Research Report

BRADLEY MARTIN, HENRY H. WILLIS, AARON STRONG

Managing Systemic Supply Chain Risk to the U.S. Economy from Trade Concentration and Geopolitical Conflict

The Roles of Insurance and other Hedging Strategies

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About This Report

Global trade delivers materials and manufactured goods through supply chains worldwide to fuel national economies. Supply chain disruption affects companies individually and economies collectively. Many events in the last five years illustrate the scale of economic consequences that can result from disruption of trade. This report examines public policy issues related to managing systemic supply chain risks to the U.S. economy from trade concentration and geopolitical conflict. The purpose of this analysis is to improve understanding of this area of economic risk so that the private and public sectors can work together to manage them effectively. The findings should be of interest to federal agencies attempting to manage geopolitical and trade risks, which could include Departments of State, Defense, Treasury, and Commerce, as well as to companies and insurance industry associations seeking to better understand systemic supply chain risks and responses to them.

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Summary

Global trade delivers materials and manufactured goods through supply chains worldwide to fuel national economies. This report examines policy issues related to managing systemic supply chain risks from trade concentration and geopolitical conflict. The purpose of this analysis is to improve understanding of this area of economic risk so that the private and public sectors can work together to manage it effectively.

Key Findings

- Geopolitical conflict has a significant impact on supply chain security. We can see this from analysis of the most recent cases of significant geopolitical conflict. The degree of impact does, however, vary. The most significant potential impacts center around tensions with China.
- However, when trade data is cross-referenced with conflict data, other vulnerabilities become apparent. For example, the potential for conflict-caused supply chain disruption in trade in nonferrous metals and electrical components is significant and underappreciated in many countries, including Brazil, Colombia, India, Indonesia, Pakistan, the Republic of the Philippines, South Africa, Thailand, and Turkey.
- Private insurance policies to cover physical loss and damage exist, as do some kinds of business disruption insurance. However, these do not in general cover the kinds of disruptions likely in the event of conflict, not even at the company level. They are not intended to be hedges against systemic risk, which is at a breadth and scale that individual insurance could not meet.
- Systemic supply chain resilience is a collective good, meaning that it has value for a broad community but does not generate sufficient individual value for the market on its own to deliver it. Actors must work together if the good is to be delivered, but individual actors face numerous incentives to eschew cooperation.
- Collective goods normally need some kind of government intervention to force cooperation where incentives work against it. Government programs to promote systemic supply chain resilience exist, but they have limitations. They in particular do not have the market sensing mechanisms that would shut off unsustainable private practices. and might thus might actually encourage behavior that damages resilience.
- There are mechanisms that might potentially hedge against future demand and give suppliers the ability to plan for surge. One such example is “Til Needed” options. If enough actors seek these options, governments might also have a clearer idea of where systemic gaps exist.

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Managing Systemic Supply Chain Risk to the U.S. Economy from Trade Concentration and Geopolitical Conflict: The Roles of Insurance and Other Hedging Strategies

Global trade delivers materials and manufactured goods through supply chains worldwide to fuel national economies. The vast majority of supply chain activity in the world, even among economies such as China with a large government presence, is conducted by private actors carrying out production and delivery of goods and services.[1] While governments play enforcement and regulatory roles, such as customs, supply chain decisions and activity largely occur in the private sector.

Supply chain disruption affects business firms individually and economies collectively.[2] Disruptions could come from several different sources, from natural disasters to geopolitical conflict. The type of damage resulting might not be something immediate, such as physical loss, but rather lost business and lost opportunity because a company does not receive an essential part needed to develop its product.

Understanding the criticality of these supply chains to their revenues and profits, businesses and organizations take steps to protect themselves, and they often have a very detailed understanding of their immediate suppliers and potential vulnerabilities. Businesses and business schools have been studying supply chains for decades. Accordingly, a company can understand a considerable amount about its supply chain exposure simply from looking at its internal data and its immediate suppliers.

There are several ways businesses—and sometimes governmental agencies—guarantee their own supply chains and mitigate against disruptions. These include measures such as stockpiling or increasing redundancy through contracts with multiple potential suppliers.

There are, however, limitations to what individual organizations can do to limit their supply chain risks. The most obvious is that businesses cannot anticipate the extent or severity of many disruptions. Stockpiling is only useful if it is applied to the correct commodity, and that can be extremely difficult to predict. Further, the disruptions may be systemic in nature, of such a magnitude that no single organization could reasonably be expected to possess the means to correct the problem. The most severe supply chain disruptions to trade could pose risks that extend beyond individual companies to threaten an entire economy nationally or even globally.

Many events in the last five years illustrate the scale of economic consequences that can result from the disruption of trade. For example, the blocking of the Suez Canal by M/V Ever

[1] Yossi Sheffi and Jarrod Goentzel, "Private Sector Supply Chains and Emergency Management," FEMA, undated.

[2] We use firms, companies, and businesses interchangeably and distinguish them from insurers.

Given in 2021 had a major impact on multiple supply chains.[3] Other events, such as, the conflict in Ukraine and the Middle East, trade wars, and cyber-attacks, illustrate how geopolitical conflict can be a significant cause of severe trade disruptions.[4]

Situations where risks of conflict intersect with concentrated economic activity may present the most significant risks of economic disruption. For example, the potential for supply chain disruptions to the heavily concentrated advanced semiconductor manufacturing industry has captured policymaker attention about economic risks that could result should tensions between China and Taiwan escalate.[5] The geopolitical conflict need not extend to all-out war. Events of lesser intensity such as coercive quarantines can disrupt trade by disrupting operations at ports or transit through shipping channels. Such lesser events can include damaging manufacturing facilities, pipelines, trains, or ships, displacing workers supporting manufacturing or supply chains, or imposing restrictions on access to ports or facilities or commerce with them.

Motivated by these examples, this report examines three questions about risks that affect whole sectors of the economy and not just individual actors within them:

- How might the potential for systemic economic risks from trade and conflict exist beyond those commonly recognized?
- What actions could the private sector consider to manage these risks?
- What gaps are the private sector unlikely to address and what policy options do governments have to fill them?

We approached this effort from two different perspectives: from a general systems level and from the perspective of actors in the system. To accomplish the first line of effort, we performed preliminary analysis of systemic economic vulnerability using global trade statistics, which was an attempt to map commodity concentration with conflict levels. We followed this with a series of interviews, with a small number of experts from the manufacturing and insurance industry sectors.

The purpose of this analysis is to improve help the private and public sectors can work together to manage systemic economic risk effectively. Specifically, we suggest that:

1. Systemic economic risks to global economies exist in many sectors and regions because of exposure of concentrations of trade to the threat of conflict.
2. These risks can be managed both proactively and reactively.
3. Both the private and public sectors can play a role in managing these risks to improve economic security.

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[3] Editorial Team, "Ever Given: The Grounding That Changed the World's View of Shipping," SAFETY4SEA, March 28, 2023.

[4] UN Trade and Development, "UNCTAD Raises Alarms on Escalating Disruptions to Global Trade Due to the Geopolitical Tensions and Climate Change Affecting the World's Key Trade Route," press release, January 26, 2024.

[5] Bradley Martin, *Supply Chain Uncertainty: Building Resilience in the Face of Impending Threats*, RAND Corporation, RR-A2558-1, 2024.

The remainder of this report:

- summarizes recent history of systemic economic disruptions and reactions to them
- identifies in which countries and in which sectors systemic risks from the intersection of trade and conflict may exist
- describes a framework for identifying strategies for managing these risks
- describe steps the private sector could take to manage these risks
- describes approaches the public sector could take to manage these risks.

The report concludes with a summary of policy questions for each sector to consider when working to improve systemic economic risk management and appendices that describe the analysis of trade data and interview protocols used in discussions with industry experts.

The Recent Past: Economic Risks Revealed by Tensions with China and Wars in the Red Sea and Ukraine

The world's economy is interconnected in complicated ways, and although there has always been a connection between economic activity and security, recent and potential conflicts have highlighted the degree to which routine commerce can be affected by international crises. In some cases, this is because the production of key inputs is in areas likely to be affected by conflicts, but in other cases it is because the conflict has affected or could affect shipping. Most of the world's commerce - around 90 percent[6]- moves by surface ship. Insurance of both ships and cargo has been a feature of maritime trade for centuries.[7]

We examined three recent conflicts with possible supply chain effects: tensions with China, the war in the Red Sea, and the war in Ukraine. These three conflicts are ongoing at various levels of intensity as of the time of this writing. Our focus is not on the conflicts directly but on the potential impacts on international supply chains resulting from the conflicts, and whether some kind of supply chain mitigation might have been, or might still be, practical.

Tensions with China

China and the United States have large economies that rely on international trade, with China being the world's largest manufacturing and trading nation. China's trade follows its economic requirements and commercial interests. It has a well-developed system of control and ownership that minimizes the likelihood of supply chain disruption. Its shipping goes to the well-established international hubs for container and bulk traffic. These include ports such as New York and Long Beach in the United States, Pusan in Korea, Rotterdam and Antwerp in the European Union, the

[6] Spencer Feingold and Andrea Willige, "These Are the World's Most Vital Waterways for Global Trade," World Economic Forum, February 15, 2024.

[7] Gregory D.L. Morris, "A Brief History of Marine Insurance," *Risk & Insurance*, March 6, 2018.

port of Singapore, and the port of Yokohama. In general, this is a matter of Chinese shippers delivering manufactured material to ports closest to the markets.[8]

In its Belt and Road Initiative China has also secured port facilities near its sources of critical materials and uses those ports as part of an integrated supply system. These include ports in Africa and Latin America,[9] where China is principally interested in taking raw materials from countries of origin to China. Even where China does not directly control port and shipping infrastructure, its shippers and other supply chain components are well insulated against risk. Market power is itself a hedge against disruption. For example, the United States and its allies have designated and control "strategically important ports" in the United States, Europe, Singapore, Japan, Australia, and Korea. "Strategically important" in this context means that even something important to its economy or national security must pass through a particular port on its way to or from China, regardless of what China might need or desire. Australian ports are particularly critical to China as shipping points for iron ore (roughly 60 percent of China's supplies), lithium, and a variety of other raw materials. Port Hedland in Australia is the largest port in the world for mineral export, and China has no ownership or regulatory control over its operations or scheduling.[10] China should therefore have limited ability to influence how its commodities are prioritized or which carriers are allowed to use it.

However, China has substantial investments in other Australian ports. For example, it also provides Port Hedland with considerable traffic and revenue. Although China does not control Port Hedland, the importance of investment and trade is likely sufficient to induce Australia to allow Chinese carriers to continue using this port. China does not need to employ its usual hedging strategy of trying to control everything in a vertically integrated supply chain. Short of an all-out war where both sides cut off trade, supply chain hedging in this case might not be necessary for either side. China retains considerable market leverage and as a result has little need to hedge.

In a different example, China imports about 80 percent of its soybeans from the United States and Brazil, and the ports of New Orleans and South Louisiana handle 70 percent of the soybeans leaving the United States.[11] The Chinese container carrier company COSCO moves only a small amount of product from these sources, and its leverage should thus be limited and exposure somewhat increased.

However, in both cases, the incentives for the suppliers to continue providing the goods and allowing use of facilities generally work to reduce supply chain disruption. China is a major market for U.S. soybeans and any kind of interference with soybean sales would likely have a political impact in the United States. Indeed, as this report was being completed, restrictions by

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[8] Mercy A. Kuo, "Shipping, Ports, and China's New Maritime Empire," *The Diplomat*, February 6, 2024.

[9] Julieta Pelcastre, "China's Network of Ports Grows in Latin America," *Diálogo*, January 23, 2023.

[10] Aakrati Dubi, "8 Major Ports in Australia," *Marine Insights*, April 17, 2022.

[11] Daniel Grant, "Port of New Orleans Critical to Growth of Ag Exports," *Farmweek Now*, April 18. 2023.

China on the import of U.S. soybeans in response to U.S. tariffs had become a major diplomatic and political issue.[12]

The United States, on the other hand, owns a comparatively small amount of shipping, has no ports in the top ten and only two in the top 20 for throughput capacity, and in general relies on shipping owned by other nations to provide transportation to and from the country. As the world's largest economy, the United States has significant market and investment power. But, while China has presence and ownership, the U.S. relies primarily on its buying power to induce suppliers to provide products, including those critical to supply chains. The U.S. has power to influence but it does not directly control sources or shipping the same way China does. .

As this report was being written, the United States and China are engaged in negotiations on tariffs and trade arrangements, and neither the outcomes nor the impacts are yet known.[13] A key piece in how each economy weathers these changes may be willingness to accept and underwrite risk. As noted, China controls most of the port capacity and infrastructure world-wide, making an effort to consolidate supply chains under its control.[14] Its state-owned companies routinely accept risk, knowing that governmental action will cover any disruptions, and, collectively, the nation has access to a variety of sources for most key supply chain elements. The United States, in contrast, is relying almost solely on other nations wanting to trade with it as the basis for minimizing supply chain risk.

Although there are factors that could undermine China's actual resilience in the event of a disruption, China is specifically planning for such a disruption in ways that the United States has not, and indeed has no specific mechanisms for doing. This is not to suggest that the U.S. should follow Chinese practice. Besides being ideologically antithetical to historical U.S. attitudes toward the relationship between public and private sectors, the U.S. simply does not have a web of state-owned enterprises nor a government mechanism for taking over sources and transportation modes for a prolonged period. There may be hedging or insurance strategies that could be pursued to promote system-wide supply chain resilience, but those have not been formally developed, let alone employed.

Conflict in the Red Sea and Bab Al Mandeb Straits

The disruptions that have occurred or might occur with China have not so far involved the use of force or actual physical disruption of shipping. We will now examine a case where actual force was employed by Houthis against shipping in the area around the Arabian Peninsula and in the Red Sea. This campaign is for now in abeyance but could resume.

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[12] Ken Roberts, "China Purchased No U.S. Soybeans For An Unprecedented Fifth Straight Month," *Forbes*, January 17, 2026.

[13] Arendse Huld, "Trump Raises Tariffs on China to 145%—Overview and Trade Implications," China Briefing, April 11, 2025.

[14] Raunek Kantharia, "Top 10 Busiest Ports In The World," *Marine Insight*, May 2, 2024.

Following the October 7, 2023 attack by Hamas on Israel, Israel responded by attacking Hamas in Gaza. This in turn led to actions by the Houthi rebels in Yemen, who began attacking ships transiting the Red Sea,[15] the Gulf of Aden, and the Bab al Mandeb Straits, stating that the attacks were intended to stop shipping bound for or originating from Israel. Approximately 100 ships were targeted since the attacks began in November 2023.[16] The U.S. Navy and other allied navies attempted to provide air defense protection, to include escort of selected merchant ships.[17] The number of attacks against shipping decreased markedly after a ceasefire between Iran and Israel, but the U.S. Navy remained on station to provide area defense.

Despite the presence of escort and the likely minimal danger, most merchant ships found the insurance costs of transiting through the Red Sea to be too onerous and opted to divert around the Cape of Good Hope, despite the additional fuel expense and time delay. Ship insurance rates, which are predicated on the cost of the ship itself, are generally expressed as a percentage of the ship's cost and applied for a limited period in which a ship enters and leaves a contested area. The rate calculations are proprietary and vary by case but they reflect an assessment of attack and damage likelihood. Rates in the Red Sea went from 0.5 percent of a ship's total value in October 2023 to 2 percent in September 2024. Carriers applied this cost to the overall voyage costs, such that the cost of moving cargo on an $80 million dollar ship would have gone from $400,000 to $1.6 million for a single Red Sea transit. This rise in the cost of insurance exceeded the cost of going around the Cape of Good Hope, which added an additional five to seven days to destinations in Europe and the United States from the Middle East.

The overall economic impact of Houthi attacks on shipping was globally relatively modest, largely due to relatively low fuel prices and the availability of alternate routes. The importance of insurance cost in the choices shippers made with respect to routing is significant. The cost of insurance to underwrite a shorter Red Sea transit exceeded the cost of rerouting and insurance was thus never seen as needed by shippers. Insurance against supply chain disruption – as opposed to insurance against the loss of cargo or the ship – might have changed the calculation if nations had made a determination that the broader market disruptions from the longer transit were worth considering. But no nation chose to make broader disruption a priority.

War in Ukraine – 2022-2025

Russia invaded Ukraine on February 24, 2022, and the war is still in progress as of the time of this writing. Here, we focus on aspects of the world's supply chains that have been affected by this conflict through the period 2022-25, against which hedges such as insurance might have

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[15] Christian Edwards, "Who Are the Houthis and Why Are They Attacking Ships in the Red Sea?" CNN, February 4, 2024.

[16] Project 44, "The Red Sea Crisis: A Year of Houthi Attacks Their Impact on Global Shipping," December 10, 2024.

[17] Johnson, 2024.

been applied. A generalization about this conflict might be that global supply chains have been little impacted, but that there are potential impacts that are largely mitigated.

Soon after the war started, the United States and European Union imposed sanctions[18] on Russia that were specifically designed to have an impact on Russia's supply chains, particularly those associated with its military. These sanctions appear to have had some effect on Russia's ability to conduct combat operations[19] early in the war but took nearly two years to show a cumulative impact on Russia's economy.[20] This delay in domestic economic effects occurred largely because Russia continued to have access to markets in most of the world, including China, and also because energy exports were never seriously limited.

There were, however, restrictions early in the war on Black Sea navigation, which could have had a major impact on grain exports. When the war began, the Black Sea was initially unavailable for navigation because both Russia and Ukraine had the ability to sink ships in a confined area. This could have affected both Ukraine and the global economy. A significant portion of Ukraine's national income comes from grain exports.[21] Ukraine has historically exported most of its grain[22] (up to 90 percent) for the world market through Black Sea ports. Russia had also used the Black Sea for a portion of its grain and other raw material exports, to include liquid natural gas.[23]

Indeed, Russia's initial calculation[24] appears to have been that potential grain shortages would drive the global south toward Russia as a supplier of grain and toward a demand that Ukraine come to a rapid settlement. However, Russia abandoned this approach and grain continued to flow, first by agreement from July 2022 to 2023 and subsequently because while both sides had the ability to sink shipping[25], neither had the ability to launch a selective blockade[26].

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[18] European Council, "EU Sanctions Against Russia Explained," webpage, October 23, 2025.

[19] Oliver Ruth, "The Impact of Sanctions and Alliances on Russian Military Capabilities," RUSI, January 10, 2025:

[20] Rebecca M. Nelson, "The Economic Impact of Russia Sanctions," Congressional Research Service, February 20, 2025.

[21] Foreign Agricultural Service, U.S. Department of Agriculture, "Ukraine Agricultural Production and Trade," fact sheet, April 2022.

[22] Noah Berman and Mariel Ferragamo, "How Ukraine Overcame Russia's Grain Blockade," Council on Foreign Relations, February 27, 2024.

[23] Poliana Devitt and Vladimir Soldatkin, "Significance of Black Sea Ports for Russian Commodities Exports," *Reuters*, July 20, 2023.

[24] Hugo Bachega and Paulin Kola, "Ukraine War: Russia Halts Grain Dela After 'Massive" Black Sea Fleet Attack," *BBC News*, October 29, 2022.

[25] Ibid.

[26] The simple ability to sink merchant shipping is not necessarily an effective means for imposing a blockade, where the blockading country is attempting to impose control without necessarily destroying the ships attempting to transit. An effective blockade should include the option of querying, boarding, and diverting shipping. This, in turn, requires a persistent presence of surface combatants. Although Ukraine does not have a Navy, it does have the ability to make the Black Sea hazardous to the Russian Navy, hazardous enough that Russia had no options between sinking or allowing merchants to transit.

Both sides could stop flow, but neither could prevent the other side from also stopping flow. The result was that both sides found that allowing transit was preferable than a campaign of simply sinking merchant ships.

As a result, although the Ukrainian ports of Mykolaiv, Kherson, and Mariupol have remained closed, maritime traffic is flowing relatively freely from Odessa, Chornomorsk, and Pivdennyi.[27] Ukraine has periodically interdicted ships that contain Russian grain and natural gas, but for the most part, the flow continues unimpeded. Consequently, the overall impact on the global supply chains has not been substantial.

The kinds of mitigation that might have applied – insurance or other hedges – turned out to not be relevant in this particular case. The actors arrived at a political settlement and thus avoided the need for those impacted by supply chain disruptions to seek mitigations. It is worth noting that without the political settlement, no mitigations would have been sufficient. Insurers would likely not have been willing to underwrite vessels or cargoes if conflict had continued.

Systemic Risks from Trade Concentration and Conflict Exist Beyond Recent Events

The recent high-profile cases discussed above provide a mixed message with respect to the importance of supply chain vulnerability. In the cases of Houthi attacks on shipping and the war in Ukraine, supply chain vulnerability could have been present, but in one case was simply worked around, and in the other resolved by political negotiation. In the case of conflict with China, the vulnerabilities are numerous but for the U.S. overcome by the sheer size of its consumer markets. Leverage comes from the desirability of access to U.S. markets. It is not clear that supply chain hedges would be helpful or practical.

These results are, however, related to specific case studies and might not be generally true. Trade is global, supply chains highly connected, and conflict present in regions throughout the world. The potential for events with potential systemic effects on the U.S. extends beyond areas of current tensions like the Middle East, Ukraine, and China and widely recognized commodities such as advanced microchips or petroleum or grain. We need a method for identifying potential areas where conflict and supply chain dependence overlap before they become major disruptions.

To achieve a broader view into the breadth and nature of systemic risks to the U.S. economy involving trade concentration, we carried out an analysis of global trade data and then cross-referenced this with data on global conflict (details in Appendix A).

This methodology takes as inputs:

- value of imports to the United States worldwide across all sectors of the economy
- potential loss of trade and economic output associated with reductions of inputs from different sectors from different countries through input-output modeling

[27] Jonathan Saul and Carolyn Cohn, "In Ukraine's Bombarded Ports, Ship Buyers Scout for Deals," *Reuters*, March 15, 2024.

- import dependence of the United States by sector and country
- potential conflict risk associated with the countries providing imports.

We created a matrix of the impact of all imports by country and sector and considered only those that had more than $1 billion worth of economic impacts. This provided a means to consider specific imports from specific countries that affect the U.S. economy. Next, we incorporated both the INFORM index and the economic impact. To do this, we aggregated all economic impacts at the country level and combined that with the INFORM rankings.

Table 1 provides a list of countries that have more than $1 billion of impact on the U.S. economy and their corresponding Global Conflict Risk Index (GCRI), drawn from the European Union INFORM hazard exposure data set. We ordered the countries by economic impact and the highlighted the nations have a conflict risk index score of greater than five. Note that eight of the ten countries with the greatest economic impact on the U.S. also experienced high levels of conflict risk.

Table 1. Global Catastrophic Risk Index and Impact on the U.S. Economy, 2023

Country	Global Conflict Risk Index	Economic Impact ($ billions)
Mexico	7.0	1,130.2
China	1.7	660.0
India	7.0	192.0
Brazil	7.0	175.0
Thailand	5.4	147.0
Russian Federation	5.6	78.6
Indonesia	6.1	52.9
Turkey	6.6	48.0
South Africa	5.5	38.7
Germany	0.4	34.7
Philippines	7.0	33.6
Colombia	7.0	21.0
Pakistan	7.0	20.8
United Kingdom	0.6	17.0
Peru	2.7	16.4
France	0.4	15.3
Canada	0.1	14.7
Ukraine	7.0	10.5
Saudi Arabia	8.0	9.3
Ecuador	4.8	7.9
Japan	0.1	7.6
Venezuela	4.6	6.5
Spain	0.4	5.2
Egypt	6.9	5.0
Algeria	4.4	4.4

Kazakhstan	8.0	4.4
Korea Republic of	0.1	3.0
Italy	0.1	2.9
Israel	0.3	2.8
Austria	0.3	2.6
Malaysia	0.2	2.2
Nigeria	9.0	1.9
Morocco	2.0	1.9
Viet Nam	0.1	1.8
Switzerland	0.1	1.8
Australia	0.2	1.2
Belgium	0.2	1.2

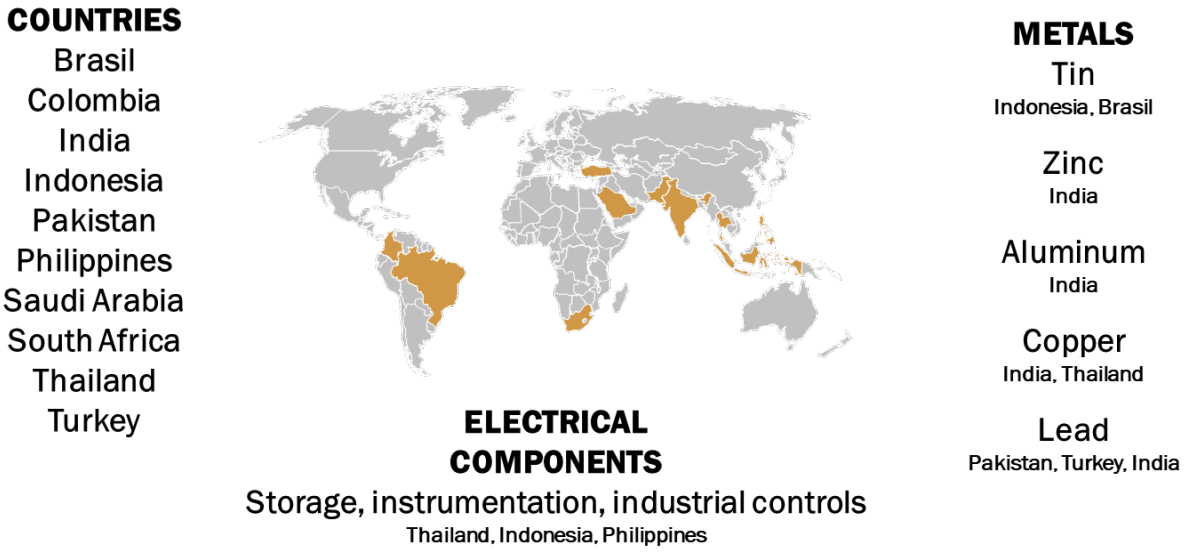
Source: Authors' analysis of Global Catastrophic Risk Index (GCRI) and Bureau of Economic Analysis import-export data

Table 1 shows only the aggregate economic impact as determined by import balances. However, not all imported goods necessarily create significant vulnerability. The United States imports numerous goods, from hand tools and cutlery, which are not essential to the economy, to petroleum products and critical minerals, which generally are. Therefore, when evaluating the actual vulnerability to supply disruptions, it is important to consider the specific commodities and not just the total dollar value of trade.

Accordingly, we examined the composition of U.S. imports from the countries with a GCRI greater than five to determine whether these commodities might be systemically important to the U.S. Even omitting conflict in obvious areas that we considered elsewhere in detail,[28] several countries in the top ten list of conflict-prone countries are exporters of strategically significant commodities, specifically non-ferrous metals and electrical components. Among non-ferrous metals, we considered tin, zinc, aluminum, copper, nickel, and lead. All these commodities, except for nickel, show a concentration of imports from areas where conflict rankings are also high. Electrical components for control systems, instrumentation, and storage also come from nations with high conflict risk. Figure 1 highlights the specific commodities and sectors that might originate from countries with high conflict potential.

[28] To better highlight possibly not well considered risk, we excluded Russia, Ukraine, Mexico, and China from this analysis of potential supply chain risk in areas of potential conflict. The risks associated with those countries are widely known and indeed undue consideration might cause us to miss effects from less well-illuminated countries.

Figure 1. Commodities Critical to U.S. Industry Originating from Nations with High Conflict Scores



SOURCE: Authors' analysis based on GCRI data and Bureau of Economic Analysis Import-Export Data
NOTE: The figure does not include Russia, China, Mexico, and Ukraine since the conflict risk in these areas are well understood.

The existence of imports important to the U.S. economy from conflict-prone areas does not prove vulnerability to supply disruption. This information was specific to 2023 and does not reflect the possibility that conflict potential could go down or that other import sources might be available. This figure does suggest that there are concentrations of important commodities in areas where conflict is a strong possibility. Awareness of degrees of concentration in areas prone to conflict might be an important part of mitigating supply chain risk. The data-bases exist, and we have shown one way to aggregate and compare conflict and trade data. The data and the demonstrated method might prove useful as we try to characterize systemic risk.

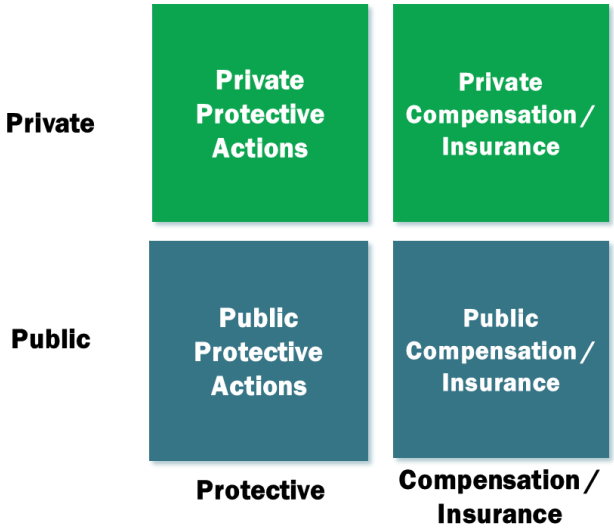
Protective and Compensation Strategies for Risk Management

Strategies for managing economic risks from trade and conflict can be considered both in terms of who takes the actions to manage the risk and how the actions contribute to risk management (see Figure 2). Within this framework, private actions are those taken by companies and organizations acting to achieve individual goals. While these typically include actions by single organizations, they could also include collaborations or agreements among private firms and organizations. In contrast, public actions are considered those taken by governments.

Actions taken to manage risk can work to either prevent events that create risk from occurring or reduce the resulting damage should such events occur. In Figure 2, this category of approaches is referred to as *protective actions,* and they are generally implemented in advance of events occurring. Alternatively, actions can be taken after events occur to reduce the

consequences for those organizations and communities affected by providing compensation for losses incurred. These are referred to in the figure as compensation or insurance actions. Insurance is a common approach of this type and is covered in more detail in the subsequent sections, which discusses approaches that could be taken in each of these four categories, first considering actions that could be taken by the private sector and then those that could be considered by the public sector.

Figure 2. Framework for Identification of Public and Private Risk Management Actions That Are Either Protective or Compensatory



Private Sector Actions Exist but Are Insufficient for Addressing Systemic Risk

Options exist for individual companies to protect their businesses against supply chain disruption. We interviewed both insurance providers and those potentially seeking insurance to gain a sense of what the current options might be. (Appendix B contains interview questions.) The numbers of interviews were limited and do not support broad generalization. However, we did receive useful information shedding light on what insurers and businesses seeking insurance view as feasible ways to mitigate supply chain disruption. It is worth noting that these options generally are not oriented toward improving the ability of supply chains to anticipate supply chain disruption, react effectively, and rapidly repair gaps as they develop. They are instead oriented towards offsetting financial losses after the fact. These interviews were conducted in 2024 before the United State began using tariff policies to influence global trade, yet the observations and descriptions of decisions being made are in response to perceptions about how events like those involving tension with China could spawn systemic risks.

Private Firms Are Taking Steps to Address Risks, Yet Gaps Remain

Companies are taking proactive steps to protect their supply chains. Yet, the collection of individual actions does not appear to be adequate to ensure that the nation or even individual sectors have secure supply chains or a means to mitigate shortages. Gaps remain due to challenges associated with each strategy companies are taking and fundamental challenges in addressing systemic supply chain risks.

Supply chains have become complicated to the point of opacity. Surprises arise because it is impossible to know where vulnerabilities might exist. Many firms are trying to increase visibility into their supply chains, analyzing chains by location, geographical exposure, and capacity concentration. Companies are trying to identify gaps in supply chains below the first tier of suppliers and, in some cases, directly contracting with suppliers deeper tiers in the supply chains. There is a market for data and technology providers who are supporting firms in doing so.

Companies are also taking steps to decrease concentration in their supply chains. Using the information gained from improved supply chain mapping, they are promoting greater geographic sourcing, which includes concentration on local and domestic sourcing, and supplier diversity, with multiple vetted sources. These efforts might be coupled with efforts such as securing multi-year supply commitments to improve supply-chain reliability. These approaches are all intended to lower the probability of completely losing the supply of key inputs or the ability to move outputs.

However, such solutions are limited in scope and applicability. Three principal factors limit their effectiveness for addressing much beyond the limited needs of individual corporations. First, the volume and scope of risks can be quite large, and the mechanisms selected to safeguard parts of the chain may not meet the challenge in an effective way. For example, having diversified supply sources for a particular part of the supply chain might not mean much if the disruption is from somewhere unexpected. Companies do not know what they do not know. Second, for insurance to be effective, enough companies have to participate to generate sufficient funds to pay claims, and it was not clear from our discussions that interest would be sufficient absent guarantees. This leads us to the final problem, which is that mitigation against individual company risk cannot address broader systemic issues. One company with a stockpile does not translate into a national economy's ability to deal with large-scale disruption across the supply chain.

Insurance is Not Well Suited to Addressing Systemic Risks from Trade and Conflict

Several insurance brokers, insurers, and reinsurers we spoke with are either initiating or knew of efforts to develop products that could help companies manage supply chain risks. But, like individual protective measures, these first forays into insurance against systemic risks appear inadequate. The market for supply chain insurance is fractionated across many lines of insurance and provides niche products. The most significant line of insurance for supply chains involves

Property and Casualty coverage. This insurance generally covers physical damage by named perils to manufacturing facilities, vessels, or cargo and can include the business interruption losses associated with the physical damage. Such coverage would not cover the losses resulting from systemic risks that spread across sectors and the global economy.

Systemic risks can be covered by some non-damage contingent business interruption[29] lines of insurance. But these markets too are fractionated. Some losses in firm net revenue might be covered under trade disruption policies or political risk policies. In theory, these lines of insurance could cover companies against perils that could spark systemic risks like sanctions, political unrest, or trade disputes among countries. In practice, we heard that recognition of the potential for systemic risks, especially those associated with tensions with China, has led these business interruption insurance products to become less available. Companies are writing fewer policies, with lower limits, and more defined and constrained triggers. We heard examples of companies now seeing policy terms that required naming facilities and triggers that are more directly related to those named facilities (e.g., smaller radii around a facility for covered events).

As a result, it appears that the availability and uptake of supply chain insurance to address systemic supply chain risk is limited. When facing limited and expensive policies, larger firms may be opting to self-insure instead of purchasing policies. And, for smaller firms, coverage may be unavailable or prohibitively costly.

In interviews, we also heard of special cases where firms were able to find coverage, but only in narrow circumstances. For example, small geographically concentrated firms with a small number of manufacturing or non-substitutable supplier facilities uniquely exposed to risk (e.g., due to earthquake or cyclone hazards) had little choice but to seek insurance for those risks, even when the premiums are high. Insurers are in turn willing to provide insurance because the risks are specifically identified and limited to specific firm exposure. Similarly, pharmaceutical manufacturers cope with a long and complicated process of gaining approval for pharmaceutical products, which could be seriously disrupted by supply chain lapses. Insurance to cover these specific lapses is essential, even if very expensive.

Fundamental aspects of the nature of systemic supply chain risk make it unlikely these conditions will change. The ideal conditions for insurability of a particular risk favor four conditions:

1. large numbers of insured entities across which risks are uncorrelated,
2. risks that can be defined by clear triggers for which losses can be estimated.
3. The magnitude of losses must both be proportional to the costs of premiums that can be collected and

[29] "Non-Damage Contingent Business Interruption" insurance is provided as the result of transactions and production being interrupted and is not contingent on actual physical loss or damage having occurred.

4. not be affected by decisions and behaviors of the insured in ways that cannot be reflected in underwriting.[30]

Systemic supply chain risks violate almost all these conditions. Risks may be correlated because concentration in specific regions causes connections across sectors and economies. Probabilities of triggering events may be unknowable and supply chain opaqueness may further hinder estimation of likelihood and consequences of events. Firm decisions about how to respond to disruptions (such as stopping production rather than seeking alternative suppliers) could exacerbate business interruption losses. Collectively, the systemic nature of risks demonstrated by our trade analysis indicated the potential for losses to scale catastrophically.

Private arrangements as they currently exist cannot sufficiently protect supply chains to safeguard anything more than individual businesses. This means sectors and nations will remain exposed. System-wide supply chain resilience requirements are too widely diffused and the claims potentially much larger than anything insurers could provide.

From a public policy and collective good perspective, the limitations suggest that privately provided insurance cannot be expected to provide a path to supply chain resilience at the system level. Indeed, it might not even be effective at the firm level except in very specific circumstances. Market incentives work against purchasing or offering insurance for unpredictable events for which the impact cannot be readily valued. There is very little incentive for insurance companies to offer such coverage or if it does, to offer it at a cost companies can afford.

There are many ways private actors try to protect themselves against supply chain disruption, but individual actions are not enough to insulate against systemic risk. Big systemic events concern everyone, and their collective nature means that individual responses are likely not adequate. Public good - and its synonym collective good - describes a kind of commodity which cannot be delivered by individuals acting in their best interest and which requires some kind of coercive or cooperative mechanism to allow it to be delivered. The fact that a company has successfully secured a reliable supply chain does not mean that any other entity around it has, and, in fact, companies competing to secure supply chains might mean that multiple private actors are competing for the same limited resources. Hoarding, black markets, and price-gouging are common private sector reactions to supply chain disruptions.[31]

If a crisis were to occur in which China decided to act against U.S. economic interests, supply chain disruptions would be significant, firms would find it difficult to keep operating, and the U.S. government would find itself dealing with an economic crisis beyond the ability of private enterprise to manage. We will examine potential governmental actions, but we emphasize

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[30] Joan T. Schmit, "A New View of the Requisites of Insurability," *Journal of Risk and Insurance*, Vol. 53, No. 2, June 1986.

[31] Michael Levenson, "Price Gouging Complaints Surge Amid Coronavirus Pandemic," *New York Times*, March 27, 2020.

that decisions about supply chain management largely reside within the private sector. Government actions that do not acknowledge the many incentives working against hedging against disruptions are likely to be ineffective and possibly counter-productive.

Public Options for Managing Supply Chain Risk are Essential, But Can Have Complex, Unanticipated Effects

Collective goods have as a general characteristic that providing them requires more than individual market effort. When such goods are provided, access to resources is guaranteed to everyone requiring them. In command economies like China, the government goes to great lengths to ensure supply chain security across the economy and in international trade, beyond what the market could reasonably underwrite as risk.

The types of mechanisms typically used to deliver collective goods involve the government using compulsion to generate and apply the resources needed to ensure delivery of a collective good. These efforts could include taxation regardless of whether the recipient has immediate benefit (such as in general public education) or regulation (such as in environmental protection or workplace safety). Specific to supply chain resilience, governments already regulate many aspects of the supply chain. Black market activity and price gouging are illegal. Insurance coverage of every description is regulated at the national, state, and local level, and internationally.[32] There are other governmental actions involving underwriting and investment, which we will discuss in more detail.

However, government actions may be blunt instruments and may be incapable of processing and applying market signals. In fact, as we discussed, they may in fact distort behavior in counter-productive ways. Even China's proactive efforts to secure its supply chains through government actions depend largely on guessing correctly about where disruptions might occur, depending primarily on government-based assessment not necessarily a dynamic perception of the market. The market follows where the government leads, not necessarily where the greatest risks and values exist.

Government Policy Can Address Risks by Influencing Investment

China clearly has absorbed the idea that state intervention is necessary to underwrite supply chains and minimize risk.[33] China operates seven of the ten largest ports,[34] has controlling

[32] Ryan Hearn, "The Global Perspective: Comparing Insurance Laws Across Countries: Don't Let Your Coverage Get Lost in Translation!" Insightful Coverage, May 21, 2025.

[33] By underwriting, we mean provide support for an endeavor or initiative and covering losses if it fails.

[34] World Shipping Council, "Top 50 Container Ports," webpage, undated.

interests in ports all over the world,[35] and maintains a merchant fleet under state-owned enterprises.[36] These are not primarily matters of commercial need but are very much connected to directly investing in access to materials, with immediate profitability not held to be the primary consideration. The government of the People's Republic of China guarantees against systemic risk by underwriting investments to ensure the flow of critical materials and commodities.

As we were writing this report, the Trump Administration was attempting to remake the international trading system in ways that would likely reorient supply chains. Part of the reason for doing this is to ensure secure supply chains that are largely contained inside the United States.[37] The U.S. government has options other than tariffs to build resiliency to supply chain risk. One is the Defense Production Act (DPA), when invoked, gives the Department of Defense broad authority to allocate productive resources in accordance with national priorities.[38] Industries that receive the highest levels of priority get preferential access to resources. Although DPA is generally associated with actions taken in times of extremity, it can in fact be used in more routine contexts to ensure the establishment of a secure supply chain. It is not intended, however, to be a mechanism for long-term sustainment.

The ideal outcome when DPA is invoked is that the industry involved becomes self-sustaining or the intervention is suspended when the need no longer exists. Failure to have a transition plan can lead to over-investment or even investment in the wrong thing. As an example, early in the COVID-19 pandemic, DPA was invoked to facilitate the production of ventilators,[39] which were in short supply due to the rapid increase in demand from patients requiring this treatment. This shortage proved to be a transitory condition, and indeed the outcome was an oversupply of ventilators as those most likely to need ventilators passed and vaccines emerged to reduce vulnerability. [40]

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[35] Zongyuan Zoe Liu, "Tracking China's Control of Overseas Ports," interactive map, Council on Foreign Relations, August 26, 2024.

[36] Devin Thorne and Ben Spevack, "The Chinese Merchant Marine Supports Beijing's Security Interests," *The Maritime Executive*, July 17, 2019.

[37] The White House, "Fact Sheet: President Donald J. Trump Declares National Emergency to Increase our Competitive Edge, Protect our Sovereignty, and Strengthen our National and Economic Security," April 2, 2025.

[38] Alexandra G. Neenan and Luke A. Nicastro, *The Defense Production Act of 1950: History, Authorities, and Considerations for Congress*, Congressional Research Service, R43767, Updated October 6, 2023.

[39] Greg Slabodkin, "An Insider's Look at How GM, Ventec Ramped Up Ventilator Production Amid COVID-19," MedTech Dive, July 13, 2020.

[40] Frank Fox, Jessica Hayes, Barbara Whelan, Dympna Casey, and Márie Connolly, "Key Factors Impacting a Medical Ventilator Supply Chain During the COVID-19 Pandemic: Lessons for Pandemic Preparedness," *Disaster Medicine and Public Health Preparedness*, Vol. 18, April 12, 2024.

Government as Insurer of Last Resort

As we have established, private insurance is limited to identifiable damage to specific beneficiaries. As we have discussed, private insurance against widespread risk from market disruption does not and probably could not exist. As a result, governments have in some cases become "insurers of last resort" where a public interest exists in supporting some kind of risky activity but where private resources are unavailable. Governments, for example, can ensure wartime shipping in contested areas,[41] coverage which private insurers would simply never supply. This is government underwriting at its most expansive.

However, there are cases where underwriting is less extensive than war risk and can directly benefit public interests. One example[42] is the Development Finance Corporation (DFC), a governmental entity formed in 2018 that has a budget of about $1 billion.[43] The DFC has a variety of tools it can use to promote development, which can include direct government investment[44][. The DFC prefers to enable private capital, which can be underwritten by government insurance or reinsurance for the specific investment that a company might want to make. While it is not the equivalent of supply chain insurance, DFC insurance can have the effect of inducing investors to seek supply chain sources in areas not previously developed that might otherwise be too risky for private actors to insure.

Although this approach has promising aspects, there are limitations. The major is that while it creates opportunities for investment, it is not clear that the opportunity would exist, or ought to exist, absent the government making it profitable. This could be beneficial – possibly the government's priorities are the right ones – or it could be a case of the government propping up an undeserving winner.

Other examples of the government providing insurance have included flood insurance programs,[45] state and federal unemployment insurance,[46] and a variety of programs that support domestic and international investments. These have as a premise that the government can provide support in areas where the private sector does not have adequate capacity or incentives. They allow companies and individuals to continue behavior and make investments that the market would not support.

There are, however, limits to how effective government underwriting can be, for both expansive and limited applications. Government underwriting can allow risky but sound

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[41] U.S. Code, Title 46, Chapter 539, War Risk Insurance.

[42] U.S. Development Finance Corporation, "About Us," webpage, undated.

[43] U.S. Development Finance Corporation, Congressional Budget Justification: Fiscal Year 2023, undated.

[44] Congressional Research Service, "U.S. International Development Finance Corporation: Overview and Issues, January 20, 2022.

[45] Federal Emergency Management Agency, "Flood Insurance," webpage, November 26, 2025.

[46] U.S. Department of Labor, "How Do I File for Unemployment Insurance," webpage, undated.

investments to begin and reach a point of self-sustainment. But it might not be in itself a source of good ideas about how best to ensure resilient supply chains. Government agencies are not likely to be as aware of market trends as businesses and have only limited insight into where companies are experiencing risk. Underwriting might in fact reinforce poor choices.[47] Indeed, if public underwriting amounts to enabling companies to continue behavior that would best be met with avoidance, it is in effect reinforcing bad habits.[48] There may be times when it will be beneficial to underwrite collective risks but there may also be times when the best outcome is for companies to stop a particular behavior. Unless very selectively applied, underwriting might not serve to encourage better and more diverse supply chains and indeed might abet undesirable support of insecure supply chains.

Harnessing Private Interest to Promote Systemic Supply Chain Resilience

Markets left to themselves are likely insufficient for addressing a collective challenge. Governments, on the other hand, are likely to miss key market indicators. Some mechanism that effectively harnesses the sensing and flexibility of the market while still recognizing the need for a focus beyond a private company's immediate needs may be the key to finding an effective mechanism for coping with systemic shocks to supply chains.

"Hedging" is a broad financial term that implies taking measures to offset risks.[49] For our purposes, "hedging" means that we have options that not only compensate loss from disruption but prevent disruption from occurring in the first place. In a supply chain context at a system level, effective hedges would mean that buyers and sellers had arrangements across most supply chains that predictably provided critical pieces across different levels of demand.[50]

This level of resilience would imply that the shortages resulting from surges in demand would be short-lived. Mechanisms would exist across broad sectors of the economy that anticipate and then allow reaction to surges as they develop rather than after surge has occurred and disruption has already occurred. These mechanisms would overcome the private sector propensity to focus on short-term cash-flow based decisions but not rely on goverment actions uninformed by market forces. The mechanisms would ensure delivery of critical items in the event of supply chain disruption but contains a means for preventing multiple consumers from

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[47] Flood insurance is only indirectly related to supply chains, but it stands as an example of the government underwriting a questionable investment and behavior pattern.

[48] https://natlawreview.com/article/effects-government-change-and-political-instability-supply-chain-management-how

[49] In a narrow sense, "hedging strategies involve investing in companies whose performance would be negatively correlated: if one goes up, the other is likely to go down. We are using the term more broadly in our analysis.

[50] The Investopedia Team, "Beginner's Guide to Hedging: Definition and Example of Hedges in Finance," Investopedia, April 27, 2025.

drawing from the same supplier or one supplier making promises to deliver products it could not possibly under conditions of surge demand.

"Til Needed Options", discussed in an earlier report[51], is an example of this kind of mechanism. This approach establishes a privately operated exchange for suppliers and consumers of key commodities to offer and purchase rights to specified levels of commodities under conditions established by the agreement. This instrument functions somewhat like a futures market in that a commodity is offered at a particular price against a future delivery. The commodity price is locked and access to it guaranteed by contract. The difference is that the consumer is paying a fee to assure the delivery, and the supplier is maintaining either sufficient inventory or production capacity to meet the delivery within a specified timeline. Both parties benefit: the consumer from a reduction of risk in the event of disruption and the producer from a guaranteed source of monthly income. This approach differs from insurance in that the obligation is not to provide indemnification for loss but to provide actual supplies when the need occurs. Moreover, risk is not pooled but is instead priced between two actors, one paying the other to keep capacity available for emergency conditions. The incentives involved are wholly private and priced according to what one company thinks about the likelihood and impact of a future event and another's assessment about what it would have to do to respond rapidly to surge demand. To go to an earlier example of ventilators, "Til Needed" contracts would involve potential users finding potential suppliers and paying for options that would require potential suppliers to be ready to manufacture ventilators at scale but not necessarily to keep a large supply of ventilators on hand. The potential buyer pays a premium against risk; the potential provider maintains ready capacity and raw materials to produce on demand. A similar arrangement could apply with personal protective equipment or pharmaceuticals or any number of commodities where surge and steady-state demand are different.

Although the incentives are private, this approach depends on a regulatory framework with public disclosure. Agreements cannot be treated as proprietary. A supplier's ability to provide surge output must be clearly evident, and a consumer's record of regular premium payment and honest damage claim must also be known. In addition, the government must be able to track which risk systemic risk areas are covered and which not. If there are "Til Needed" contracts covering most areas of systemic risk, government action might not be required. If there are gaps, the absence of "Til Needed" contracts might indicate that the government needs to do something. This could include generating "Til Needed" contracts of its own with potential suppliers or it could include direct investment in areas where risk is simply too great for any business to request or offer such contracts. But the important feature - now missing - is that the degree of coverage would be known, by the parties involved and other potential suppliers or users and by the government.

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[51] For examples of these types of arrangements, see Bradley Martin, *Supply Chain Uncertainty: Building Resilience in the Face of Impending Threats*, RAND Corporation, RR-A2558-1, 2024.

Availability of such an instrument does not wholly eliminate the collective challenge of meeting systemic risk. The fact of widely proliferated private agreements does not necessarily mean that the collective need is being met. However, the public availability of these kinds of contracts means that there is at least some hedge in some places against surge demand and, moreover, clearer understanding about which entities have successfully hedged against what future demands and at what level.

If, for example, most companies in a particular sector have publicly reported Til Needed contracts, that sector may be largely protected against systemic risk. Moreover, since these are offered through an exchange and require public contracts, the government might have a relatively clear idea of where risk exists and where it might already have been mitigated..

This instrument is now being offered in New York state and is administered as a matter of ordinary contract law. Companies contract with one another to pay a fee for a guaranteed supply or to provide some level of service once the conditions of the contract are triggered. There is no reason to doubt that companies would honor contracts any more than there would be doubt about fulfillment of any contract. However, if this mechanism were to be used on a widespread basis, regular stress tests and audits to ensure ability to meet demands would be essential, particularly if the contracts become commoditized and traded as mortgages and other obligations are frequently. Whenever the contract is triggered, the manufacturer must be ready to provide the material promised, and, moreover, the totality of contract demands cannot exceed the ability of the overall system to meet it.

This approach could provide a degree of individual assurance of supply resilience and, perhaps more importantly if implemented widely, a mechanism for seeing the degree to which resilience requirements would be met across sectors. This is not, however, a compulsory program. While there may be government regulation and oversight, there is no conception of it being something every business must join. Its success instead depends on potential consumers viewing it as a hedging option available at reasonable cost and the provider views it as a product it can reasonably deliver at short notice at high levels of demand. It carries the additional attraction of simplifying relationships between producers and consumers. Intermediaries are not necessary, as the producer and consumer are making deals with one another.

This approach has limitations. Because it is not compulsory, it may be difficult to bring enough companies into the program to make it economical. If only a few companies participate, they might create some certainty among themselves, but this might not amount to a significant reduction in systemic risk.

However, even with these limitations in mind, this mechanism does provide a means for different actors to insulate themselves, via contract with other private actors, from some aspects of supply chain uncertainty. Although the mechanism is not enough in itself to ensure systemic supply chain resilience, it might contribute to both specific private and more general collective resilience.

Conclusions and Recommendations

An interconnected world economy with multiple and overlapping supply chains creates complexity and vulnerability for actors within the system and across the system itself. Even in cases where private actors believe they have secure supply chains, the system itself may be vulnerable from multiple actors all attempting to access the same limited resources. Our research identified several points of vulnerability and also identified reasons why mitigating vulnerability might be difficult absent cooperation between sectors.

Known and unknown conflict sources create vulnerability

Factors from natural disasters to infrastructure failures may cause supply chain disruption. Geopolitical conflict adds the complication that actors may be actively trying to create disruption, not just react to the consequences. Our case studies indicated did show that supply chain impacts might be overcome, either by shippers accepting additional costs for different routing (the Red Sea case) or by governments agreeing to forego interference (Russia-Ukraine). However, in the case of tension with China, the potential impacts of disruption are enough to be highly destructive to both economies, the U.S. because it loses supplies and China because it loses the ability to sell in an important market.

Some examples of supply chain vulnerability from geopolitical conflict are obvious, such as in our three case studies. However, our analysis of trade data concentration and conflict areas also suggested that there are areas of vulnerability that have not yet been widely considered. For example, the potential for conflict-caused supply chain disruption in trade in nonferrous metals and electrical components is significant and underappreciated in many countries, including Brazil, Colombia, India, Indonesia, Pakistan, the Republic of the Philippines, South Africa, Thailand, and Turkey. There is, however, no warning system in place to indicate that a critical supply chain might be vulnerable.

Private and public mitigations against geopolitical vulnerability will likely be ineffective on their own

Our interviews and case studies indicated that public and private sectors recognize increasing risks and a need for improved resilience. Yet neither sector is able to adequately manage these risks alone. Systemic supply chain resilience is a collective good, meaning that it has value for a broad community but does not generate sufficient individual value for the market on its own to deliver it. Actors must work together if the good is to be delivered, but individual actors face numerous incentives to eschew cooperation.

Private insurance policies to cover physical loss and damage exist, as do some kinds of business disruption insurance. However, these do not in general cover the kinds of disruptions likely in the event of conflict, not even at the company level. These policies are not intended to be hedges against systemic risk, which is at a breadth and scale that individual insurance could not meet. These risks remain too ambiguous and potentially catastrophic to privately ensure.

Collective goods normally need some kind of government intervention to force cooperation where incentives work against it. Government strategies to manage systemic supply chain risks can, however, be costly, require significant time for implementation, and may lack consideration of unintended consequences. These measures are essential to deal with the more extreme consequences of conflict - such as provision of war insurance for merchant shipping - but the tools available to government are not well-suited to by themselves reduce supply chain risk. Government programs in particular do not have the market sensing mechanisms that would shut off unsustainable private practices. and might thus might actually encourage behavior that damages resilience.

Hedging strategies with private and public cooperation may improve individual and collective resilience

Given that neither markets nor the government can offer methods that by themselves can ensure supply chain resilience, hedges that harness private sector incentives to public goods may improve ability of consumers and producers to plan as well as give governments a clearer idea of potential hazard.

The example we provided was "Til Needed" options, which is a nascent effort originating in New York. This approach relies on reported agreements between producers to provide a contractually agreed on capacity to consumers to provide surge capacity. Reliance on government goes no further than enforcement of contracts and licensing – although government agencies could be purchasers of "Til Needed" agreements. The contribution to providing systemic supply chain resilience would be enablement of prior planning by multiple private organizations and a clear signal to government where plans and agreements exist.

Recommendations:

No perfect solution exists for insulating systemic supply chain resilience against geopolitical conflict. Mechanisms that authoritarian regimes might find appropriate would not be appropriate in the United States, and it is indeed not clear that these would be effective. There are, however, several steps that could be taken that would improve risk assessment and mitigation.

- The U.S. government, as well as private trade associations, should track and report the overlap between conflict risk and supply chain dependency. This information is essential for anticipating future developments, even if insurance mechanisms are not contemplated.
- The U.S. and state governments should assume that private insurance cannot provide meaningful improvement in systemic supply chain resilience.
- The U.S. and state governments should evaluate their supply chain resilience efforts for efficacy and resilience. We did not review every effort but the ones we considered were well-intentioned but not obviously effective. The U.S. and state governments should consider encouragement of "Til Needed" exchanges and facilitate licensing and develop oversight mechanisms.

- U.S. industries should not look to the U.S. government as the insurer of last resort and should instead look for options that strengthen their long-term resilience – such as Til Needed options. They should also be ready to disclose to the government and other companies that they possess such contracts as a means to clarify where supply chain gaps may be appearing.

Appendix A: Quantitative Methodology

We estimated import values from analysis of annual value of imports in 2023 from 238 countries, U.S. output, and domestic supply reported at the four-, five-, or six-digit North American Industry Classification System (NAICS) code by the U.S. Census Bureau from USA Trade Online as well as the Annual Manufacturers Survey. The Annual Manufacturers Survey only allowed us to consider NAICS codes that begin with 31–33, which broadly cover the manufacturing sector. To estimate the important import dependencies, we considered not only imports from all countries but also domestic production. We took this approach because there may be import concentration from a single country but enough domestic production to overcome the imports from that country should a disruption occur. That is, import dependence in sector s from country c, $Import\ Dependence_{cs}$, is defined as:

$$Import\ Dependence_{cs} = \frac{Import_{cs}}{\sum\ Import_s + Dometic\ Production_s}$$

Input-output analysis[52] traditionally considers the impact that changes in demand have on activities that provide inputs into final demand, referred to as "upstream" activities.[53] Upstream impacts would indicate that a change in demand in a particular sector would affect the various other sectors providing inputs. These effects may be estimated using the inverse Leontief matrix.[54]

A complementary approach outlined by Welburn, Strong, et.al.[55] allows consideration of downstream impacts on sectors that receive outputs from a given disrupted sector. In this method, we estimate that if there is a reduction of sector A inputs, it is distributed proportionally across all sectors based on each sector's relative input of sector A. That is, if sector B uses 10 percent of all inputs from sector A, then sector B input of sector A would be reduced by 10 percent of the reduction. Because of the nature of the input-output model, we could linearly scale the impacts of a single sector disruption to consider the range of imports from all countries as

[52] "7.2 Application to Economics: Leontief Model," webpage, undated.

[53] Sampson Quain, "The Definitions of 'Upstream' and 'Downstream' in the Production Process," Chron, undated.

[54] "Inverse Leontief matrix" shows the gross output from sectors required to meet the demand for a specified product. See: Open Risk Manual, "Leontief Inverse Matrix," webpage, October 30, 2024.

[55] Jonathan W. Welburn, Aaron Strong, Giovanni Malloy, Prateek Puri, James Syme, and Jessie Wang, *The Global Economy at the Firm-Level: Estimating Input-Output Linkages in Production Networks and the Potential for Systemic Risk*, RAND Corporation, WR-A2625-1, 2023.

well as add impacts across sectors if we considered a broad policy of eliminating trade with a particular country.

Our approach was to consider a 1 percent reduction in output of each sector and then use that output scaled by each country's imports in that sector. To make these calculations, we used the Bureau of Economic Analysis' 402 industry table from 2017, the most recently available data source at this level of disaggregation. Although the data are relatively old, as long as the production functions have not significantly changed, these data should capture the supply chain effects, even if the total output has drastically changed. That is, we were concerned only about the relative inputs rather than gross output. This approach shows how imports are used as inputs to production and how those outputs cycle through the economy rather than focusing on value added which is akin to GDP.

We estimated the potential for conflict risk using the 2023 Projected Conflict Risk indicator in the EU INFORM hazard exposure dataset).[56] This index is calculated by the European Union Joint Research Commission and provides a measure of the potential for conflict in the next four years based on 26 variables related to a country's governance type; conflict history; and recent socioeconomic, political, geographic, and security context.[57]

[56] Global Governance Forum, "Global Catastrophic Risk Index," webpage, undated.

[57] M. Marin-Ferrer, L. Vernaccini, and K. Poljansek, *INFORM Index for Risk Management: Concept and Methology Version 2017*, European Commission, 2017.

Appendix B. Summary of Interview Themes

This appendix contains a summary of the themes from two sets of interviews we conducted. The first is with companies and organizations that might require insurance and the second with insurers. We include the interview questions that motivated the discussions and a synthesis of the results.

Companies and Organizations That Might Require Insurance

We carried out several interviews that we believed would illuminate aspects of the issues associated with supply chain insurance. We divided these into two main categories: companies that might use insurance and companies that provide insurance. For the first, we asked the following questions:

- Given your organization's supply chain, what parts of the supply chain do you view as being particularly vulnerable?
- What kinds of risks are most salient? (Weather? Labor force disruption? Raw materials shortages? Conflict?)
- How do you assess the risks from these sources for your organization?
- Our analysis shows that certain supply chains possibly relevant to your business are highly concentrated in some geographic areas known to also be significant areas of geopolitical conflict. How does this analysis compare to what you've assessed?
- What actions could be taken to mitigate the potential risk?
- What actions would also require action by partners or governments to increase effectiveness of your own risk mitigation efforts?
- How do you ensure against disruptions of these types? What kinds of events does it cover and exclude?

We identified common themes from responses to these questions across interviews. We emphasize that these are matters of expert opinion, not necessarily fully substantiated findings. The interviewees we spoke with were from the manufacturing sector, the semiconductor production and packaging sector, and the maritime transportation sector. Many of these questions ran together, and the main themes consolidate several of these questions.

Company Supply Chains are Highly Vulnerable to Disruptions from Conflict

Clearly companies working directly in semiconductor manufacturing viewed disruptions of the businesses themselves as a significant hazard, but they are equally worried about disruptions to precursor chemicals.[58] Manufacturers are concerned with disruption of semiconductors, both

[58] Date of interview, 8 October 2024 - AMKOR

legacy and advanced, as well as shortfalls in critical minerals.[59] There are many different sources of potential disruptions to supply chains, to include natural disasters, tariffs, factory closures due to fires or other accidents, critical mineral shortages, work stoppages, and labor shortages.[60]

Some of these are episodic and are eventually resolved by market forces. When there is damage to property, normal forms of property insurance help in recovery. However, there are systemic challenges that largely center on conflict. Conflicts, geopolitical or civil, can continue for an extended period and could include a determined effort by actors to disrupt and sustain the disruption. Shipping industry representatives emphasized the costs and difficulty of ensuring some routes and even some cargoes, which in turn results in supply chain delays and sometimes more significant disruptions.[61] They cited the ongoing challenges in the Red Sea and noted that the costs of simply ensuring for physical loss, let alone for supply chain disruption, are major impediments to some carriers.

The examples most frequently cited centered around the potential for conflict between the United States and China over Taiwan, partly because of the many areas where China influences the supply chain and because of the potential impact on production and packaging of high-performance logic chips in Taiwan. Companies are not even attempting to ensure against the large-scale impact that such a conflict would likely entail. The business-interruption potential was so large that ensuring against it would be prohibitive.

Most Companies Have No Specific Plans for Mitigating Risks from Conflict

Companies are generally aware of challenges that might come from conflict, but to a degree view themselves as powerless to directly protect themselves. Nearly all property insurance involves a war exclusion clause[62] and companies noted that the exact courses of conflict are difficult enough to predict that hedging may be impossible. This is particularly true when we are dealing with conflicts involving countries contain major elements of the supply chain, which is true of China but is even true to some extent of Russia and Iran.

Interviewees noted that, for their manufacturing business, that 30 percent of their business is with China, but that the understanding of the specific markets in China was at best incomplete.[63] Hedging is thus difficult because it is unclear what is to be hedged against. Measures such as business disruption insurance are thus held to be largely futile. Systemic effects from conflict are likely to be so broad, with largely unknown consequences, that companies cannot realistically anticipate the size and nature of the impacts.

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[59] Date of interview, 12 April 2024 – National Association of Manufacturers

[60] Date of Interview: 12 April 2024 – 1100 Summary General Motors

[61] Date of Interview, 29 October 2024 – Maritime Security Conference

[62] Julia Kagan, "What is a War Exclusion Clause in an Insurance Contract?" Investopedia, August 16, 2023.

[63] Date of Interview: 12 April 2024 – 1100 Summary General Motors

Some Governments, Notably China, Do Underwrite Risks, Particularly Those Associated with Shipping

One interviewee reported that Chinese authorities incentivize shipowners to take risks by promising expedited loading, guaranteed future cargo, and faster turnaround on ship repairs and new construction. This agility enables them to minimize the impact of disruptions while increasing their influence. "For instance, a shipowner may not be able to afford insurance to transit the Red Sea. However, backdoor promises to recover the costs of a sunken ship through future cargo contracts and expedited operations could enable the owners to recoup their financial losses over time." [64] Such arrangements are matters of routine in response to increased risk in areas where the government of China perceives supply chain exposure to be significant.

Most Companies Have Relatively Few Options for Mitigating Against Systemic Level Supply Chain Disruption

Companies are aware of significant risk to their supply chains from any number of factors but do not always know the depth and extent of this exposure. One interviewee noted that the COVID crisis demonstrated that supply chains are complicated and opaque but also noted that companies had little ability to move past their immediate suppliers as far as establishing visibility.[65]

Calling the attitude "fatalistic" might insinuate helplessness when in fact potential purchasers of insurance might be making a rational assessment of relative vulnerability and determining that systems level disruptions are beyond their ability to individually hedge against. and might in fact be counting on governments being unwilling to let the system collapse in the face of a systemic threat.

Company and Organizational Perspectives From Insurers

However, there may be insurance or other hedging mechanisms that simply have not been developed to the point of commercial viability. We interviewed insurance company representatives in an effort to determine whether and how actions might be taken to improve hedging options for companies, including supply chain insurance. We asked the following questions:

- How prevalent is insurance for disruptions in supply chains?
- What limits are typically included on the policies? Which events are excluded?
- Are policies specifically for supply chain disruption or is disruption one of the effects that might be covered in some larger policy?
- How does conflict risk enter coverage decisions or rate calculation?

[64] Date of Interview, 29 October 2024 – Maritime Security Conference

[65] Date of Interview: 12 April 2024 – 1100 Summary General Motors

- How would specific sector risks enter coverage? How would an insurer know the criticality of some part of the supply chain?
- Our analysis shows that supply chains are highly concentrated in some areas known to also be significant areas of geopolitical conflict. How does this analysis compare to what you've assessed? How do you manage this exposure across your policies?
- How does overall systemic risk factor into overall risk determination?

Many of these questions significantly overlap with those asked of companies requiring insurance. However, the perspective is different. The insurance business model is to offer coverage against risks at a price that the insured company is willing to accept. Interviewees stated that they wanted to "commercialize good ideas with innovative coverage" that effectively matches coverage with risk. But the business case for broadly contingent insurance, which might be implied for supply chains, is difficult from both the insured and insurer perspective.[66]

Insurance Coverage is Oriented Toward Specific Things of Specific Value

Insurers, like businesses, are acutely aware that systemic risks can hurt large numbers of businesses. However, the process of estimating risk and arriving at premiums requires some relationship to a specific cost. Basic property insurance could cover supply chain disruption but only for a covered loss, which is generally associated with a specific location.[67] Supply chain insurance could also be a "manuscripted product" for business interruption, which allows a payment for lost business due to damage to a specific property or even for an adjacent enterprise.[68]

But, these policies, including business interruption, are triggered by physical damage and not general disruption. Some interviewees could be interested in providing contingent coverage for disruptions beyond physical damage to plant and immediate suppliers. These could be enabled by better understanding of supply chains beyond immediate suppliers, but, absent this, very general coverage would be expensive and unlikely to fit the needs of potential customers.[69]

Insurance for Political Events and Even for Civil Conflict Does Exist, but Insurance for War between Nation-states is a Different Category

Companies and insurers are aware of political instability and the potential impact this can have on, among other things, supply chain security. Business disruption insurance in the case of political upheaval is a niche offering, highly dependent on geography and circumstance. The U.S. International Development Corporation, a government-backed agency, does provide

[66] Interview, 14 March 2024, Marsh

[67] Interview, 2 April 2024, APCIA

[68] Interview, 2 April 2024, APCIA

[69] Interview, 11 April 2024, Waters

insurance against political risk in developing countries.[70] Even with this kind of event, what is insured is generally physical loss rather than loss of business opportunity.

When we consider conflicts among nation-states, the calculation changes, and effectively every policy includes a war exclusion clause. There can be a difficult to define line between war and other kinds of conflict, which can complicate efforts to insure disruptions. Sanctions might be insurable under political coverage, as might even some kinds of belligerent action, such as delays due to a visit, board, search, and seizure operation, which could result in a vessel being detained. There are even companies that will insure against unspecified risk. But, no commercial insurance covers losses from the occurrence of a general level of conflict.

Sectors Vary Considerably in the Potential Value and Applicability of Supply Chain Insurance

Some sectors, such as pharmaceuticals, count on an inherent high level of diversification, which it believes reduces the potential impact of disruption.[71] Companies in these sectors outsource, distribute risk, take advantage of property risk insurance, and can effectively stockpile some material. In other sectors, when company supply chains are relatively well understood, contingency insurance may make considerable sense, since the insured company can reasonably specify the likely sources of risk and the magnitude of loss. This might apply in the energy sector.

However, most businesses do not have such a level of understanding, and, as a result, are reluctant to insure against risks they cannot reasonably specify.[72] Insurers are applying different kinds of analytics to identify points of risk, but insurers noted that the impact of concentration is poorly understood in many sectors. A company might think it has a secure supply chain but in doing so, it is relying on the same sources as other companies that think they are secure against disruption. Interviewees indicated that the kinds of concentration analysis we described earlier might prove useful. Many sectors simply do not understand the degree and implications of concentration.

Vulnerability to China and to Disruptions to Trade with Taiwan Is a Particular Concern

Insurers noted that China is the center of many supply chains and that effectively every supply chain passes at some point through China. Accordingly, the potential impacts of conflict with China are potentially severe. The actions China might take would not necessarily breach the level of wartime exclusion, and actions below that level of conflict might potentially be covered by business interruption insurance.

However, the sheer size of the potential exposure will likely make insurance a highly difficult option. Similar concerns obtain when considering insurance against disruption of high-

[70] Interview, 02 April 2024, APCIA

[71] Interview, 11 April 2024, Waters

[72] Interview, 11 April 2024, Waters

end semiconductor chips coming from Taiwan, which would likely occur if China began imposing coercive measures to end Taiwan's autonomy. The impact of such disruption is undeniable, but the ability to insure against the systemic impact is highly questionable.

Supply Chain Analysis Would Likely Enhance Coverage for Contingent Events

To a degree, the failure to consider contingent events reflects a combination of short-term thinking and simple lack of visibility into points of vulnerability. Some interviewees discussed vulnerability mapping tools to "support the global ecosystem of supply chains".[73] However, there does not appear to be any kind of large-scale modeling effort. The business case for such an effort is not yet clear.

Steps that would be required to construct an effective tool would start with collection and validation of data for suppliers below the immediate level of the insured companies. This would involve identifying suppliers then suppliers of suppliers and analyzing in each case the degree of dependency. For some sectors, this can be established using manufacturing data. For others, it may require different ways of measuring concentration. In cases where data would have to be collected, businesses would need incentives to share their own and pay for the collection of other information.[74]

That would be followed by sector analysis, using microeconomic tools to identify concentrations and vulnerabilities. This could then be used for individual businesses to seek insurance for specific vulnerabilities at different places in the supply chain. Insurers indicated a willingness to consider this kind of policy, which goes beyond immediate suppliers but is still based on a tangible value.[75]

[73] Interview, 14 March 2024, Marsh

[74] Interview, 12 April 2024, Millette

[75] Interview, 14 March 2024, Marsh

Abbreviations

COVID-19	Coronavirus SARS-CoV-2
DFC	Development Finance Corporation
DPA	Defense Production Act
NAICS	North American Industry Classification System

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