarding the perception of risk, hence the terms of derisking will need to be negotiated.
- 154 Borin et al (2021) find that greater GVC integration supports growth. It also diminishes exposure to domestic shocks and those associated with traditional trade, however, it increases the exposure to global shocks. The swift recovery of East Asian GVC networks following the Covid 19 shock is testimony of their resilience (ADB 2023a).
- 155 Following the Covid 19 shock, Indonesian firms that participated in GVCs coped more effectively than ones that did not. (Ghose and Montfaucon 2023).
- 156 <https://www.pewresearch.org/global/2020/10/05/in-u-s-and-uk-globalization-leaves-some-feeling-left-behind-or-swept-up/>; Ulgen and Inan (2022) draw attention to other issues such as inequality associated with globalization. These would need to be addressed by policies to safeguard globalization; Chancel (2018); On active labor market policies and other ways of assisting the left behind, see Asatryan et al (2014); Merler (2017); Economist (2018); Obstfeld (2016). LLMs such as ChatGPT4 and DALL-E make it harder to determine what skills will be in

- most demand in the future and current training institutions may not be up to the task. That standard policies have a weak track record is noted by Davies (2016). Stephany and Teutloff (2023) suggest an approach to skill acquisition that takes advantage of complementarities among skills.
- 157 Political polarization can be mitigated by taking steps to build or rebuild tolerance. Social media, which has exacerbated polarization, can play a constructive role as well. (Forest and Daymude 2022; Overgaard and Wooley 2022; Combs et al. 2023).
- 158 Trade and transport are also responsible for GHGs and with so much trade conducted via GVCs, climate smart outcomes will necessitate collective effort (ADB 2023a). Labonte et al. (2011) highlights the need for global action against health hazards.
- 159 The Economist (January 6th 2024), observed that the World Bank and the IMF are a shadow of their former selves.
- 160 For example, progress in two areas would quickly check GHG emissions. One is a rapid scaling back of subsidies for fossil fuels. In 2022, explicit subsidies amounted to \$1.3 trillion (undercharging for supply costs) and implicit subsidies (not accounting for environmental costs and foregone consumption taxes) equaled \$5.7 trillion. Together the two added up to 7.1 percent of global GDP. (Black, Parry and Vernon 2023). Widening the use of carbon taxes and emission trading schemes is another item that needs to be high on the global policy agenda. Financial Times (2023) <https://www.ft.com/content/921381a8-48a4-4bb9-9196-b1d49f871bb7>
- 161 Financial Times (2023). Hint of thaw in the new cold war. <https://www.ft.com/content/354bbaac-89c1-4fb7-a8a1-4951a448c6d9>
- 162 <https://unfccc.int/news/cop28-agreement-signals-beginning-of-the-end-of-the-fossil-fuel-era>
- 163 <https://www.planetary.org/worlds/pale-blue-dot>