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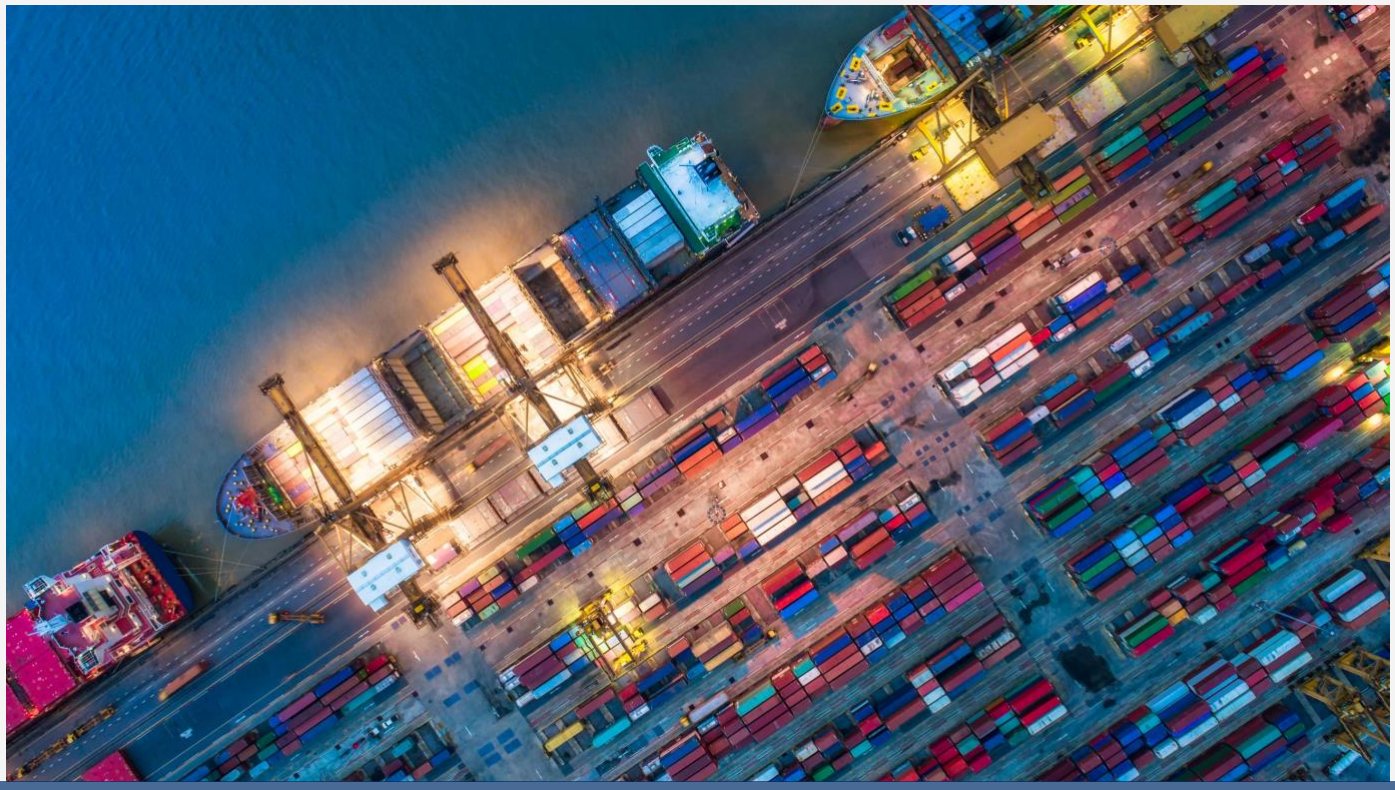

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Second Order Impacts of Aggression Toward Taiwan by the People's Republic of China

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Executive Summary

With tensions in the Taiwan Strait on the rise, the goal of this report is to identify how an increase in hostilities towards Taiwan by the People's Republic of China (PRC) could impact global economies and industries. The threat has grown in recent years, as the PRC asserts with increasing provocations its long-held claim that Taiwan is part of mainland China, while the Taiwan government seeks to maintain its de facto independence. The importance of understanding the risk profile of aggression directed by the PRC to Taiwan is underscored by the impact on world economies of Russia's 2022 invasion of Ukraine. Unprepared at the time of the initial attack for the extent of Russian aggression, global policymakers were forced to scramble to prevent widespread damage to food systems. Against a backdrop of growing PRC hostilities in the Taiwan Strait, the research that makes up the body of this report is designed to provide a foundation for ensuring greater preparedness in the event of further PRC aggression.

Section 1 of the report introduces our core analysis of how tensions might play out. In Section 2 we identify potential tools of economic coercion available to the PRC. We find that quarantine and blockade are the tools of economic coercion the PRC is most likely to use against Taiwan. The section includes an examination of possible responses by the United States and its allies, including financial sanctions on individuals, financial sanctions on state-owned enterprises, and import restrictions on dual-use goods.

Section 3 of the report contains an analysis of six potential scenarios. These include the following:

1. Blockade with minimal response.
2. Quarantine of Taiwan or takeover of surrounding islands with United States bilateral economic response.
3. Blockade with United States bilateral economic response.
4. Quarantine of Taiwan or takeover of surrounding islands with multilateral economic response.
5. Blockade with multilateral economic response.
6. Regional war

These scenarios are the basis for modeling downstream consequences of escalation in the Taiwan Strait that form the basis of Section 4, which explores the relationship between each scenario and GDP outcome indicators.

It is the finding of this report that, given the interconnectedness of the global economy, downstream economic fallout of significantly increased PRC aggression toward Taiwan could exceed that of both the 2009 global financial crisis and the 2020 COVID-19 pandemic. This mirrors a 2024 analysis by Bloomberg Economics and the International Monetary Fund, which found that a PRC war with Taiwan would have a larger negative impact on global GDP than both the 2009 global financial crisis and the 2020 COVID-19 pandemic, with especially large shocks felt in Korea, Southeast Asia, Japan, Mexico, and the United States.

Also in Section 4, the report examines the effects of increased PRC aggression towards Taiwan on individual regions. The analysis finds that:

- **In Africa:** least developed countries would be severely affected in the medium-to-long run. GDP would decline the most in the Southern Africa countries of Equatorial Guinea, Gabon, South Africa, the Central African Republic, Namibia, Zambia, Botswana, Congo, Angola, Mozambique, and Malawi with GDP decline by between 1 and 6 percent. In the Western Africa countries of Senegal, Burkina Faso, Mali, Mauritania, the Ivory Coast, Sierra Leone, Cameroon, Liberia, Togo, and Ghana GDP would decline by 1 to 2.5 percent.

- **In Eurasia:** Moldova, North Macedonia, Albania, and Belarus are likely to experience acute impacts given their ties to the PRC and to the informal grouping of the world's most advanced economies known as the G7. GDP declines in the region are projected by the findings of this report to range between 4.5 and 9 percent in the case of a blockade in the Taiwan Strait by PRC forces.

- **In Asia:** GDP in Cambodia, Thailand, Burma, the Philippines, Laos, Indonesia, Mongolia, Vietnam, Kazakhstan, Turkmenistan, Iran, India, and Russia would all be expected to decline by 1 to 3.5 percent. Downstream impacts are expected to be more persistent for economies in Central Asia, especially Mongolia, Uzbekistan, Kazakhstan, and Tajikistan.

- **In Latin America:** Chile would be most affected, with an expected decline in GDP of 1.7 percent. Overall, countries in Central and South America are expected to experience less severe downturns than those in other regions.

In terms of humanitarian and developmental challenges, many of the 17 Sustainable Development Goals (SDGs) adopted by all members of the United Nations in 2015 would experience setbacks due to the conflict. The most significant direct effects would likely be on SDG1 (no poverty) and SDG8 (decent work and economic growth). Other SDGs that would face headwinds include SDG2 (zero hunger), SDG2 (good health and wellbeing), and SDG4 (quality education).

Section 5 of the report employs network analysis to assess how various conflict scenarios might shock selected supply chains. The potential effects are dramatic. For supplies of critical minerals in particular the following countries lack an alternative supplier or market other than the PRC or Taiwan and would be expected to face economic downturns:

Cobalt: Cameroon, Mauritius, Pakistan, and Vietnam.
Lithium: Niger and Rwanda.
Nickel: Papua New Guinea and Somalia.
Rare Earth Elements: the Ivory Coast, Colombia, and Paraguay.

In addition, the analysis undergirding this report finds that a quarantine or blockade of Taiwan by the PRC is likely to create economic turmoil in commodity-based developing countries such as the Democratic Republic of Congo, Chile, Nicaragua, and Zimbabwe.

Because Taiwan is a major exporter of advanced semiconductors, the entire global IT trade network and dependent industries, including those of electronics and automobiles, would feel reverberations if Taiwan were to be quarantined or blockaded. Trade in downstream products including computers and cell phones would experience prominent disruptions. Economies that rely on the import and export of semiconductors or depend on semiconductors and processed critical minerals would also experience significant challenges. This list includes Malaysia, the Philippines, and Vietnam. Definitions of key terms are provided in Section 5.1.

Sanctions regimes face challenges, as evidenced by the Western response to Russia's invasion of Ukraine. Economic sanctions are less likely to be successful when they 1) target authoritarian countries, 2) are ambitious, and 3) are implemented on rivals. Section 6 of the report offers potential strategies for stakeholders to consider as they move forward.

Table of Contents

List of Figures

List of Tables

1. Introduction: What is the context of tensions in the Taiwan Strait?

Key Points

- Lessons drawn from prior instances of crisis in the Taiwan Strait have limited application to the current tensions.
- PRC capabilities and importance to the global economy are much greater now than in previous crises, and the current PRC leadership has prioritized "reunification" with Taiwan as a key objective.
- Interests of the United States remain focused on "dual deterrence" of both aggression by the PRC and provocation by Taiwan.

Tensions over Taiwan are perhaps the highest since the 1950s. PRC president Xi Jinping has suggested that reunification between the PRC and Taiwan is a "historical inevitability." Taiwan recently elected William Lai, who favors Taiwan's pursuit of independence. Meanwhile, rhetoric from United States President Joe Biden has been less equivocal in threatening a United States response to PRC aggression against Taiwan than the United States's longstanding posture of "strategic ambiguity."

Against this backdrop, the PRC and the United States appear to be preparing for potential active conflict in the Taiwan Strait, the arm of the South China Sea lying between the Chinese mainland and the island nation of Taiwan. The PRC has invested heavily in military capabilities for use against Taiwan and has stepped up naval and air operations that simulate efforts to reunify Taiwan with the PRC by threat or use of force. PRC-based entities have also been associated with an increased number of cyber-attacks against Taiwan, as well as against the United States and regional partners.

The PRC has taken steps toward economic and energy independence, reducing its vulnerability to sanctions that could be imposed by the United States and other supporters of the status quo. In recent years the PRC has also tightened security partnerships with Russia and Iran and economic partnerships via its Belt and Road Initiative (BRI) and Global Development Initiative, and the expansion of the Brazil-Russia-India-PRC-South Africa (BRICS) group. In part due to its growing economic influence in the Asia-Pacific region, the PRC has convinced Nauru, Kiribati, and the Solomon Islands to replace official recognition of Taiwan with recognition of the PRC.

In response to the rising threats, the United States has stepped up overt support for Taiwan. Actions it has taken in recent years have included a 2022 visit to Taiwan by then-Speaker of the United States House of Representatives Nancy Pelosi and by other congressional delegations including a May 2024 delegation led by Rep. Michael McCaul, chair of the House Foreign Affairs Committee. The United States has also firmed up its partnerships in the Asia-Pacific region by investing in greater economic and security coordination with its partners in the Quadrilateral Security Dialogue, India, Australia, and Japan. These investments have included the deployment of advanced missile defense capabilities in South Korea, a commitment to delivering advanced attack submarines to Australia, and the initiation of trilateral dialogue on the issue with Japan and South Korea. The United States has also increased military assistance to Taiwan and other allies in the region, including $8.1 billion in military aid as part of a package passed by the United States Senate in April 2024.

1.1. What lessons can we learn from previous crises?

There are precedents to the current tensions.[1] One throughline over the last 70 years is the importance of United States positions and actions in contributing to de-escalation. Successes and failures by the United States in signaling its commitment to defend Taiwan and the outlying islands throughout the Taiwan Strait—potentially with the use of nuclear force—have been essential to the management and mismanagement of tensions.[i]

At the same time, United States insistence that its support for Taiwan is purely defensive has been important to reduce provocations and potentially diminish first Soviet and then Russian support for the PRC's actions.[ii] A 1962 crisis over plans by then Taiwan President Chiang Kai-shek to invade the mainland, for example, generated friction between Taiwan and the United States.[iii] The term "dual deterrence" has been coined to characterize the United States goal of both deterring PRC action against Taiwan and deterring Taiwanese provocations.[iv]

The current situation, however, differs from previous crises. That difference is due primarily to shifts in military power and to economic interdependence. In previous crises, there was a credible threat that Taiwanese offensive action could threaten PRC positions on the mainland. Moreover, the PRC was dependent on support by the Soviet Union and had relatively little economic recourse during the crises that emerged during the Cold War. As PRC military capabilities have grown rapidly in the past 20 years, the PRC has grown to represent a much more direct threat to Taiwan, even with American military support to the government in Taipei.[v]

1.2. What are the PRC's objectives?

The PRC position on Taiwan is motivated by three primary factors:[vi]

1. **Political legitimacy:** Taiwan's status is an integral part of the PRC's historical narrative, and maintaining territorial integrity and restoring Taiwan to the motherland has become central to the legitimacy of the Chinese Communist Party (CCP).[vii] President Jinping, in particular, has bound his legacy to Taiwan's reunification.[viii]
2. **Economic security:** The economic security of the PRC is tied to control of the seas. About 60 percent of PRC trade is dependent on maritime routes.[ix] Access to these routes is critical for the PRC to ensure itself a consistent supply of food, energy, and raw materials.[x]
3. **Geostrategic and military advancement:** A successful reunification would also offer geostrategic advantages to the PRC in the maritime domain. Absorption of Taiwan, located at the center of the First Island Chain, into the PRC would allow the PRC to control the heavily trafficked Taiwan Strait and position military hardware—including underwater surveillance devices—at the

[1] The International Crisis Behavior dataset identified four previous crises in the Taiwan Strait: 1) A 1954-1955 crisis that involved PRC bombardment of the Quemoy (Kinmen), Matsu and Dachen islands, with the PRC gaining control of the latter after the United States pressured Taiwan to evacuate them (Brands, Jr. 1988; Brecher 2018; Sechser and Fuhrmann 2017); 2) A 1958 crisis that also involved PRC bombardment of Quemoy and Matsu (Brecher 2018; Sechser and Fuhrmann 2017); 3) A 1962 crisis surrounding plans by Taiwan's President Chiang Kai-shek to invade the mainland (Brecher 2018); and 4) A 1995-1996 crisis surrounding the visit of Taiwan's President Lee Teng-hui to the United States and Taiwan's democratization (Brecher 2018; Gunness and Saunders 2022; Qimao 1996; Scobell 2000; Sechser and Fuhrmann 2017).

chokepoint. The benefits for the PRC would be two-fold: 1) providing it the opportunity to restrict fuel and energy in the event of conflict in Northeast Asia; and 2) impeding United States naval and air operations in the region and hampering its abilities to defend its allies by isolating Japan and South Korea to the north and the Philippines to the south.[xi]

1.3. What are Taiwan's objectives?

Taiwan's leadership strives foremost to preserve democratic self-governance and to continue development of its advanced industrial economy. In the short to medium term, the Taiwanese public prefers the status quo of de facto independence over the pursuit of de jure independence, given that the latter would be expected to provoke hostility from the PRC.

In the long run, Taiwan is more favorably disposed to a declared independence, which has created incentives for political candidates to flirt with pro-independence platforms, as seen in the recent election of William Lai. Taiwan also seeks to maintain a close security partnership with the United States, its most important potential defender in the event of a military escalation with the PRC.

1.4. What are the objectives of the United States and its partners?

The primary goal of the United States and its allies is to preserve the status quo and prevent an outbreak of cross-strait conflict, both military and economic.[xii] The need to prevent disruptions to global trading routes and to ensure freedom of navigation in the waters off East Asia is another significant consideration for the United States. Thus, the United States and its allies are invested in deterring both PRC aggression and Taiwanese provocations.

Taiwan is of great geostrategic importance to the United States and its regional security partners. It is difficult for the PRC to project its military powers with the first island chain out of its control. Should the PRC successfully absorb Taiwan, it would have the ability to extend the range of its aircrafts and missiles to the east, increasing its capacity to strike Japan or Guam.[xiii] This would heighten threats to United States forces stationed in the Indo-Pacific. The PRC would be able to base surveillance assets in the waters off Taiwan, allowing its forces to more precisely detect and strike United States surface ships.[xiv] Conflict over Taiwan could also impair global perceptions of United States resolve and commitment to democracies. Washington could lose its geopolitical edge as the PRC becomes the dominant regional power in the Asia-Pacific region.

Even without a military takeover, PRC action against Taiwan could have devastating global economic effects. Taiwan is the world's leading manufacturer of semiconductors, technology essential to the global economy. A military invasion of Taiwan—or even a quarantine or blockade—would have potentially severe implications for the United States and other major economies that depend on semiconductors for end-use information and communication technology, as well for economies that produce the critical minerals used in semiconductor manufacturing.[xv] The economic effects would compound rapidly if the United States and partners respond with punitive sanctions against the PRC, especially given the PRC's dominance in the trade of critical minerals and information and communication technology products.

Such events would also affect maritime passage in the region. As 60 percent of global maritime trade passes through the South China Sea, incursions against Taiwan could increase shipping risks and costs.[xvi] Insurance rates for ships passing through or into high-risk areas could be as high as 10 percent of the

value of the ship, while daily loss for rerouting maritime routes could be as high as two percent of the value of goods.[xvii]

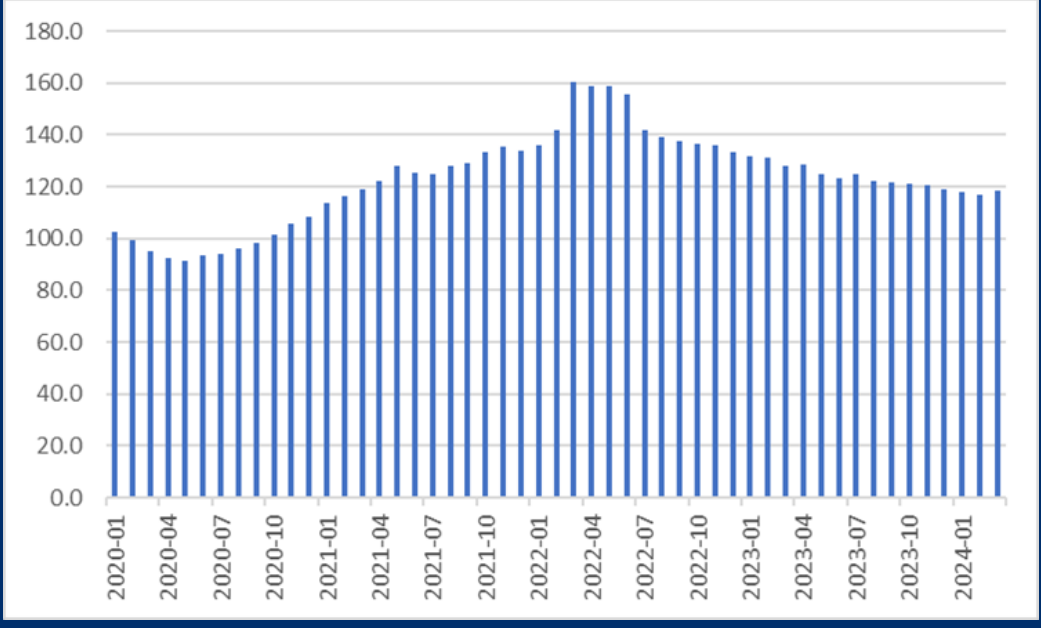
Russian invasion of Ukraine led to surge in global food prices

There is a recent analogue to the potential economic implications of an escalation in tensions in the Taiwan Strait. Russia's invasion of Ukraine in February 2022 led to a sudden spike in global food prices (Figure 1 below). Both countries are major producers and exporters of staple crops (wheat and other grains) and agricultural inputs (fertilizers) for Sub-Saharan Africa, Latin America, and other world markets. The shock prompted widespread concern of potential global famine, and the United Nations Secretary General António Guterres predicted a "hurricane" of hunger.[xviii]

More than two years after the invasion, it is possible to draw some lessons. The feared global food shortage did not unfold in 2022 as a result of the Russian invasion. What shortfalls did occur were the result of a range of factors that included speculation in key markets and embedded features of the global food system that have long left vulnerable countries dependent on imports.[xix]

Crucially for this project, disruptions to regional supply chains resulting from the Russian invasion meant that countries dependent on Black Sea production had to quickly shift sourcing patterns, often from countries that were geographically distant such as Australia and the United States. While prices have stabilized in the long run, the international community was forced to make concerted efforts to mitigate some of the most dire predicted outcomes. In the event of a Taiwan contingency, the international community would again have to coordinate to address potential shocks to global supply chains.

Figure 1. Food and Agriculture Organization Monthly Food Price Index 2020-2024



2. How might tensions in the Taiwan Strait play out?

Key Points

- All actors would bear great costs if tensions escalate to military force.
- Economic coercion–via a PRC "quarantine" or a "blockade" are more likely actions the PRC might take against Taiwan.
- Russia's ability to withstand sanctions imposed after its 2022 invasion of Ukraine illustrate some challenges that may limit the ability of the United States and its partners to implement economic coercion against the PRC in response to escalation in the Taiwan Strait.

Anticipating the sequence and severity of escalatory steps, we focus on two forms of economic coercion the PRC might take—quarantine or blockade—as well as the potential use of military force. We also consider the array of economic and military responses that the United States and its partners might implement in response to PRC aggression.

2.1. What tools of economic coercion are available to the PRC?

Economic coercion varies in scope and can focus on trade restrictions—quarantines, blockades, boycotts, and discriminatory tariffs—or capital restrictions—asset freezes and aid suspension. Less severe tools of economic coercion, including tariffs, targeted sanctions on Taiwanese political leaders, capital restrictions, and boycotts, have all or are currently being used against Taiwan by the PRC— they are characteristics of the status quo. Table 1 provides a summary of these tools and their implications.

Table 1. Tools of Economic Coercion

Scope	Tool	Likelihood	Escalatory Risk	Taiwan's Vulnerability
Trade	Boycotts	Status Quo	Low	Low
	Discriminatory Tariffs	Status Quo	Low	Low
	Quarantine	Medium-High	Medium	High
	Blockade	Medium	High	High
Capital	Asset Freezes	Status Quo	Low	Low
	Aid Suspension	Status Quo	Medium	Medium

This report limits its focus to the two most severe coercive tools that the PRC might employ: economic quarantine and economic blockade. Taiwan's reliance on international trade for necessities makes it vulnerable to these tactics. As much as 98 percent of energy used in Taiwan is imported and estimates suggest that Taiwan's food stock would last six months if not replenished.[xx] Further, Taiwan's economy is export-driven; Taiwan's exports totaled close to $480 billion in 2022, accounting for almost 60 percent of GDP that year.

An economic quarantine or blockade of Taiwan by the PRC would leverage these vulnerabilities. A quarantine or blockade of Taiwan is deemed more likely than outright military conflict for two reasons:

(1) the PRC's current military capacities; and (2) the potential consequences of an invasion of the island.[xxi] While these two tools are the most escalatory instruments of economic coercion, they differ in scope and risk for outbreak of military conflict. Table 2 below provides a summary of key features of a quarantine versus a blockade.[2]

Table 2. Economic Quarantine vs. Blockade

Tool	Goal	Primary Means of Enforcement	Scale	Historical Examples
Quarantine	Demonstrating control, coercion	Military, commercial, paramilitary	Small-Medium (partial)	Operation Sharp Guard (NATO action against Yugoslavia and Serbia)
Blockade	Capitulation	Military	Large	British naval blockade of Germany during WWI

2.1.1. Economic Quarantine

An economic quarantine is less escalatory than a blockade and is therefore the lower risk approach of the two.[3] It could be achieved via both air and maritime patrols.[xxii] Through inspecting ships and diverting some to Chinese ports, the PRC could prevent some goods from reaching Taiwan and greatly increase the cost of trade for Taiwan and its economic partners.

Economic quarantine is primarily perceived as a coercive tool, aimed not at cutting off Taiwan's food and other supplies completely but instead demonstrating PRC sovereignty. Beijing might also utilize its paramilitary forces, including government-sponsored fishing vessels, to carry out maritime control activities.[xxiii]

2.1.2. Economic Blockade

Blockades also disrupt trade, but the overarching goal is to curtail the flow of goods to and from Taiwan. It is larger in scale than a quarantine, with the higher risk of spilling over into military conflict and may be implemented in preparation for invasion.[xxiv] The larger strategic intent is to exert the maximum pressure on Taiwan and undermine Taipei's will and warfighting capabilities without an outright military assault.[xxv]

Blockades would impact almost all imports into and exports out of Taiwan. Assets such as ships, submarines, aircraft, and missiles would be used to control maritime and air domains. There are at least three possible blockade scenarios:

- **Kinetic:** The PRC would actively sink or disable ships in Taiwanese waters.
- **Non-kinetic:** Beijing would use its military and paramilitary forces to block ships from reaching Taiwan. This type of blockade is most likely to occur.

[2] As detailed later, we model the impact of a blockade as a 10 percent decline in Taiwan's economic production, and a quarantine as a 2.5 percent decline in Taiwan' economic production.

[3] The severity of a quarantine could vary widely to the point of being on par with a blockade. For the purposes of modeling distinct scenarios, the analyses focus on quarantines that are at the low end of the severity spectrum. Such quarantines that we consider are those that merely make trade with Taiwan more expensive, not prohibitive.

- **Sporadic and tailored blockade:** A combination of kinetic and non-kinetic blockades, whereby the PRC could utilize uncertainty over a longer period to erode the will of Taiwan and its allies to resist.[xxvi]

A declared blockade is considered an act of war under international law. It is possible that the PRC, seeking to reduce escalation or the likelihood of response from the United States and its allies, would prefer a non-kinetic, undeclared blockade. Regardless of which scenario comes to pass, a PRC blockade of Taiwan has a high potential for escalation into military conflict.[xxvii]

2.2. What are possible responses by the United States and its allies?

The United States and its allies may engage in a range of economic responses to PRC action. These include targeted sanctions against PRC political and military leaders through asset freezes or travel bans to counter blockades.[xxviii] Within this range are sectoral sanctions, which target specific PRC industries and import and export controls.[xxix] The United States could expand its current restrictions on PRC access to advanced technology or dual-use products. It could also implement financial sanctions by blocking PRC-backed banks or removing PRC institutions from the Society for Worldwide International Financial Telecommunication (SWIFT) secure financial messaging system, as do the current sanctions on Russia. Table 3 summarizes potential non-military responses available to the United States and its allies.

The three tools with the highest likelihood of being used—financial sanctions on individuals, financial sanctions on state-owned enterprises, and import restrictions on dual-use goods—may be imposed regardless of the severity of PRC actions, especially as currently used by the United States. The scope and severity of the instruments used will vary based on different factors, including PRC actions, cooperation of allies, and the broader economic environment. The potential costs are dependent on the PRC's ability to circumvent sanctions, the size of the sanctioning coalition, and the ability of the United States and its allies to enforce economic sanctions. Further, the United States could carry out these sanctions unilaterally or, more likely, in conjunction with its allies. Multilateral sanctions impose more severe costs than unilateral action.

Table 3. Possible United States Responses to PRC Action

Scope	Target	Likelihood	Cost for PRC	Escalatory Risk	Examples
Financial	Individuals	High	Low	Low	Sanctions against Russian oligarchs for Russia's invasion of Ukraine
	Non-financial state-owned enterprises	High	Medium-High	Medium	Sanctions against PRC military-industrial complex (including Semiconductor Manufacturing International Corporation, China National Offshore Oil Corporation, China Telecom)
	Financial state-owned enterprises/Financial institutions	Medium-Low	High	Medium-Low	SWIFT ban against Russian banks
Export Restrictions	Commodity	Medium-High	Medium-High	Medium-Low	Luxury goods ban on Russian exports
	Industry/ Sectoral	Medium	Medium-High	Medium-High	Oil sanctions on Venezuela

Import Restrictions*	Commodity/ Dual-Use products	High	Medium-Low	Medium	Semiconductor sanctions against the PRC
Embargo	Entire country	Low	High	Extremely High	Cuban embargo

* = Import restrictions most likely to be used for dual-use products in a conflict scenario. The United States and its allies have more leverage over the supply chains of dual-use goods, especially semiconductors. Denying the PRC access to these products would have more direct impact on PRC's ability to engage in conflict. However, import restrictions may also be used for other commodities, including knowledge through limits on research cooperation.

2.3. What is the military balance?

In the past two decades, PRC military capabilities to initiate conflict in the Taiwan Strait have narrowed the gap with United States capacity and greatly exceed Taiwan's sole capabilities.[xxx] While the United States has both conventional and nuclear capabilities—in additional to warfighting experience—that give it advantages over the PRC in the event of a war over Taiwan,[xxxi] PRC capabilities are sufficiently advanced that the United States might hesitate to escalate to war in defense of Taiwan, especially if the PRC initiates a non-kinetic blockade or a quarantine as its mean to capture Taiwan.[xxxii]

Controlling airspace over Taiwan is particularly challenging, given PRC capabilities and the sheer amount of material that would need to be delivered to sustain Taiwan.[xxxiii] Taiwan is currently investing in anti-air and anti-ship capabilities that are less vulnerable to PRC counterforce attacks,[4] and Japan and South Korea are developing their own capabilities and could intervene in the event of a PRC attack.[xxxiv] The United States has placed a heavy emphasis on enhancing its own capabilities, as well as those of Taiwan and regional security partners.[xxxv]

[4] Taiwan's so-called "porcupine strategy" includes less emphasis on purchases of expensive advanced fighter aircraft and submarines and more emphasis on cheaper munitions and asymmetric capabilities.

What are the lessons from the recent sanctions imposed on Russian oil exports?

Russia's ability to blunt United States-led sanctions imposed on oil exports after its invasion of Ukraine provides important context for consideration of the potential economic ramifications of quarantines or blockades in the Taiwan Strait. Several factors worked in Russia's favor.

First, Russia had conducted sanction-proofing since its 2014 annexation of Crimea, anticipating future actions. This included stockpiling foreign currency reserves, de-dollarization, and some degrees of import substitution and shifting of trade away from the West.

Second, Russia is a major exporter of critical exports, including gas, oil, and minerals. This limited the United States' options for imposing sanctions—more severe restrictions could shock the global energy market and hurt consumers in the United States and partner countries, especially combined with ongoing sanctions on major oil producers such as Iran and Venezuela.[5]

Finally, Russia has been adept at circumventing sanctions using "shadow fleets"—ships that do not meet the maritime industry's standards—and ship-to-ship transfers to transport banned commodities. India and the PRC have also seized the opportunity to purchase more Russian oil. India alone bought $37 billion of crude oil from Russia in 2023, 13 times more than in 2021. Outside of the energy sector, Russia has also evaded restrictions on imports of dual-use goods through parallel trade via friendly third-party countries like Kazakhstan.

Policymakers can draw the following lessons from the experience:

- **Sanctions that harm United States or European Union consumers are difficult to implement.** The Russian sanctions have demonstrated that stringent sanctions face headwinds. The PRC is a crucial player in the critical minerals supply chain, exporting rare earth elements (REE), lithium, and other sought-after commodities. The Russian experience suggests the downstream effect on technology and manufacturing sectors may result in delayed implementation of sanctions that would cut off access to PRC commodities.

- **Countries do not bear the cost of sanctions equally.** European nations are more dependent on Russian energy than the United States. Although the European Union has been consistent in its support of the Russian sanctions, made exemptions for Eastern European countries like Hungary that are highly dependent on Russian energy. Unequally distributed costs could decrease the political will to sanction and the cohesiveness of multilateral sanctions, opening potential loopholes.

- **Relationships with security partners can limit options for harsher sanctions.** As a strategic United States partner, India has purchased Russian exports, including oil and weapon systems, without penalty. Considering the PRC's position in the international trade network, sanction responses may be limited.

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[5] It took until late 2022 for the Price Cap Coalition, composed of the United States, European Union, Australia and G7 nations, to form, and for the European Union to ban seaborne Russian oil and petroleum products. As of May 2024, Gazprom remains the only energy company with majority Russian state ownership on the Non-SDN (Specially-Designated Nationals) Menu-Based Sanctions List.

3. What are the most likely scenarios?

Key Points

- Six likely scenarios are identified as the basis for modeling downstream consequences of escalation in the Taiwan Strait.
- The scenarios vary by severity of PRC coercion against Taiwan, severity of response by the United States, and participation of US partners in the response.

Considering recent developments, this report considers six plausible scenarios for how any conflict might evolve between the PRC and the United States and its allies.[6] This section outlines each. While some look very different from the perspective of loss of life, they are grouped according to similar downstream consequences.[7]

In the short term, it seems unlikely the PRC would launch a full military invasion of Taiwan. Given the logistical challenges and the high financial cost of an invasion, the PRC would appear to prefer reunification through peaceful means.[xxxvi] The PRC's goal is most likely to degrade Taiwan's resistance or, equally important, the will of Taiwan's allies by leveraging economic or diplomatic coercion and grey zone tactics like cyberattacks and information manipulation campaigns.

3.1. Scenario I: Blockade with minimal response

In this scenario, the PRC significantly disrupts Taiwan's participation in global economic markets, forcing Taiwan's trade partners to either work through the PRC or its proxies or take risks in probing the PRC's capabilities and willingness to enforce the blockade. The blockade is assumed in this scenario to last for one year, after which either the status quo resumes or incorporation into PRC economic activity. This scenario isolates the downstream consequences pertaining solely to economic dependencies on Taiwan.

3.2. Scenario II: Quarantine of Taiwan or takeover of surrounding islands with United States bilateral economic response

In the event of quarantine or PRC military action against the outlying islands of Taiwan, economic impacts are dependent on the international response, as we assume only minimal disruptions to

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[6] We arrived at the six scenarios based on contingencies in academic and policy analyses highlighted in Section 2. While the actual set of possible scenarios is much larger, an examination of these six scenarios allows the analysis of a variety of key moving parts involving severity of the consequences for Taiwan, the PRC, and the United States.
[7] This section orders the scenarios in order of increasing severity in impact to the global economy. We do not model less severe scenarios such as a relatively minimal quarantine with minimal response.

economic activity in Taiwan.[8] In this scenario, the United States responds bilaterally, including with targeted smart sanctions on the PRC, prioritizing political and business leaders in the PRC and their overseas businesses, with an emphasis on entities connected to the military or financial sectors. The PRC retaliates economically against the United States.

3.3. Scenario III: Blockade with United States bilateral economic response

A PRC blockade of Taiwan is met by United States bilateral sanctions akin to those in Scenario II. The PRC retaliates economically against the United States.

3.4. Scenario IV: Quarantine of Taiwan or takeover of surrounding islands with multilateral economic response

This scenario is akin to Scenario II, but with the difference that sanctioning countries includes all the G7 (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States), as well as South Korea and Australia. The PRC retaliates against all the sanctioning countries.

3.5. Scenario V: Blockade with multilateral economic response

This scenario is akin to Scenario III, with an PRC blockade of Taiwan met by sanctions levied by the G7, South Korea and Australia.

3.6. Scenario VI: Regional war

Regional war includes a conventional war between the PRC and the United States over Taiwan, with United States allies (the G7, South Korea, and Australia) providing security support and additional economic coercion against the PRC. The PRC retaliates economically against United States partners.

[8] While a quarantine could vary in severity and entail a major disruption of Taiwan's economy, we treat it as a minor disruption of Taiwan's economy for the sake of considering distinct scenarios.

4. What do economic regression models indicate are challenges that would emerge in USG partner countries?

Key Points

- The downstream economic fallout could exceed those of both the 2009 global financial crisis and the 2020 COVID-19 pandemic, given the interconnected nature of the world economy and the economic slowdown affecting the two largest economies in the world.
- Small economies in Eastern and Southern Europe, Southern Africa, and Southeastern Asia are most vulnerable in the short run to escalation of hostilities in the Taiwan Strait because of direct dependencies on both the G7 and PRC economies.
- Many of the United Nation's Sustainable Development Goals–most prominently SDGs 1, 2, 3, 4, 7, 8, 12 and 13–will experience setbacks either directly or indirectly because of the economic disruptions.

This section of the report uses Global Vector Autoregression (GVAR) models to allow for different measures of economic performance to affect one another, as well as for spillovers into the economies of countries with high levels of interdependence.[9] The models are adapted from an International Monetary Fund report that estimated GVARs for African states, using GDP and inflation as endogenous variables, and oil price and interest rates as weakly exogenous variables.[xxxvii,10]

The models successfully estimate the extent to which economic processes shape one another. However, they have limitations that are important to consider when interpreting the results. First, they are limited in uncovering specific mechanisms by which the variables and economies are related.[11] Second, they are dependent on correlations observed in the data and thus should be interpreted with caution when considering unprecedented scenarios.

[9] GVAR models capture how variables like GDP shape and are shaped by the values of closely-linked economies—defined here by the percentage of trade between two economies in 2019—as well by other domestic economic variables.

[10] Endogenous variables serve as both outcomes and influencers of other variables. Weakly exogenous variables potentially influence other variables for all countries, and they are only potential outcomes in a single country.

[11] Methods that rely on input-output tables to model specific mechanisms were not feasible for this study because they require more data availability than possible for most developing and least-developed countries.

Model Feature[12]	Variables	Weights[13]
Endogenous variables, always included	GDP (constant prices, logged) Inflation rate	2010-14 average bilateral trade
Weakly exogenous variables, always included always included	United States interest rate United States oil price	2010-14 average bilateral trade
Weakly exogenous variables, selectively included	Global semiconductor exports Global cobalt imports Global lithium imports Global nickel imports Global rare earth imports	2022 semiconductor imports 2022 cobalt trade 2022 lithium trade 2022 nickel trade 2022 rare earths trade

4.1. How did we set up the GVAR models?[14]

The economic consequences of the six scenarios were modeled through impulse response functions in which changes to the economies of the PRC, Taiwan, and the G7 (plus South Korea and Australia) countries were "pulsed." The model results were then used to simulate predicted outcomes in individual countries.

- **Scenario I (blockade with minimal response):** The pulse for Scenario I involved a drop in Taiwan's GDP of 10 percent.[15]
- **Scenario II (quarantine of Taiwan or takeover of surrounding islands with United States bilateral economic response:** The loss to Taiwan's GDP is 2.5 percent, and there is a decline in PRC and United States GDP by 1 percent.[16]

[12] Some variables are "selectively included" because it was not possible to estimate models with too many variables, given both the computational demands of more complex models and data limitations. They are thus included in models "piecewise," entering in and out of models separately.
[13] For trade across all goods, the average between 2010 and 2014 is used to capture much of the observed period. For trade in specific goods (i.e., critical minerals, REE, and semiconductors), we used the same data utilized in the network analyses below to capture specific dependencies that are more current.
[14] Bayesian GVAR models (using the BGVAR package in R) were run on yearly data from 131 countries from 2002 to 2022. The data set includes countries for which complete data is available on GDP (natural log of constant prices), inflation, and trade. It excludes small city-states and island nations with little potential to provide feedback with other economies. Because the GVAR models did not perform well with groupings of more than 25 countries, the models were run separately for 10 regions spanning most of the developing world: Southern Africa, Western Africa, Eastern Africa, North Africa, South and Central Asia, Southeast Asia, West Asia, Central America, South America, and Southern and Eastern Europe. Each regional grouping also included the PRC and Taiwan, as well as the G7 countries, South Korea, and Australia. Predictions were calculated for same-year changes, as well as changes after one year, two years, three years, four years, and five years.
[15] We chose the 10 percent reduction based on estimates from a wargaming simulation of a "de facto blockade" imposed by the PRC against Taiwan, reported by Heginbotham and Kwon (2024).
[16] The decline in Taiwan's economy is based on our definition of a quarantine as much more limited in scope than a blockade. A 2.5 percent shock to Taiwan's economy is significant, consistent with PRC objectives involved in this choice of tactic, but only a quarter as disruptive as a blockade. With the United States response and PRC counter-response, we assume that both economies would enter a recession because of the high level of interdependence of

- **Scenario III (blockade with United States bilateral economic response):** A 1 percent decline in PRC and United States GDP is added to Scenario I.

- **Scenario IV (quarantine of Taiwan or takeover of surrounding islands with multilateral economic response.** Like Scenario II, expect the decline to the PRC economy to be 2 percent, with a 1 percent decline in the economies of the G7, South Korea, and Australia.[17]

- **Scenario V (blockade with multilateral economic response):** Like Scenario III, except the decline to the PRC economy is 2 percent, and there is a 1 percent decline in the economies of the G7, South Korea, and Australia.

- **Scenario VI (regional war):** Entails a loss to Taiwan's GDP of 10 percent, a drop to PRC's GDP by 2.5 percent, and a loss in GDP for each of the G7 countries, South Korea, and Australia of 2.5 percent.[18]

Nested within the scenarios above, additional pulses to weakly exogenous variables related to specific traded goods were considered.[19] Each of these exogenous variables was weighted by a given country's imports of semiconductors and trade of cobalt, lithium, nickel, and REE. In other words, the pulses to the trade in the specific goods will be felt by each country in proportion to the trade that the country does in that good.

4.2. What are the implications for GDP outcome indicators?

The panels in Figure 2 show expected changes in GDP immediately (within the same year) after the pulses described above. The countries depicted are arranged by the regional groupings used for the models. The focus is on Scenario V since it has relatively high likelihood and severity. The Annex includes figures for the other scenarios.

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the two economies and of financial and insurance markets treating investments in both economies as higher risk. This is also in line with the 1 percent decline modeled using GVAR analysis by Abdel-Latif and El-Gamal (2024).

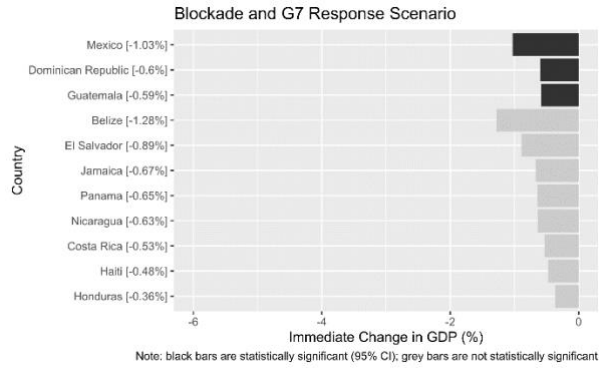
[17] The increased decline in the economy of the PRC is due to additional participation by major economies in the sanctions regime. Declines for the sanctioning countries are in line with minor GDP contractions for major economies like Germany as a result of sanctions imposed against Russia. They are also in line with outcomes assessed in the wargaming simulation of Heginbotham and Kwon (2024)).

[18] The 2.5 percent number is chosen as an indicator of significant disruption to trade and financial markets across the major economies.

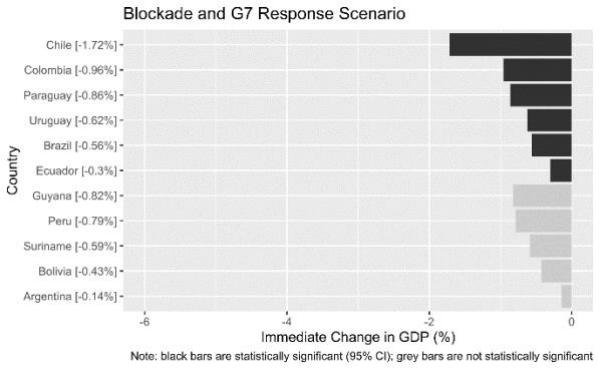
[19] The specific goods: global exports of semiconductors—computers and mobile phones—to measure the supply of semiconductors (HS#s 8541, 8471, 850650, and 851712); and global imports of cobalt (HS#s 2605 and 8015), lithium (HS#s 282520 and 850650), nickel (HS#s 2604 and 75), and REE (HS# 2805), to measure the demand for critical minerals. Natural logs of global values were taken. GVAR models require exogenous variables be attached to a given economy, so we attach the trade in semiconductors to Taiwan and the trade in critical minerals to the PRC.

Figure 2. Immediate (Same Year) Responses, Scenario V

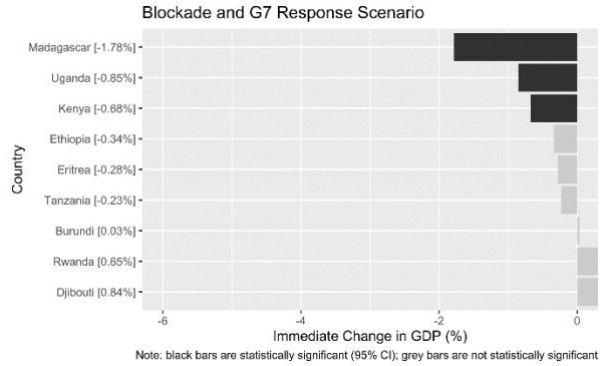
Central America



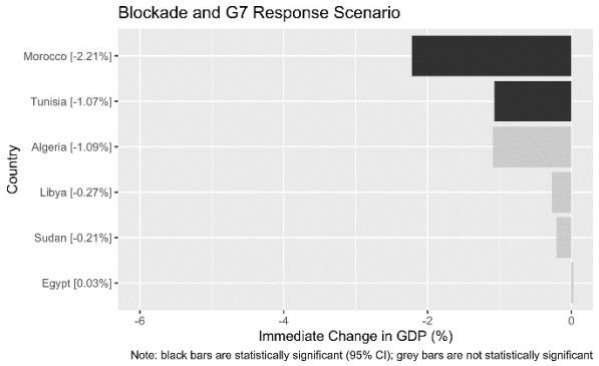
South America



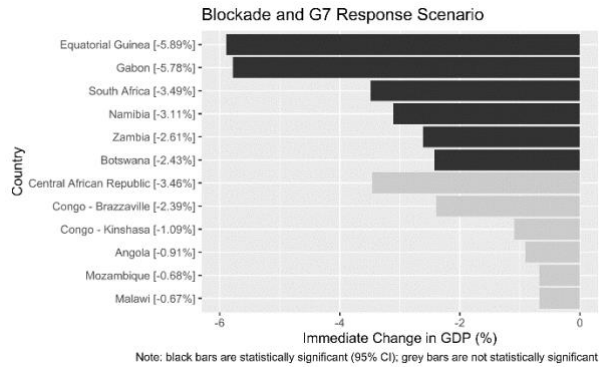
Eastern Africa



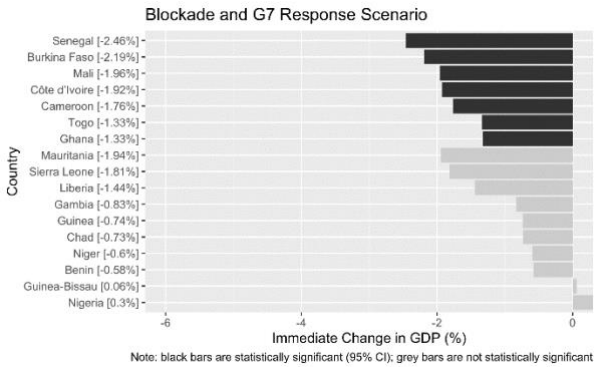
Northern Africa



Southern Africa

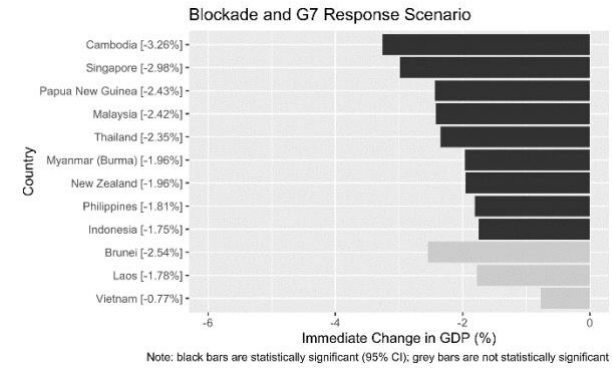


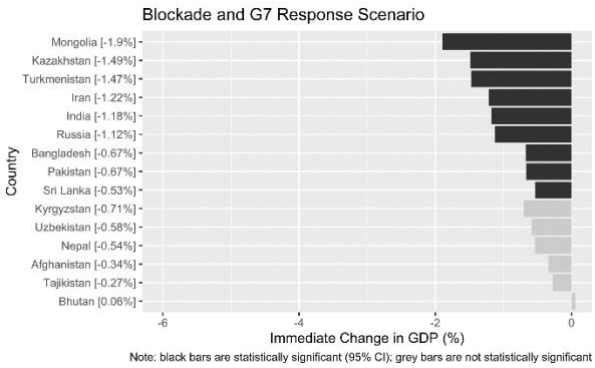
Western Africa



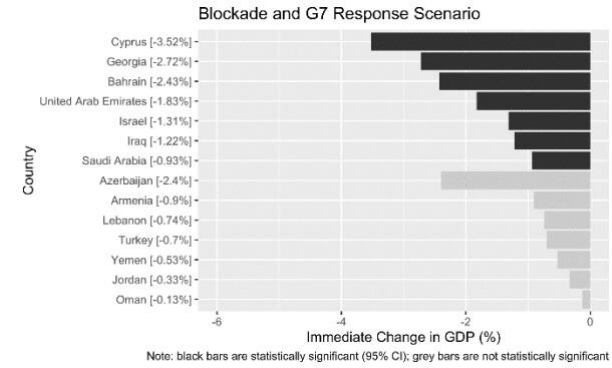
Southeastern Asia

South and Central Asia

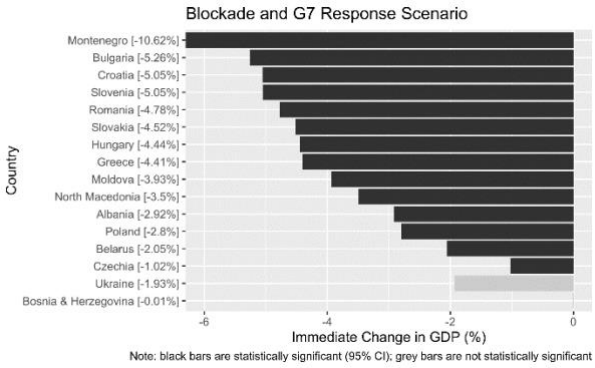




Western Asia and Middle East



Eastern and Southern Europe



In each of the scenarios the countries of Eastern and Southern Europe are severely impacted. Select countries from Sub-Saharan Africa and Southeast Asia also experience substantial impacts. Many of the most affected countries are small economies in their respective regions, like Montenegro and Equatorial Guinea. Overall, countries expected to experience the greatest downstream impact from major disruptions to the economies of the PRC and G7 are those with smaller, dependent economies.

One striking observation is the extent to which Montenegro is an outlier, with expected losses much greater than other countries. While the specific magnitudes of change for Montenegro should be interpreted with caution for reasons discussed below, it is informative that Montenegro is a small European economy that counts Italy (a G7 country) and the PRC as two of its largest trade partners. It is particularly sensitive to shocks modeled in the scenarios that involve contractions to the economies of both the G7 and the PRC.

For the same reasons, the economies of Eastern and Southern Europe more generally are vulnerable to escalating economic coercion between the PRC and the Western nations. They are deeply dependent on the economic health of Europe, the United States, and the PRC.

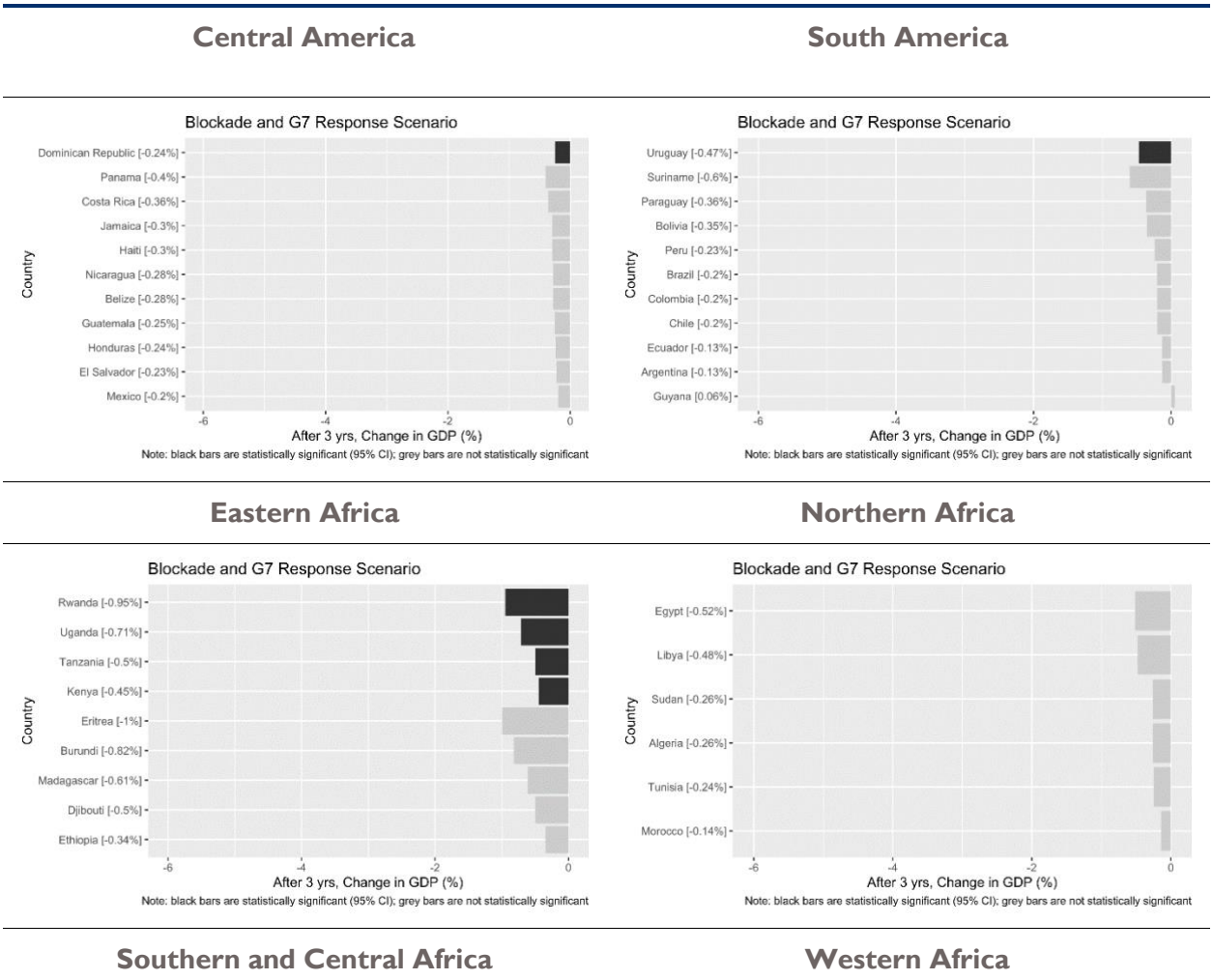
Our analysis also found relatively acute effects among countries in resource-rich regions such as Southern and Western Africa. Countries in Central America, South America, and Eastern Africa generally experienced the least decline, with few countries in these regions experiencing contractions greater than 1 percent.

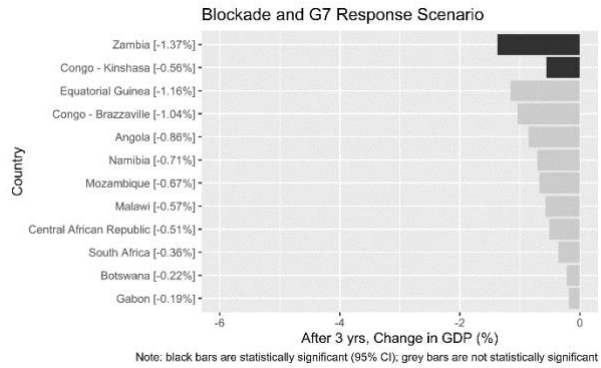
On balance, we conclude that many of these scenarios would result in a global recession and potential depression. All economies that show a statistically significant change in GDP are ones that experienced a

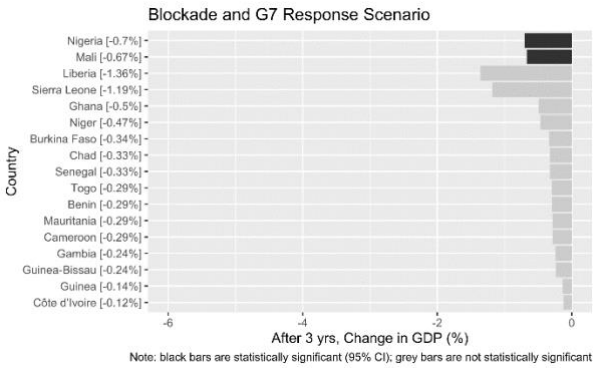
contraction. The reality is that changes in the economies of the PRC and the G7 countries have strong influence on the economic health of a multitude of other economies. It is also reasonable to conclude that countries like Montenegro—small economies with trade dependencies on both the PRC and G7—are particularly vulnerable to potential escalation in the Taiwan Strait.

The economic disruptions would likely persist for an extended period, but some economies are likely to be more resilient than others. Figure 3 demonstrates the potential persistence of the economic shocks, with a focus on three years after onset.

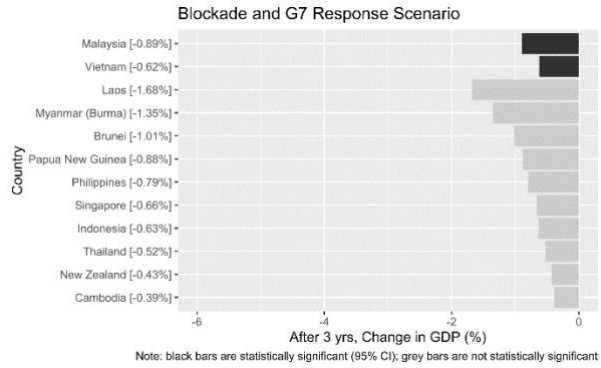
Figure 3. Medium-Term Responses, Scenario V



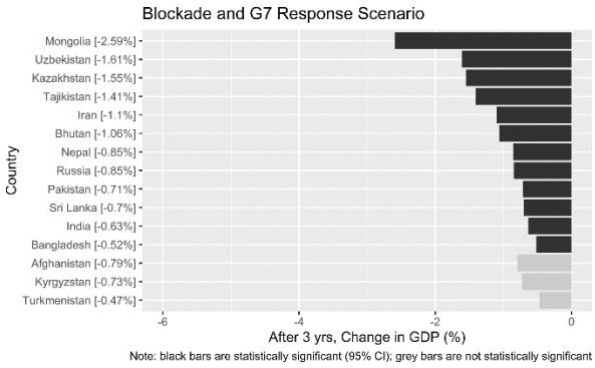




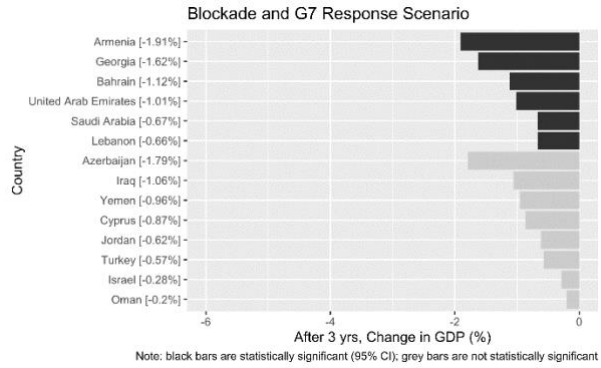
Southeastern Asia



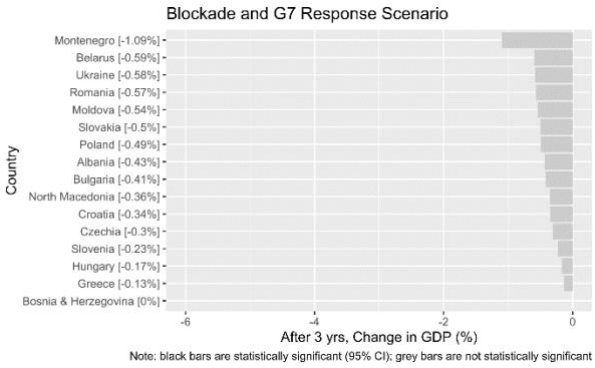
South and Central Asia



Western Asia and Middle East



Eastern and Southern Europe



A key observation is the major shift in the countries that experience the most *immediate* effects to those that experience more *persistent* effects. Eastern and Southern European countries are expected to experience much less economic decline after the initial period of impulse. The GVAR model estimated almost no tendency for those countries to experience persistent departures from normal growth. Here it is important to recall that the modeled impulses to the PRC, Taiwan and G7 economies are for only one year. Given that Eastern and Southern Europe are so dependent on those economies, they are estimated to return to status quo growth as soon as those larger economies do. However, this also means that protracted escalation of PRC-Taiwan-G7 tensions will translate into longer-term, deep impacts for Eastern and Southern European countries.

Countries in other regions are estimated to suffer longer negative consequences, even if the PRC-Taiwan conflict is brief. Even after three years, the model finds countries such as Mongolia and Armenia still experience large decreases in their economic outputs, with many experiencing annual contractions of more than 1 percent. Again, when the PRC and the G7 economies are both shocked, no countries will be insulated from the downturn, and countries will continue to drag each other down in the recovery phase as economic challenges compound. The analysis here confirms that the road to recovery will have substantial variation from region to region and country to country.

It is worth noting there is no recent precedent for a contracting PRC economy. The PRC has experienced annual growth every year for more than four decades, maintaining robust growth through the Great Recession, which in turn buoyed many of the economies in Asia and Africa. The scenarios in which the PRC economy contracts along with the G7 economies would not only be unparalleled but would also mean that almost no part of the global economy would be unaffected.

The unprecedented nature of the scenarios cannot be overstated. It is particularly important to be cautious when interpreting specific percentage changes for scenarios like the war scenario (Scenario VI) that are not well captured by the data. Plainly, there are no analogous periods in the observed data in which the Taiwanese, PRC, and G7 economies contracted at anything close to Scenario V (or VI) levels, nor are there any periods in the observed data in which the PRC is experiencing war. The specific predictions for less extreme scenarios can be interpreted with more confidence because they require less extrapolation, but even then, they are uncharted territory.

While this Section only presents the results of the GVAR model for Scenario V, further analysis can be found in Annex 2.

4.3. What are the potential humanitarian and development consequences?

With some countries experiencing declines of 3-10 percent in economic output years after the initial pulse, potential humanitarian and development consequences for many of the scenarios are expected to be both acute and long-lasting. The humanitarian consequences of a blockade on Taiwan specifically would be severe, given its limited food stocks and dependence on food imports (Ferreira and Critelli 2023). GVAR models were also run with undernourishment (as a percentage of the population),[20] foreign aid,[21] and foreign direct investment as endogenous, outcome variables.[22] The models, however, produced results with too much uncertainty around predicted responses for undernourishment, foreign aid, and foreign direct investment for almost all countries in the sample to be useful for formulating conclusions. As a result, the discussion here focuses on the GDP outcome responses, which are estimated with more certainty.

[20] From the United States Food and Agriculture Organization.

[21] Total development resource flows from the Organisation for Economic Co-operation and Development, and total development finance aid from the PRC as collected by AidData

[22] Foreign direct investment is only for Organisation for Economic Co-operation and Development member countries, collected by the Organization.

Using the SDGs as a framework, we can imagine the implications touching many facets of the global development agenda. These include:

- **Significant direct effects for SDG1 (no poverty) and SDG8 (decent work and economic growth).** Most directly, SDGs1 and 8 will experience substantial effects. Consumption of economic goods by the PRC and G7 are important drivers of economic growth and employment in export-oriented sectors around the world. Reduced consumption will depress economies and employment in sectors that sell to the PRC and the G7 will be devastated. Sectors that depend on imports from the PRC and G7 will be affected differently—some imports may become cheaper while others become more expensive, depending on supply chain vulnerabilities (these dynamics are discussed in ensuing sections).

- **Prominent setbacks for SDG2 (zero hunger), SDG3 (good health and wellbeing), and SDG4 (quality education) from direct and secondary considerations**. States will struggle to provide public goods related to food security, healthcare access, and education amid large decreases in economic revenues. While the GVAR models did not produce statistically significant responses in the undernourishment variable, this reflects model limitations rather than an indicator that food security is immune to worldwide contractions in economic productivity. One model limitation is that the time lags by which GDP and inflation move together within and across economies in near real time are potentially different than the movement of food insecurity, which could take a few years to be fully affected.
  The difference between economic flows and economic stocks is relevant. The GVAR model impulse-response functions shown above can be considered as changing the flows of economic productivity. However, food insecurity is better understood as related to the stock of economic resources available to a country. As employment and incomes fall, some countries will have deep reserve pools of resources to provide nourishment for their people. Even among vulnerable economies, it may take some time for the economic shock to be manifested in undernourishment measurable at the country level. Further complicating the relationship between economic decline and undernourishment is the tendency of international aid to flow to countries that need it most, making it hard to establish a connection between declining GDP levels and undernourishment.[23]

- **Economic shocks could hamper progress related to SDG7 (affordable and clean energy), SDG12 (responsible consumption and production), and SDG13 (climate action).** Disruptions to the trade of information and communication technology products, critical minerals and REE will have far-reaching effects. The production and consumption of clean energy depends on further development of battery capacity and efficient computing. The scenarios that we considered involving major disruptions to trade in semiconductors, critical minerals, and REE would be particularly disruptive to the production of batteries and electric vehicles. To make up for these

[23] While the impact of a widespread economic downturn on humanitarian and development is likely to be significant, some direct consequences from the war in Ukraine on food insecurity via disruption to grain exports are not analogously present in the scenarios we have considered related to escalation in the Taiwan Strait. Countries do not depend on foodstuffs flowing out of Taiwan or the PRC and predicted economic disruptions to the G7 economies are not directly related to agricultural production. Further analysis could consider the downstream food-insecurity impact of disruptions to PRC exports of fertilizer and farm equipment, as well as the losses that some agricultural exporters to the PRC will experience if the PRC imports fewer goods such as soybeans, coffee, and wine.

losses, the PRC and G7 countries would be incentivized to step up the extraction of REE and critical minerals, potentially via less sustainable means. The race to develop independence in the production and consumption of these goods, in other words, has the potential to reduce concern for "responsible" production and erode momentum for the transition to green economies.

5. What does network analysis suggest as the challenges that would emerge in USG partner countries?

Key Points

- Economies that depend on the export of raw critical minerals–cobalt, lithium, nickel, and REEs–to Taiwan and the PRC would be especially affected by trade disruptions.
- This include the Democratic Republic of the Congo and South Africa (cobalt), Chile (lithium), the Philippines, Nicaragua, Zimbabwe, Zambia, and Ivory Coast (Nickel), Indonesia (steel), and Malaysia, the Philippines, and Vietnam (semiconductors and IT products).
- Taiwan is a major exporter of advanced semiconductors, which means the entire global IT trade network and dependent industries would feel reverberations if Taiwan were to be quarantined or blockaded, including electronics and automobiles.

The economic reverberations of increased tensions over Taiwan would be felt in many ways. In addition to general challenges highlighted in the previous section, individual sectors would be vulnerable to the escalation of conflict scenarios.

This section utilizes a networks approach and provides an in-depth examination of how specific sectors and the countries that trade in them would be affected by the various conflict-response scenarios. Network analysis is valuable in analyzing commodities trade and has widespread uses in the study of resource economics and policy. It is especially helpful in highlighting countries that would be affected most adversely in the different scenarios. This could help determine the scale and severity of response and coalition cohesion in any United States-led multilateral response effort.

5.1. What are key terms and concepts?

The key measures for this report are the largest exporters and importers (weighted by total trade), influential countries in the trade network, critical intermediaries in the trade network that exports and imports pass through, and the efficiency of trade routes (the shortest distance between nodes in the trade network).

The largest exporters (weighted) are countries that are heavy exporters of the commodities under discussion, such as the Democratic Republic of the Congo for cobalt, the PRC for REE, and Taiwan for semiconductors. The largest importers (weighted) are countries with significant import volumes of the selected commodities (the PRC is the largest importer of cobalt, nickel, and semiconductors).

The most influential countries in the trade network are countries that are also connected to other important countries, such as the PRC, Korea, and Japan, for almost all products under discussion.

Network efficiency refers to the shortest distance between two countries in the trade network. This is important when considering how much trade would be delayed if the PRC or Taiwan are disconnected from the network.[24] Table 5 below provides a quick summary of key terms. For additional methodological detail, please see Annex 3.

Table 5. Network measures, definitions, and real-world concepts

Network Measure	Definition	Real-World Concept
Weighted out degree	Number of nodes directly connected out of a particular node, weighted by total trade volume	Export
Weighted In degree	Number of nodes directly connected into a particular node, weighted by total trade volume	Import
Eigenvector closeness centrality	Influential nodes of a network (well-connected nodes)	Market/material reach/access
Network efficiency	How efficient a network is to connect two points, A and B. The longer it takes for goods to travel from point A to point B, the less efficient a network is.	Shortest/most efficient trade route

5.2. How do potential conflict scenarios interact with the network?

In this section, we simulate the resiliency of each of the commodity trade networks to targeted node removal (removing nodes in the order of importance as measured by centrality and degree measures). We focus on which countries would be disconnected from the network if we remove the PRC or Taiwan nodes as well as how removing the PRC or Taiwan nodes would affect overall network efficiency.[25]

This analysis is designed to help extrapolate what might happen under some of the scenarios outlined in Section 3. Removing Taiwan from the network loosely corresponds with what might happen under a blockade (Scenarios I, II, and III). Removing the PRC from the network in some ways replicates an aggressive multilateral response (Scenarios IV and V). Regional war (Scenario VI) could potentially remove both countries from the network. Node removal assumes the most extreme case, i.e., that sanctions or war would completely block trade with Taiwan or the PRC.

We focused our analysis on critical minerals (including cobalt, lithium, nickel, and REE) and semiconductors. The subsequent sections outline the implications of each (the two tables included in the Executive Summary also provide a summary). There are several key takeaways to emphasize from the outset:

[24] A similar scenario, the current Red Sea shipping delay, is ongoing at the time of writing. Ships are transiting around the Cape of Good Hope rather than through the Suez Canal due to security concerns in the Gulf of Aden, added approximately 15 days to shipping schedules.

[25] Node removal means complete deletion of the node from the network, along with its links. Trade could still take place via other nodes, but not through the removed node.

- The PRC is a key player in the critical minerals and semiconductors industries. It is one of the largest importers and exporters across the value chains of these industries.
- In the cobalt and nickel trade networks, the removal of the PRC through sanctions or other economic retaliations would dramatically impair network functionality, with significant implications for final product categories. Delays of up to 20 percent in cobalt supply chains would impact the production of batteries for electric vehicles and gas turbine engines used to power airplanes.
- Turbulence would also be likely in the lithium and REE industries if the PRC provocations led to its removal from those networks by United States or multilateral partners.
- Exporters of raw critical minerals (cobalt, lithium, nickel, and REE) and downstream products to Taiwan and the PRC would experience prominent negative consequences. The list of countries that would be impacted includes:
    - **Cobalt:** The Democratic Republic of the Congo and South Africa
    - **Lithium:** Chile
    - **Nickel:** the Philippines, Nicaragua, Zimbabwe, Zambia, and Ivory Coast
    - **REE:** Burma, India, Thailand, and Vietnam
    - **Semiconductors and IT products:** Taiwan, Malaysia, the Philippines, and Vietnam.
- Taiwan is a major exporter of advanced semiconductors, which means the entire global IT trade network and dependent industries would feel reverberations if Taiwan were to be quarantined or blockaded, including the electronics and automobile industries. Downstream products (including computers and cell phones) would experience prominent disruptions.
- The United States and its allies, including Germany, the Netherlands, France, and the United Kingdom, are important intermediaries in the trade network and downstream importers of PRC products across a range of commodities (including lithium, cobalt, cellphones, and lithium batteries). Disruptions to trade could have downstream second-order effects on economies that depend on Western exporters.

5.2.1. Critical Minerals

Critical minerals are defined by the United States Energy Act of 2020 as "non-fuel mineral or mineral materials essential to the economic or national security of the U.S. and which has a supply chain vulnerable to disruption." The four types of critical minerals we focus on in this analysis for their strategic importance to national security and the green energy transition are cobalt, lithium, nickel, and rare earth elements.

Regardless of the commodity, many mineral value chains share similar structures. Upstream, mining production is often concentrated in developing countries before the minerals are purified and processed closer to the markets that use them as inputs in automotive, electronics, construction, or other sectors. Because of the structure of the value chains, demand for raw minerals is often correlated with demand from the PRC and other developed economies with advanced manufacturing industries.

5.2.1.1. Cobalt

Cobalt is a critical component in lithium-ion rechargeable batteries. The network is dominated by a small handful of key producers, processors, and manufacturers:

- **Production:** The Democratic Republic of the Congo produces 70 percent of global cobalt ore.[26]
- **Processing:** The PRC processes 96 percent of the Democratic Republic of the Congo's cobalt ore for cobalt-based battery materials. The PRC accounts for almost half (49 percent) of global exports of cobalt-based battery materials, followed by South Korea (31 percent) and Japan (9 percent).
- **Final products:** Poland is one of the main importers of cobalt cathode materials for battery production.

Disruption in the Democratic Republic of the Congo-PRC supply chain would affect not only Democratic Republic of the Congo and the PRC, but also South Korea, Japan, and Poland, followed by importers of lithium-ion batteries, which contain cobalt.

The cobalt network, compared to other commodities, is less populated. The Democratic Republic of the Congo produces about 70 percent of raw cobalt ore and only exports to seven partners, the majority to the PRC.[27] The PRC imports most of its raw cobalt ore supply from the Democratic Republic of the Congo and exports to countries including the United States, Taiwan, Chile, Kuwait, and Mauritius.[28] The PRC refines cobalt and exports it to the Netherlands, Japan, Korea, the United States, and Vietnam.[29] Although a cobalt processing facility is being built in Yuma, Arizona, to produce EV batteries domestically, it is not scheduled to come into operation until 2027.

Removing the PRC from the cobalt network in the conflict scenarios (Scenarios IV and V, potentially Scenario VI) would disconnect Cameroon, Mauritius, Pakistan, and Vietnam since they are only connected through the PRC. The cobalt network loses about 20 percent of efficiency by removing the PRC, meaning the commodity must be routed through more countries. This represents the highest efficiency loss of any sector included in this analysis.

Removing Taiwan from the cobalt network (Scenarios I, II, III, and possibly VI) leaves no countries disconnected since there are alternate suppliers. The network gains 1 percent in efficiency when Taiwan is removed, suggesting Taiwan has a weak contribution to the cobalt trade network. The refined cobalt network is more robust—removing the PRC disconnects only Barbados from the network,[30] and removing Taiwan does not disconnect any other country.[31]

In summary, the PRC is the most connected country in the cobalt network. It buys the raw material from the Democratic Republic of the Congo, processes it, and exports around the world. The implications of the conflict scenarios would be significant, and not just for producers such as the Democratic Republic of the Congo. Removing the PRC from the network would make global cobalt trade 20 percent more inefficient by delaying cobalt transport and increasing costs. Countries would have to re-route trade without going through the PRC. This 20 percent delay is likely to stall the

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[26] All trade data cited in this report was accessed through the United Nations Comtrade database unless otherwise specified. Also in the Brookings Report (2022).
[27] Annex 4 includes other social network analysis diagrams for cobalt as representative examples.
[28] The PRC's top 10 cobalt export destinations are the United States, Taiwan, United Kingdom, Malaysia, the Netherlands, Switzerland, Chile, Romania, Kuwait, and Mauritius.
[29] These are the five largest export destinations for refined cobalt from the PRC. The HS code used for cobalt is 2605 and for refined cobalt is 8105.
[30] The efficiency loss of removing the PRC from the refined cobalt network is about 1.9 percent.
[31] The efficiency loss of removing Taiwan from the refined cobalt network is about 0.28 percent.

production of downstream items, including rechargeable batteries for electric vehicles and gas turbine engines for airplanes.

5.2.1.2. Lithium

Lithium is another critical material used in lithium-ion batteries, which power electric vehicle batteries.[32] The global network is quite robust. The two major producers of lithium are Australia and Chile, accounting for 77 percent of all production. The PRC is the third largest producer, accounting for 13 percent of global production.[33] The PRC's top two export destinations for lithium are Sweden and Taiwan. The PRC also exports lithium batteries to the United States, Hong Kong, Germany, United Kingdom, and India, among others.[34]

Removing the PRC (Scenarios IV and V, potentially Scenario VI) from the lithium network disconnects Niger and Rwanda, which leads to a relatively large decline in network efficiency (6 percent). Removing Taiwan from the network does not have much impact (Scenarios I, II, III, VI).[35] Downstream, lithium cells and batteries have a robust network. Removing the PRC or Taiwan makes little difference to the network, leading to an efficiency loss of 1.2 percent.

Given that lithium is mostly produced in United States-allied countries (Australia and Chile in particular) and lithium batteries are also manufactured in Korea and Japan,[36] the lithium network may be more resilient than other commodities.

5.2.1.3. Nickel

Nickel is used in stainless steel and electric vehicle batteries. It is mostly produced in Indonesia, the Philippines, and Russia, followed by the semi-autonomous French territory of New Caledonia, Australia, and Canada. Indonesia and the Philippines jointly account for more than half of the total nickel production, and Indonesia may account for 75 percent of all production by 2030.

The PRC imports nickel from many countries including Indonesia, the Philippines, Australia, and New Caledonia, among others. The PRC also exports stainless steel—a downstream product of nickel that is critical to structural elements in construction—that it exports to the United States, Japan, the Netherlands, and Poland.[37] The PRC is the largest producer of stainless steel in the world, responsible for more than half of global production.

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[32] For example, Tesla uses around 12 kg of lithium in the electric battery of the Model S. Lithium is also used in cell phones and laptops. The HS code that we used for lithium is 282520.

[33] Other major producers are Argentina (6 percent), Brazil, Zimbabwe, Portugal, and the US, accounting for 1 percent each.

[34] The HS code used for lithium batteries is 850650. The PRC is the largest exporter of lithium batteries, followed by the US, Indonesia, Singapore, Japan, and Germany. Malaysia, Russia, Mexico, and Vietnam are also major importers from the PRC.

[35] The efficiency loss of removing Taiwan from the lithium network is only about 0.08 percent.

[36] Three Korean companies (LG Energy Solutions, SK, and Samsung SDI) and Japan's Panasonic are major lithium-ion battery producers (accounting for a total of 29.5 percent of market share in 2023).

[37] The countries most connected in the stainless-steel network are the PRC, US, France, Sweden, and India. The PRC imports stainless steel from Indonesia, Korea, Taiwan, United Kingdom, and Sweden.

Of the minerals included in this study, nickel has the highest number of alternate suppliers and ample supply. Yet this does not necessarily mean hostilities in the Taiwan Strait could not lead to disruptions in its supply. The PRC has invested heavily in Indonesian nickel mines as well as smelters. Completely removing the PRC (Scenarios IV, V and potentially VI) from the nickel network disconnects Papua New Guinea and Somalia. This leads to a significant efficiency loss of about 14 percent. Removing Taiwan (Scenarios I, II, III, VI) does not disconnect any country; in fact, it leads to an 0.9 percent increase in efficiency.

The stainless-steel network is more robust since there are many alternative suppliers—network failure does not occur until around a third of nodes are removed. Removing the PRC and Taiwan does not disconnect any countries since they are also connected to other countries; removing the PRC and Taiwan leads to an efficiency loss of about 3.6 percent.

5.2.1.4. Rare earth elements

REE are comprised of 17 elements used in batteries, semiconductors, satellites, aircraft engines, and weapons.[38] They are important for national security and the clean energy transition.

The PRC is a major player in REE, producing 60 percent of the global supply and processing over 90 percent. The PRC's largest export destination is the United States,[39] which imports REEs not only from the PRC, but also from the United Kingdom, Germany, Canada, and Vietnam. Other producers include Burma, India, Thailand, and Vietnam.

Electromagnets is an example of a downstream product for REE. The PRC is the largest exporter of electromagnets, refining 89 percent of all neodymium and praseodymium. The most connected countries are advanced economies, including the Netherlands, the PRC, Canada, the United States, and Germany.[40]

Removing the PRC from the REE network (Scenarios IV, V, and possibly VI) disconnects the Ivory Coast, Colombia, Malta, and Paraguay. The efficiency loss is roughly 8 percent. Removing Taiwan (Scenarios I, II, III, VI) does not disconnect any other country, and the efficiency loss is about 0.5 percent. For electromagnets, removing the PRC disconnects no other country while removing Taiwan disconnects Puerto Rico. The efficiency loss for removing both is 1.7 percent.

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[38] REE include cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, promethium, samarium, scandium, terbium, thulium, ytterbium, and yttrium.

[39] The largest export destinations by volume for PRC 's REEs are the United States, Germany, United Kingdom, Norway, and Brazil.

[40] The Netherlands is a large trader of critical minerals for its oil and gas sector as well as its IT industry. According to the USGS, the Netherlands is the third-largest producer and exporter of natural gas as well as a significant producer of lead, pig iron, and steel, which use the critical minerals under discussion. Its semiconductor equipment company, ASML, is Europe's biggest tech company and buys critical minerals to produce equipment. Dutch demand for neodymium, one of the REEs that go into permanent magnets in wind turbines and electric vehicles, is expected to account for 4 percent of the global annual production by 2030.

5.2.2. Semiconductors

A conflict between the PRC and Taiwan would be expected to have particularly profound consequences for the advanced semiconductor industry.[41] In this section, we examine the first- and second-degree network effects of such a conflict on semiconductors as well as on three products that use semiconductors (computers, cell phones, and trucks) and have prominent linkages between the PRC and developing countries.

Various data points speak to the risks. Semiconductor exports comprise Taiwan's largest merchandise exports and accounted for nearly 25 percent of GDP in 2022. Taiwan has 92 percent of global fabrication capacity for logic chips under 10 nanometers, which process data in smartphones, personal computers, and servers and are critical to artificial intelligence. The United States International Trade Commission predicts that a disruption of semiconductor manufacturing in Taiwan would lead to a 59 percent price increase in logic chips produced and sold in the United States.

Network analysis reinforces the centrality of both Taiwan and the PRC to the semiconductor network. Taiwan is the world's largest exporter (weighted out-degrees), the fourth largest importer (weighted in-degrees), and the fourth most influential country in the trade network (eigenvector centrality). The PRC ranks second, first, and first in the same measures. The impacts would be truly global in scope.

The experience of Malaysia provides insight into potential second-degree effects of semiconductor trade disruptions. Malaysia has been active in the semiconductor value chain in packaging and back-end of production and, as tensions between the PRC and Taiwan increase, is emerging as an alternative producer (Cohen 2024). Malaysia imports mostly from Taiwan, followed by the PRC, Singapore, the United States, and Japan, while exporting to Singapore, the PRC, Hong Kong, the United States, and Taiwan.

In the following subsections, we examine how conflict between the PRC and Taiwan would affect prices in developing countries of two main products that use semiconductors (computers and cell phones).

5.2.2.1. Computers

The United States is the largest importer and exporter of computers. The crucial countries in the computer trade network are the United States, Canada, Germany, the Netherlands, United Arab Emirates, Hong Kong, France, United Kingdom, Japan, and India. Many of the PRC's computer trade partners are developed countries, but its partners also include developing countries, among them Mexico, Poland, Czechia, Malaysia, and Turkey. Malaysia, a rising IT-producing country, mostly exports to regional countries such as Singapore, India, and Vietnam, which means second-order impact of sanctions on the PRC would affect these South and Southeast Asian countries through Malaysia.

5.2.2.2. Cell Phones

Although removing the PRC from the network does not appear to have a major effect on network efficiency, the cost would keenly impact countries on the African continent. According to the World Bank/International Telecommunications World Telecommunication/Information and Communication

[41] TSMC, or Taiwan Semiconductor Company, accounts for a total of 56 percent market share in the global semiconductor foundry market.

Technology Indicators database, 89 percent of people in Sub-Saharan Africa had mobile cellular subscriptions in 2022. The PRC's ties with the African continent are strong, accounting for 60 percent of all smartphones sold there (Okafor 2024). South Africa and Nigeria are large importers of cell phones.

Table 6 below shows some PRC-financed telecom infrastructure projects in Africa between 2010 and 2020, mostly implemented by PRC telecommunications firms—Huawei, ZTE, and CITCC (China International Telecommunication Construction Corporation).

Table 6. Selected PRC Financed Telecom Projects in Africa, 2010 to 2020

Country	Borrower	Implementation	Amount	Year
Tanzania	Government of Tanzania	CITCC, Huawei	$100m	2010
Cameroon	Government of Cameroon	Huawei	$168m	2011
Kenya	Government of Kenya	Huawei	$71m	2012
Nigeria	Government of Nigeria	Huawei	$100m	2012
Ethiopia	Government of Ethiopia	ZTE	$300m	2013
Ethiopia	Government of Ethiopia	Huawei	$800m	2013
Tanzania	Government of Tanzania	CITCC, Huawei	$94m	2013
Nigeria	Government of Nigeria	Huawei	$100m	2013
Guinea	Government of Guinea	Huawei	$214.2m	2014
Cameroon	Government of Cameroon	Huawei	$337m	2015
Ivory Coast	Government of Ivory Coast	Huawei	$56.7m	2016
Cameroon	Government of Cameroon	Huawei	$85m	2017
Nigeria	Government of Nigeria	Huawei	$334m	2018
Sierra Leone	Government of Sierra Leone	Huawei	$30m	2019

5.2.2.3. Node Removals for Semiconductors

Node removal analysis may not capture the scale of anticipated potential disruptions of a conflict between the PRC and Taiwan to the semiconductor industry.[42] But the product category is still important—of all products examined in this report, computers and semiconductors are the only commodities which would be affected more by removing Taiwan from trade networks than removing the PRC. This suggests that disruption to the network would occur if the PRC initiates action against Taiwan, regardless of the response by the United States.

The dynamic is reinforced by the network efficiency data point. Removing Taiwan from the semiconductor network is the same as removing both the PRC and Taiwan. This suggests the PRC and Taiwanese semiconductor network overlaps, and that removing PRC from the network after removing Taiwan does not sever additional trade linkages. This stands in contrast with most of the other trade networks, in which the efficiency loss from removing both Taiwan and PRC is the added value of the individual efficiency loss of removing Taiwan and PRC, respectively.

[42] Mathematically, removing one node has very little impact on efficiency, or the shortest distance between nodes. Moreover, the HS codes for semiconductors (8541 for diodes, transistors and similar semiconductor devices, and 8542 for electronic integrated circuits) are quite broad, which makes it difficult to separate the advanced chips that Taiwan makes that are "critical" to artificial intelligence and other advanced electronics.

Implications for Global Energy Industries

A conflict between the PRC and Taiwan is expected to have huge implications for global energy markets. The SDGs most directly affected would be SDG7 (Affordable and Clean Energy), SDG12 (Responsible Consumption and Production), and SDG13 (Climate Action). Two types of impacts can occur in the case of conflict: 1) disruptions in raw material supply for green energy industries; and 2) a slowdown in production of global energy products.

The first impact is through disruptions in trade in commodities—cobalt, lithium, nickel, and REEs—that go into green technologies such as solar panels, wind turbines, batteries, and electric vehicles. Network analyses have shown the PRC is an influential and central player in these industries as an importer of raw materials, producer of downstream products, and well-connected trading partner of countries around the globe. Moreover, the PRC owns stakes in many mineral mines around the world. Western sanctions on the PRC, including export restrictions, would constrain the supply of refined minerals for production of green energy technologies.

The second impact is through disruptions in the PRC's own green energy industries. Currently, the PRC is the largest producer of solar panels, wind turbines, batteries, and electric vehicles. If the PRC were to engage in military conflict, government investments in these industries are likely to be reduced. Since no other countries that can produce green energy products at the same scale, any conflict and resulting sanctions would likely hamper a global transition to green energy.

6. What steps can the USG take?

Key Points

- Stakeholders should expect substantial challenges to implementing a sanctions regime against the PRC.
- Helping partner countries offset some costs connected to reducing or severing economic relations with the PRC is key to maintaining the success of a sanction's regime. This could be accomplished directly through the use of foreign aid or loans or indirectly by helping partner states find alternative sources for raw materials or markets for final products.

This report and its findings benefit the USG by giving the information it needs to be proactive and prepare its networks to respond strategically to the prospect of conflict between the PRC and Taiwan. The agency should prepare response strategies to meet the following challenges:

- **Assess debt profiles:** The Belt and Road Initiative has left many countries in Africa and Eurasia heavily indebted to the PRC. The countries that have received significant loans and investments from the PRC may suffer from reduced or halted cash flows, which could lead to large unemployment and other turbulence, including food insecurity.

Inter-agency cooperation among the United States Departments of State and Treasury and with international organizations, including the World Bank and the International Monetary Fund, to assess debt levels of developing countries to multilateral agencies, official development assistance, and the PRC, and to prepare for food insecurity scenarios from severe economic declines in such heavily indebted countries.

- **Coordinate with allies:** With this report providing insight into the scale of regional economic disruptions that can be anticipated by conflict in the Taiwan Strait, it would be prudent for the USG to work closely to share findings and develop solutions with peer organizations in the European Union and Australia. Communication could assist with maintaining commitment to a shared goal.

- **Develop processing facilities for critical minerals:** Over the long term, the biggest challenges for the US and its allies would be developing sustainable and stable processing facilities for critical minerals outside of the PRC. Even if the United States can diversify the sourcing locations of raw materials, if no other country than the PRC can cheaply process these raw materials into refined products, sanctions on Beijing would not only hurt the PRC but also developed countries and their economic production around the world, including the United States.

  The USG can activate several strategies to mitigate this challenge. Identifying potential avenues for supporting the development of critical infrastructure in suitable locations might prove beneficial. As the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act is helping foreign firms build factories in Arizona and Texas, and the Inflation Reduction Act is shoring up the domestic green industry, the United States would benefit from sustained cooperation with allied countries, especially in East Asia.

- **Help partner countries build resilient economies less dependent on the PRC:** While the analysis suggests that such efforts should continue expeditiously, it is also important to recognize that de-risking by potential supporters of Taiwan entails a weakening of deterrence against PRC aggression. De-risking goes both ways, and the PRC is already reducing its dependencies on the United States and the G7 in anticipation of future sanctions.

  To the extent that the PRC faces lower than expected consequences from hostile activity—because it has built resilience to punitive sanctions—such activity becomes more attractive. The more that de-risking proceeds, the more that the United States will need firmer commitments from partners to participate in multilateral sanctions to maintain the sanctions threat as sufficiently costly.

6.1. What challenges can be anticipated from a sanctions regime targeting the PRC?

We expect sanction responses to PRC action on Taiwan to be an extension and expansion of current sanctions and export controls. These could range from sanctions targeted towards relevant political and military leaders inside the PRC to sectoral and wide-scale financial measures like those imposed against Russia after its invasion of Ukraine.

The United States government has already put sanctions on companies that finance the PRC military and on aviation, nuclear, oil, and construction companies. Tariffs imposed on the PRC IT industry have included bans on advanced materials and equipment for semiconductors. While these measures have been effective in causing bottlenecks in the PRC semiconductor supply chain, they have also accelerated

PRC self-reliance on semiconductors produced domestically. An example of this is the new cellphone produced by Chinese tech giant Huawei's new phone that relies on advanced semiconductor chips made in China.

Levying additional sanctions on the PRC will be extremely challenging. Unlike Russia, the PRC occupies a central position in a broad range of networks of the international trade network. In general, economic sanctions are less likely to be successful when they: 1) target authoritarian countries; 2) are ambitious; and 3) are implemented on rivals.[xxxviii] Moreover, as the Treasury Secretary Janet Yellen recently remarked, broad tariffs would "make life unaffordable for working class Americans and harm American businesses" since tariffs would be passed down to consumers. There would also be political-economy calculations in other countries—United States allies and partners may face domestic constituencies who would be harmed by diminished trade with the PRC.

If the United States targets sanctions on industries or individuals, there are still challenges. As demonstrated after Russia's invasion of Ukraine, financial sanctions on powerful business leaders and government officials did not always lead to the desired outcomes. Targeted individuals were able to move capital internationally to evade the sanctions. In the case of PRC, the elite have been moving capital out of the country for decades, through Hong Kong and other locations.

Lastly, while weaponizing the dollar by cutting off Russia's access to the SWIFT system did some damage to Russia, it may be less effective in the case of the PRC, which has been increasing the supply of its currency, the renminbi, around the world for more than a decade to facilitate transactions.

6.2. What might facilitate multilateral cooperation?

One important determinant of sanction success is gaining cooperation from other countries. Multilateral sanctions can be more effective than unilateral ones, especially when the sanctioning countries can overcome coordination and enforcement issues.[xxxix] The key to maintaining a multilateral sanctioning regime is to help partner states offset some of the costs of reducing or severing economic relations with the PRC. This could be accomplished through direct action, such as foreign aid or loans, or indirectly, through helping partner states find alternative markets for their products or alternative sources for raw materials.

The difficulty of sanctioning the Russian energy sector showed that without providing a reasonable substitute, sanctions will be circumvented by countries keen to access crude oil at competitive prices. In the event of sanctions against the PRC, this would become even more crucial. The economies of many countries, including those highlighted in this report, rely heavily on being able to access the PRC's market. Here, we recommend coordination between the State Department, the United States Treasury and other stakeholders to ensure proactive measures are undertaken to alleviate the economic costs of sanctions on countries with less economic resources.

6.3. What would be the humanitarian and development impact?

We expect countries that rely on the PRC assistance would bear secondary costs from reduced investment from Beijing. Three prominent challenges would be expected for developing countries if PRC loans and aid cease:

- Increase in food insecurity from depressed economic activities.

- Increase in risk of political instability, especially in fragile countries subject to conflict dynamics.
- Instability in provision of public services, such as the lack of access to public healthcare and education.

Since economic shocks in low-income countries are associated with increased risk of civil war, interventions to reduce such instability, such as foreign aid, must be considered.[xl] Measures the USG can take to help partner countries address these issues include:

- Take stock of regional programs for countries participating in the Minerals Security Partnership, Partnership for Global Infrastructure and Investment, Energy for Growth in Africa Initiative, and Partnership for Resilient and Inclusive Supply-Chain Enhancement to earn backing for local support and adoption of these initiatives. Possible examples include increasing programming in agriculture, infrastructure, health, nutrition, water, and sanitation, which may cultivate buy-in from local community members and political leaders.
- Continue to strengthen the supply chain of critical minerals and computing by investing in alternative suppliers and producers of downstream, midstream, and upstream products.
- Nurture a unified sanctions regime by working with the European Union, Australia, and Japan, as well as medium and small economies in Southeast Asia, Latin America, Eastern Europe, and Africa.
- Expand sanctions against illicit trade in critical minerals like the Africa Gold Advisory.
- Prepare for targeted retaliation by the PRC at home and abroad on products, such as REE, plastics, soybeans, and automotives.
- Model conflict and migration scenarios for ripple effects on countries that currently depend heavily on PRC trade, loans, and aid.
- Evaluate the potential for expanding the Feed the Future initiative to countries that may be most at risk for economic harm associated with conflict in the Taiwan Strait and investigate the possibility of developing widespread multilateral support for food security programs.

7. Conclusion

This report examined the potential effects of a conflict between the PRC and Taiwan It was divided into two parts: 1) the global model of economic impact of the PRC-Taiwan conflict; and 2) the manufacturing and distribution networks of commodities crucial to economic production and green energy industries. The report found that such a conflict would have significant negative impacts not only for the involved parties but also for the global economy, including both developed and developing countries, given the wide-reaching global integration of PRC production and trade. This finding echoes external sources, which have estimated the potential financial disruptions of conflict in the Taiwan Strait to be 10 percent of global GDP, or US$10 trillion.

Using the GVAR model of twenty-one years of data from 131 countries, we found that the PRC-Taiwan conflict will have varying degrees of negative impact around the world. We modeled various conflict scenarios, ranging from blockade and quarantine to invasion and regional war, to examine economic impact in countries by region. We found certain countries would likely experience large and immediate declines in GDP, especially small economies in Eastern and Central Europe such as Montenegro, as well as economies in Southeastern Asia such as Cambodia and Singapore. Other countries, primarily in

Central and Western Asia, would likely experience more protracted declines in economic production, especially Mongolia, Uzbekistan, Armenia, Kazakhstan, and Georgia.

With respect to the second objective, we examined trade disruptions in specific commodities—cobalt, lithium, nickel, REE, and semiconductors—and their downstream products. We determined that the PRC is one of the largest trading partners of those products, both in imports of raw materials and in the exports of refined and downstream products containing those commodities. Because many countries are connected to the PRC through trade networks, removing the PRC or Taiwan through blockade or sanctions would be expected to cause inefficiencies in trade networks. Some countries, including Niger, Rwanda, Cameroon, and Somalia, would be left without alternative suppliers.

The prospect of a conflict between the PRC and Taiwan has implications for not only regional security in the Asia-Pacific region and the great power rivalry between the United States and the PRC, but also for large and small economies in Asia, Latin America, Africa, and Europe, the global provision of IT and green energy products, and the geopolitics of oil.

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Annex 1. Summary of Global Vector Autoregression (GVAR) scenarios

Table 7 is a summary of the scenarios, with sub-scenarios that reflect pulsing of specific commodities. If Scenario Ia is the base scenario as described above, Scenario Ib adds a 20 percent decline in Taiwan's semiconductor exports, which is used as a proxy for the total change in the availability of semiconductors in the global economy. For subsequent scenarios that involve economic coercion against the PRC (Scenarios II-VI, as listed above), declines in the PRC's trade in cobalt (c), lithium (d), nickel (e), and REE (f) are also considered.[43]

Table 7. Pulses used for the impulse-response functions (percent)

#	PRC GDP	TW GDP	United States GDP	G7+ GDP	TW SC	PRC Cob	PRC Lit	PRC Nic	PRC REE
Ia		10							
Ib		10			20				
IIa	1	2.5	1						
IIb	1	2.5	1		20				
IIc	1	2.5	1			50			
IId	1	2.5	1				10		
IIe	1	2.5	1					50	
IIf	1	2.5	1						50
IIIa	1	10	1						
IIIb	1	10	1		20				
IIIc	1	10	1			50			
IIId	1	10	1				10		
IIIe	1	10	1					50	
IIIf	1	10	1						50
IVa	2	2.5	1	1					
IVb	2	2.5	1	1	20				
IVc	2	2.5	1	1		50			
IVd	2	2.5	1	1			10		
IVe	2	2.5	1	1				50	
IVf	2	2.5	1	1					50

[43] The declines are of magnitude similar to the largest declines observed in total trade of these goods from 2002 to 2022. The 2.5 percent decline in the export of semiconductors for the quarantine scenarios is set to the same level of decline in the economy of Taiwan.

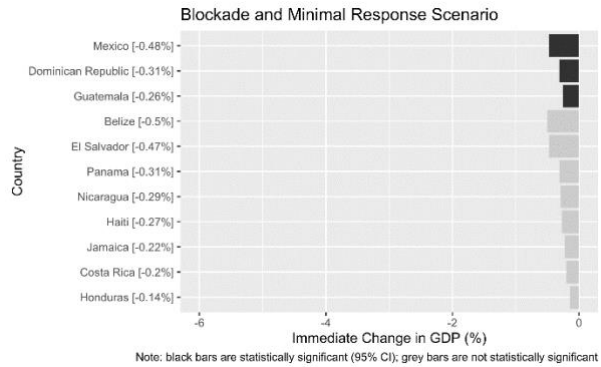
#	PRC GDP	TW GDP	United States GDP	G7+ GDP	TW SC	PRC Cob	PRC Lit	PRC Nic	PRC REE
Va	2	10	1	1					
Vb	2	10	1	1	20				
Vc	2	10	1	1		50			
Vd	2	10	1	1			10		
Ve	2	10	1	1				50	
Vf	2	10	1	1					50
VIa	2.5	10	2.5	2.5					
VIb	2.5	10	2.5	2.5	20				
VIc	2.5	10	2.5	2.5		50			
VId	2.5	10	2.5	2.5			10		
VIe	2.5	10	2.5	2.5				50	
VIf	2.5	10	2.5	2.5					50

Annex 2. Additional GVAR Models

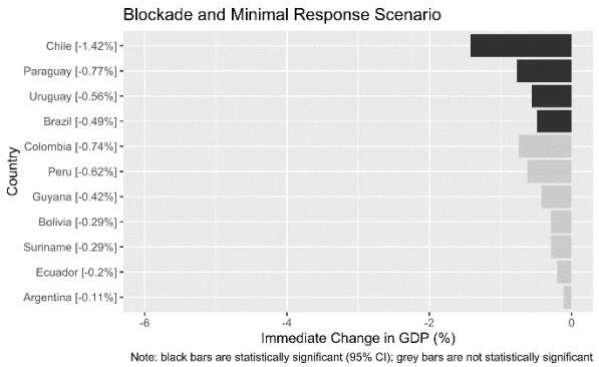
The panel graphs in Tables 8 to 13 focus on the immediate responses to the impulses in the other scenarios.

Table 8. Immediate Responses, Scenario I

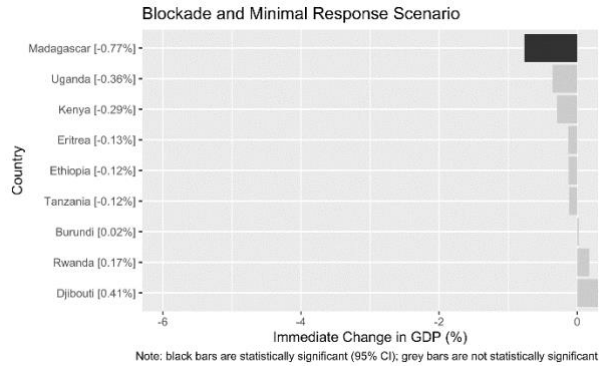
Central America



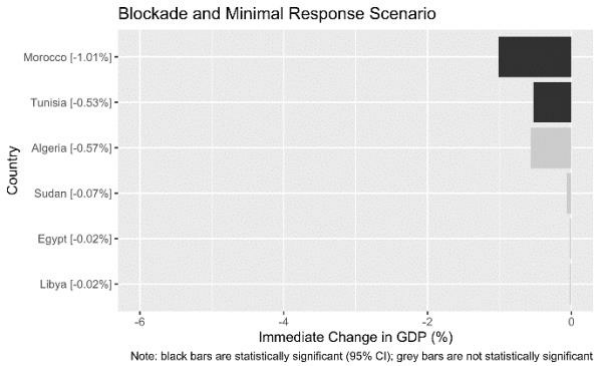
South America



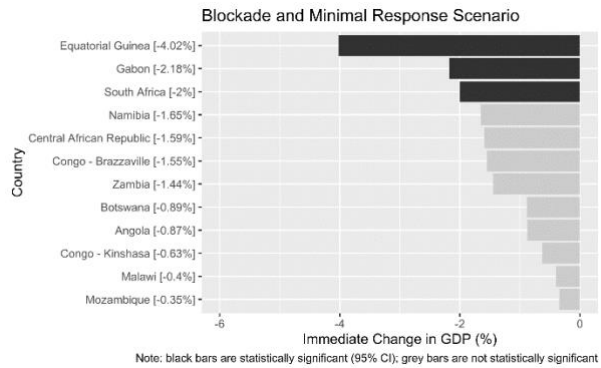
Eastern Africa



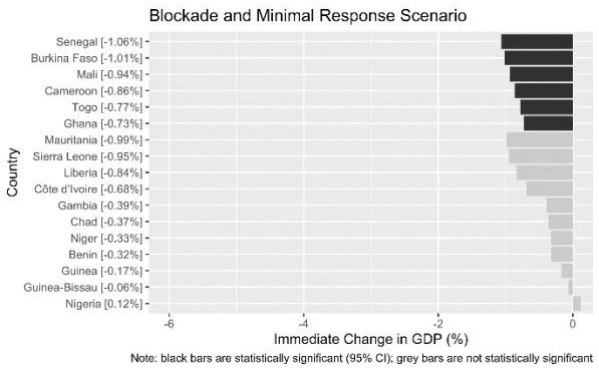
Northern Africa



Southern and Central Africa

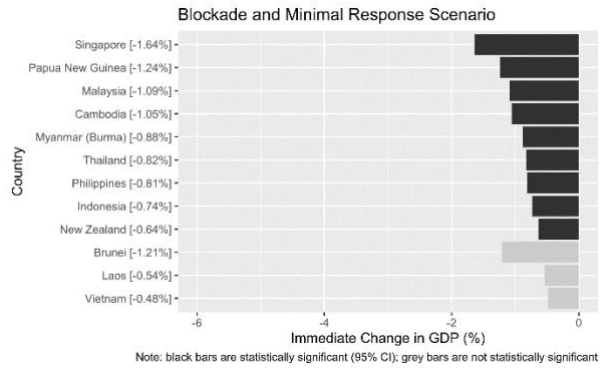


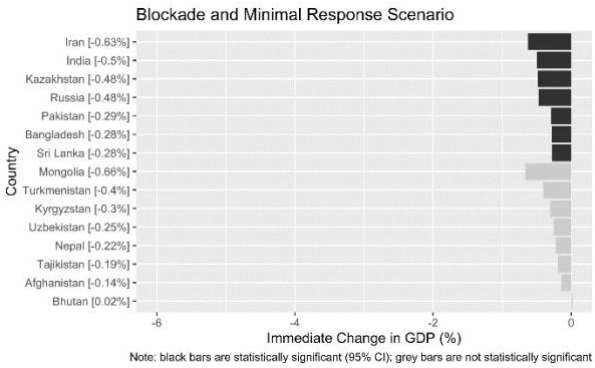
Western Africa



Southeastern Asia

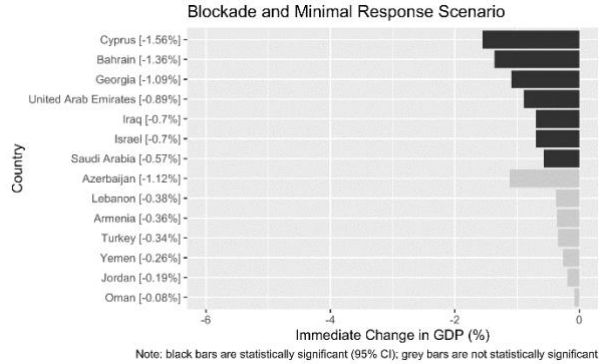
South and Central Asia





Western Asia and Middle East

Eastern and Southern Europe



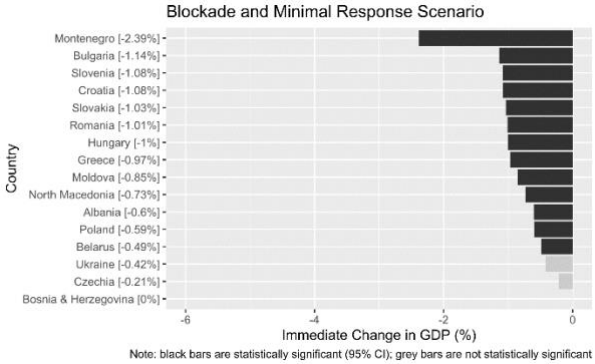
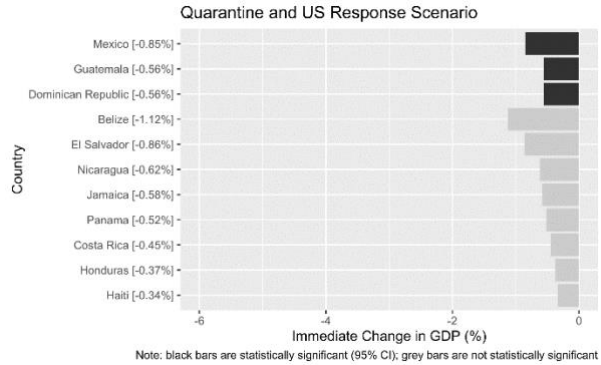
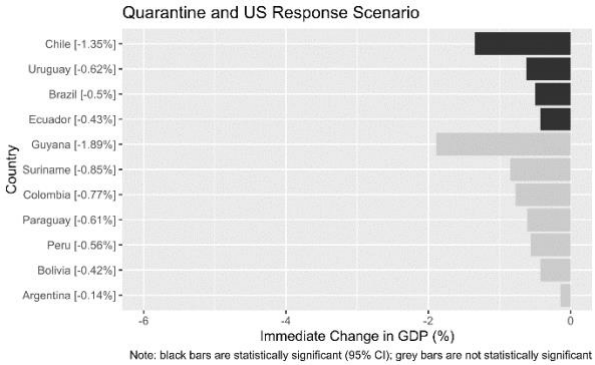


Table 9. Immediate Responses, Scenario II

Central America

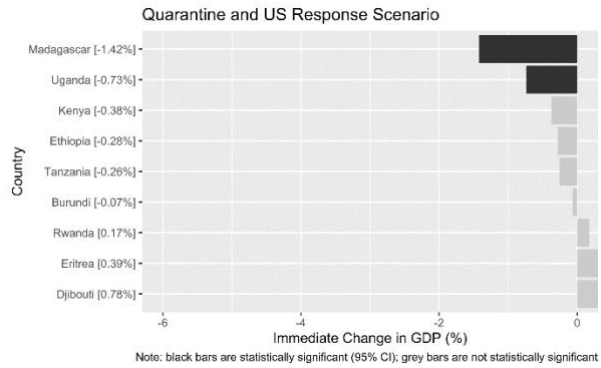
South America



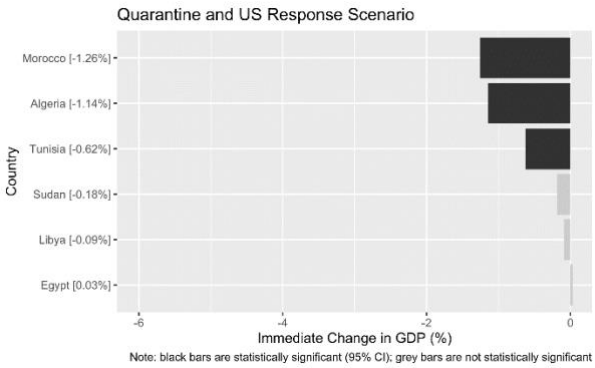


Eastern Africa

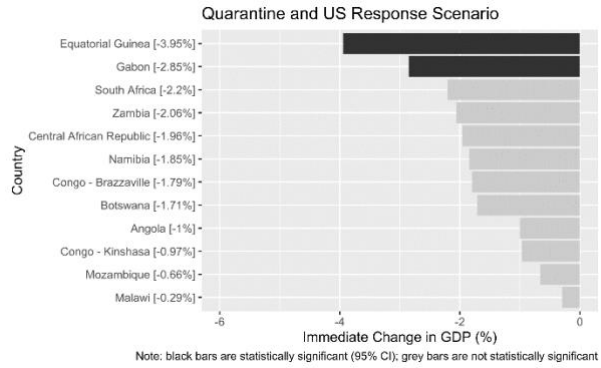
Northern Africa



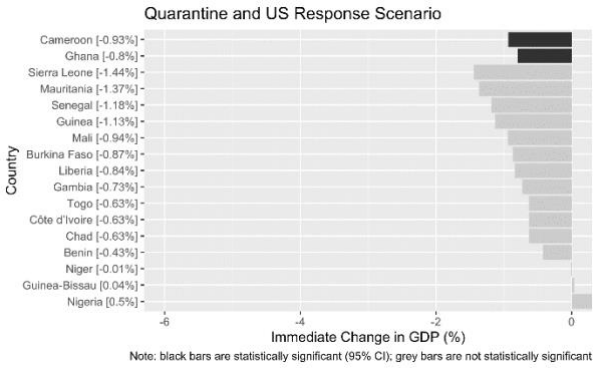
Southern and Central Africa



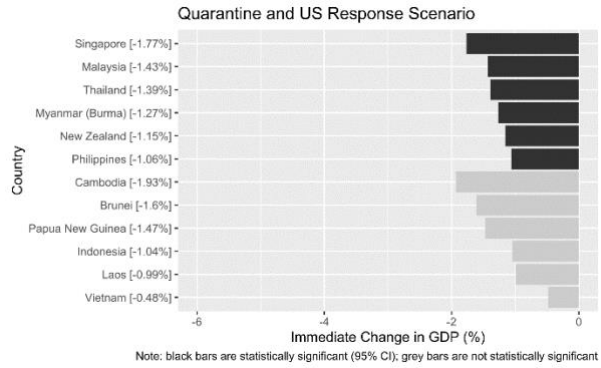
Western Africa



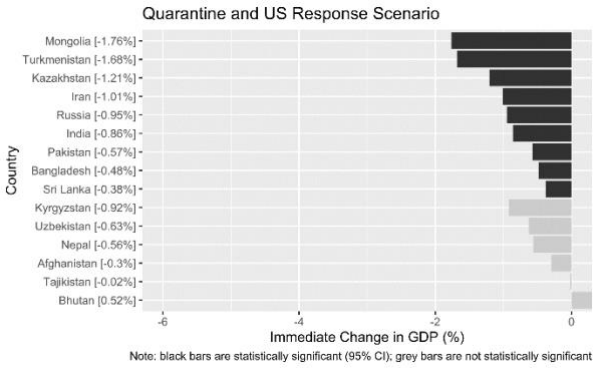
Southeastern Asia



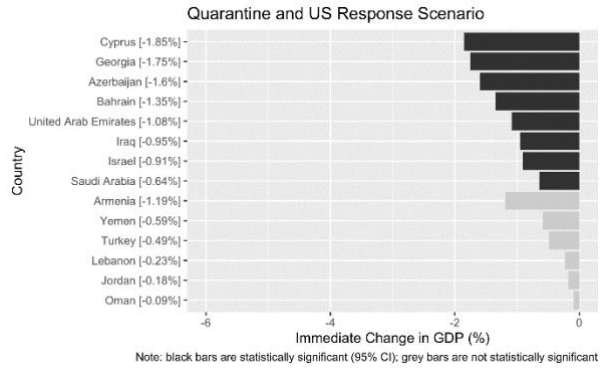
South and Central Asia



Western Asia and Middle East



Eastern and Southern Europe



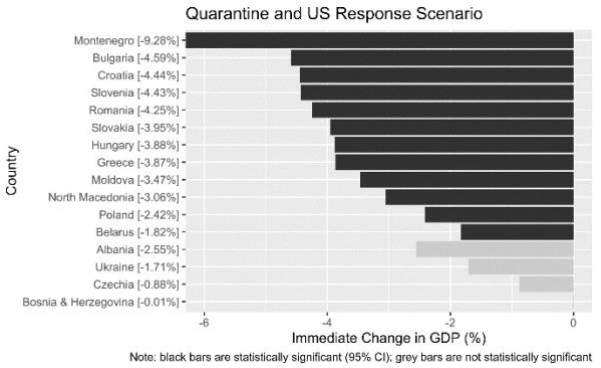
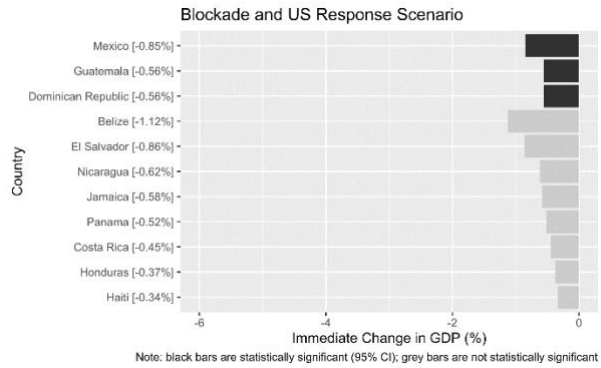
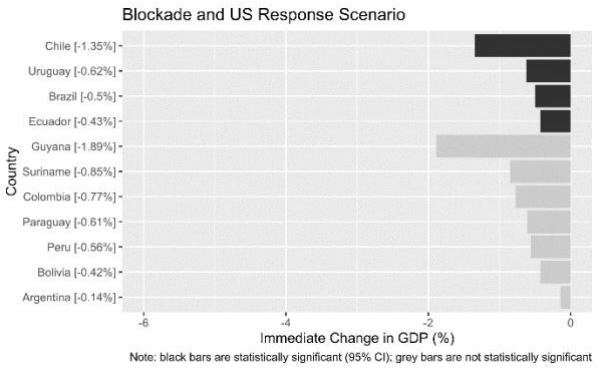


Table 10. Immediate Responses, Scenario III

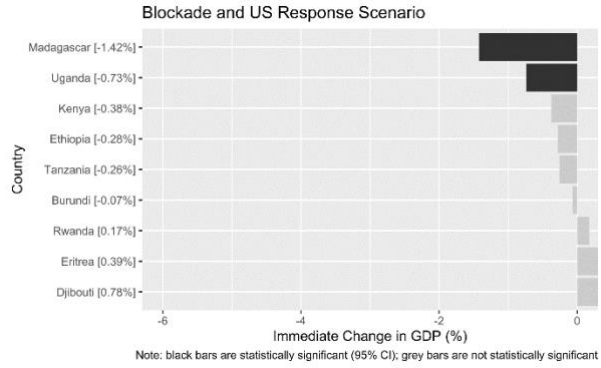
Central America



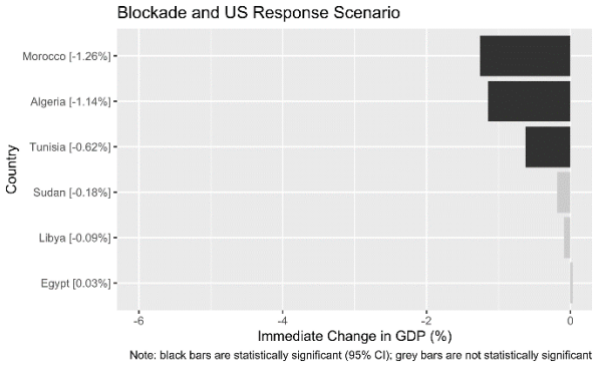
South America



Eastern Africa

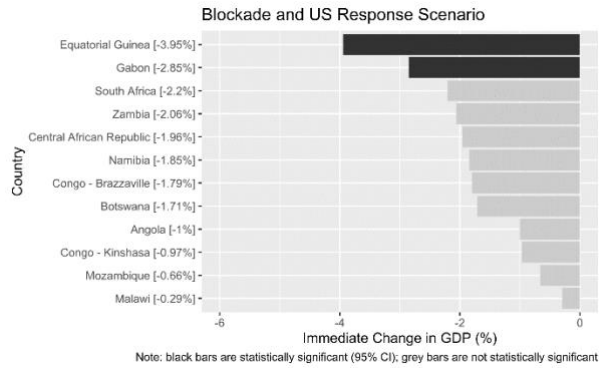


Northern Africa

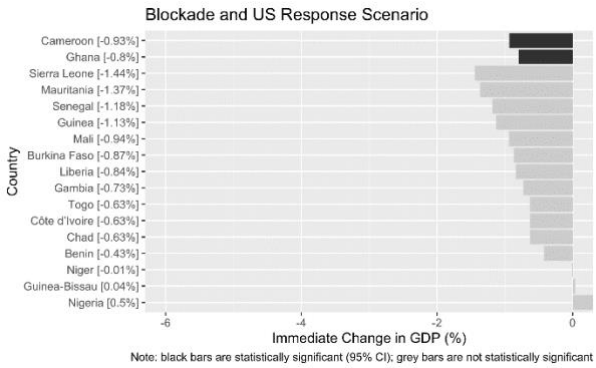


Southern and Central Africa

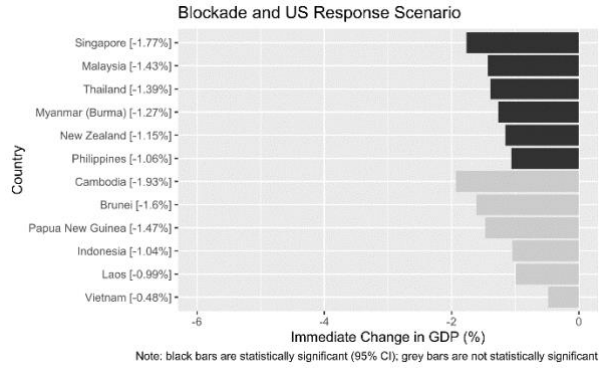
Western Africa



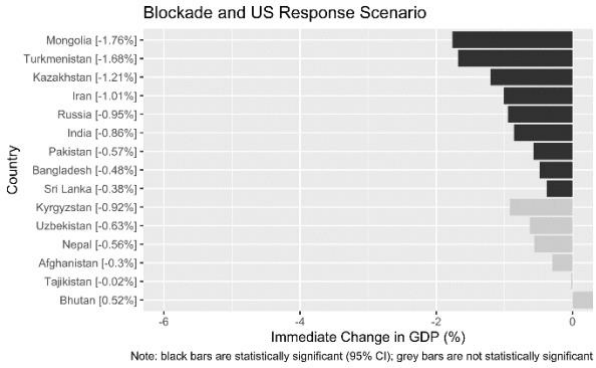
Southeastern Asia



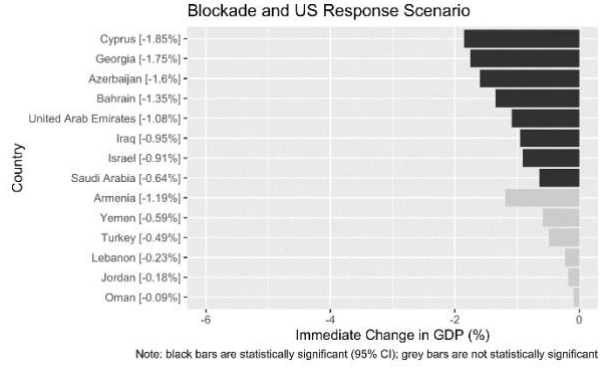
South and Central Asia



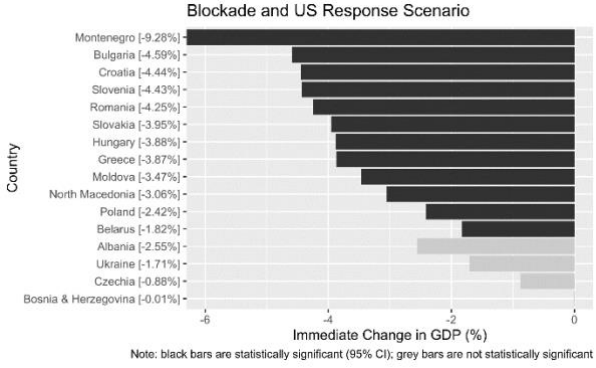
Western Asia and Middle East



Eastern and Southern Europe

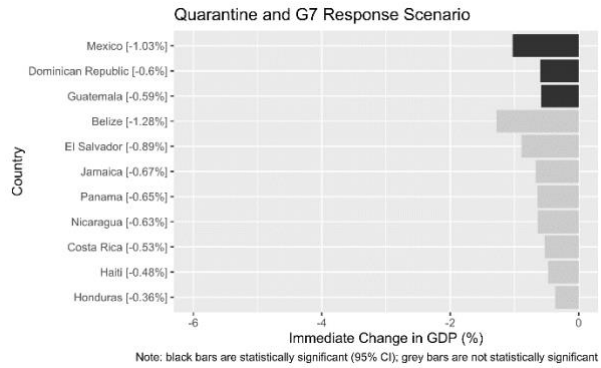


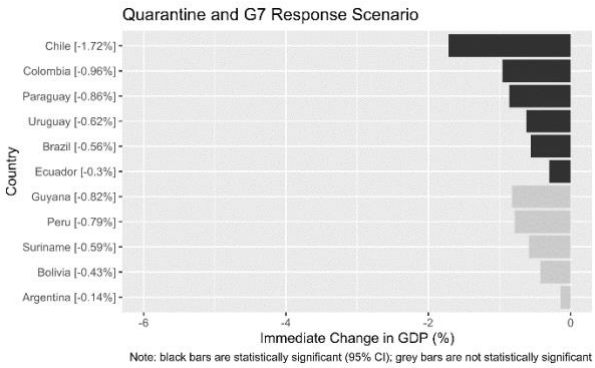
Central America



South America

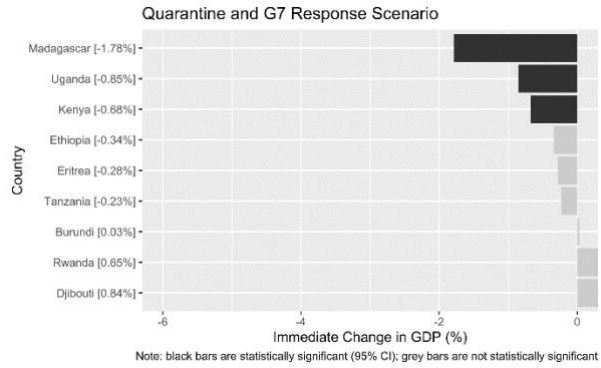
Table 11. Immediate Responses, Scenario IV

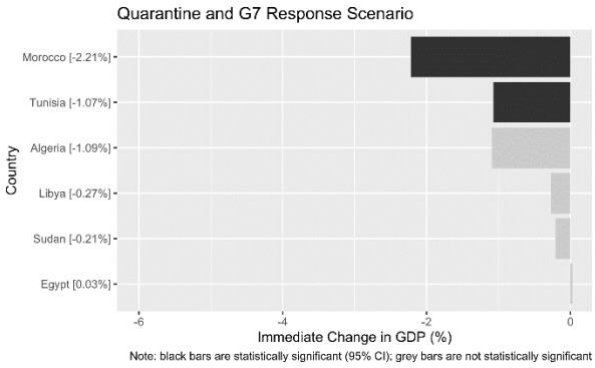




Eastern Africa

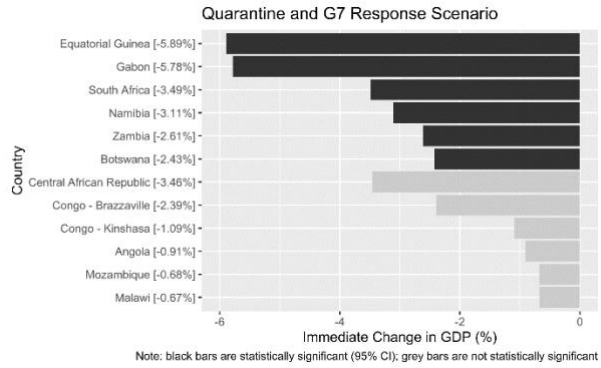
Northern Africa

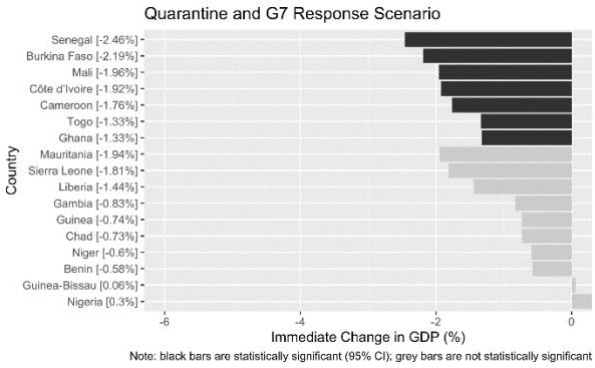




Southern and Central Africa

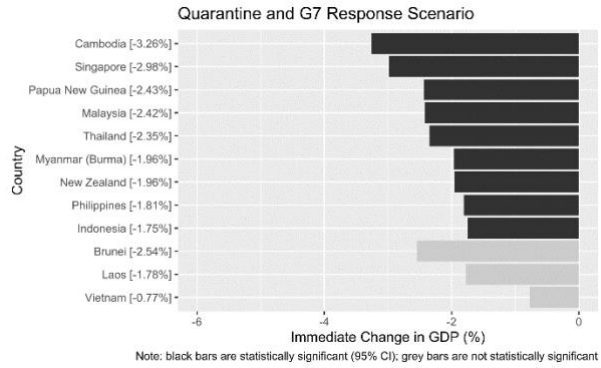
Western Africa

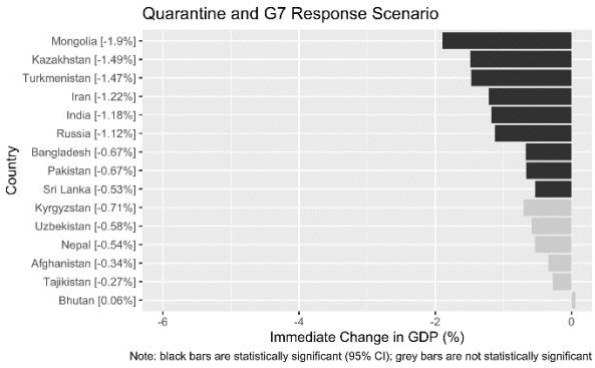




Southeastern Asia

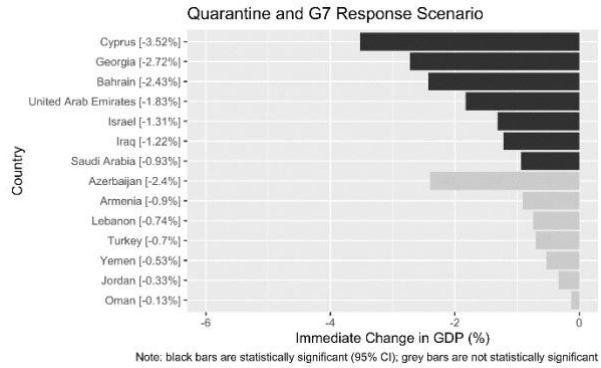
South and Central Asia





Western Asia and Middle East

Eastern and Southern Europe



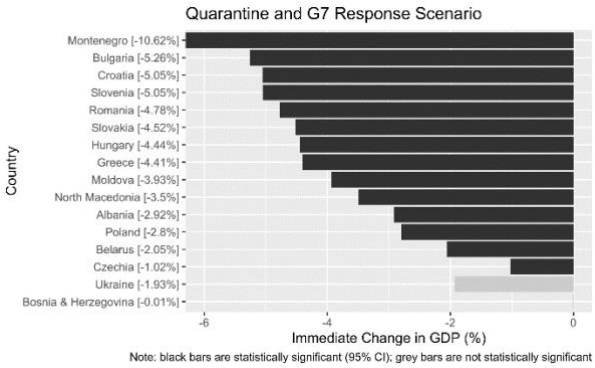
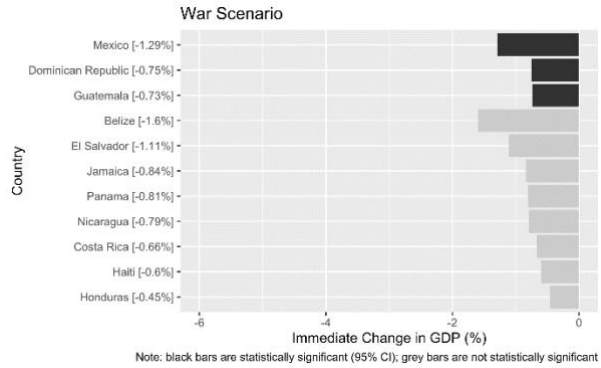
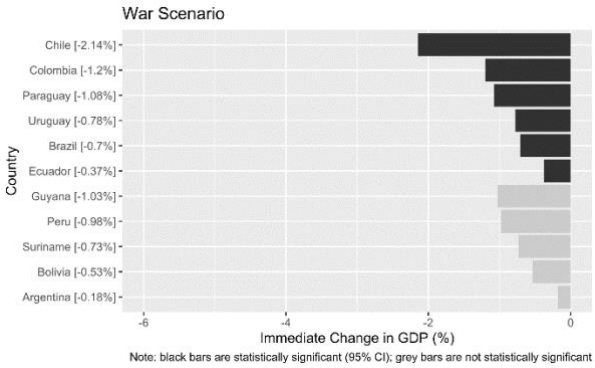


Table 12. Immediate Responses, Scenario VI

Central America

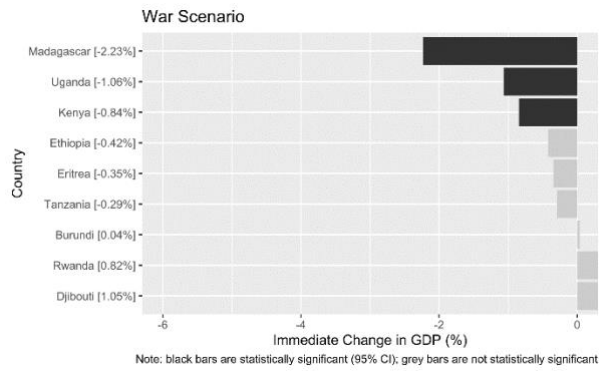
South America



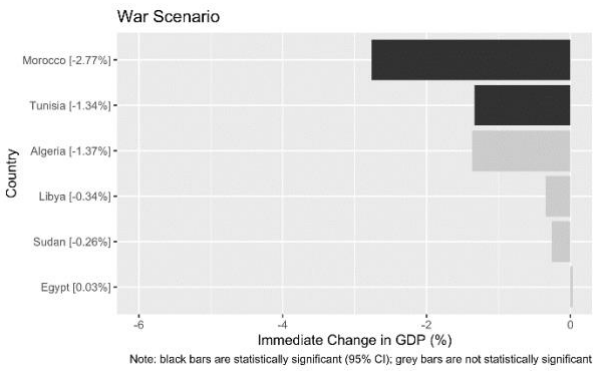


Eastern Africa

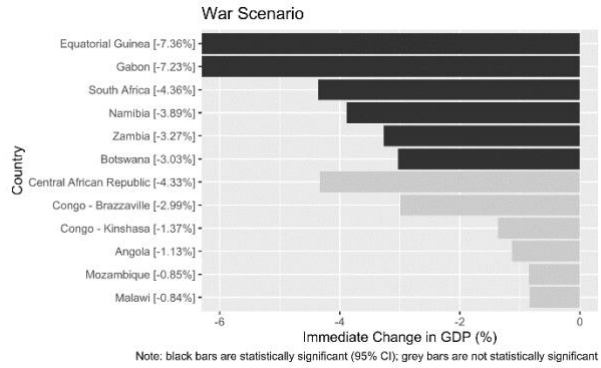
Northern Africa



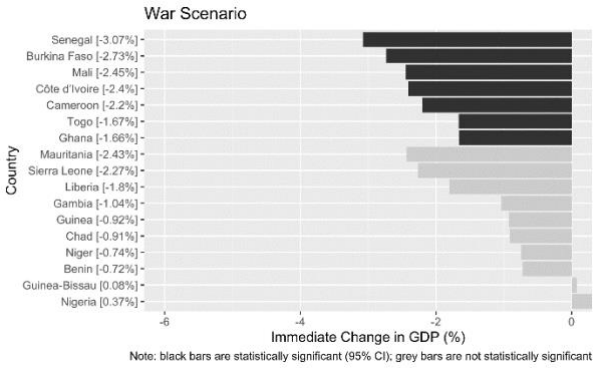
Southern and Central Africa



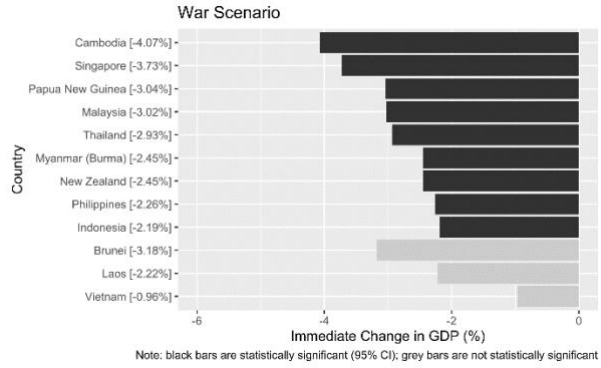
Western Africa



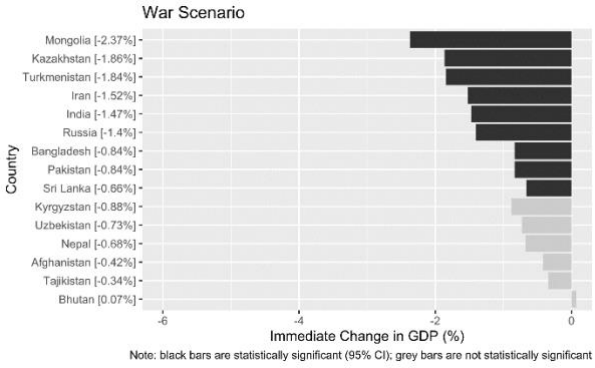
Southeastern Asia



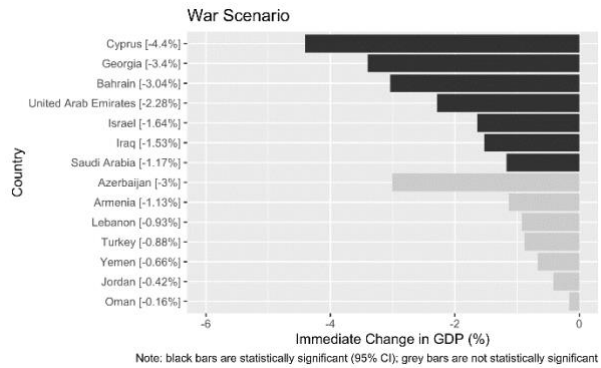
South and Central Asia

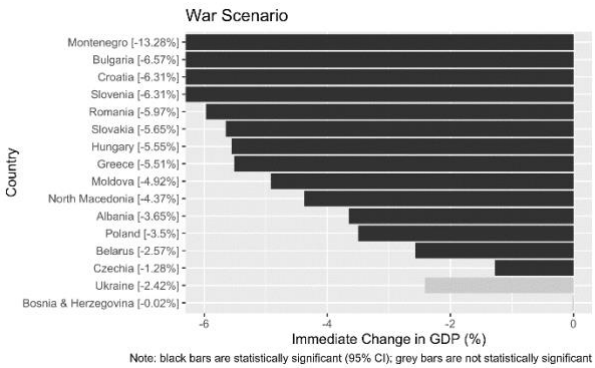


Western Asia and Middle East



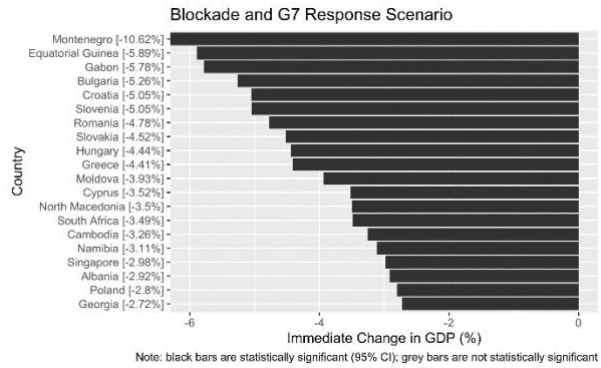
Eastern and Southern Europe

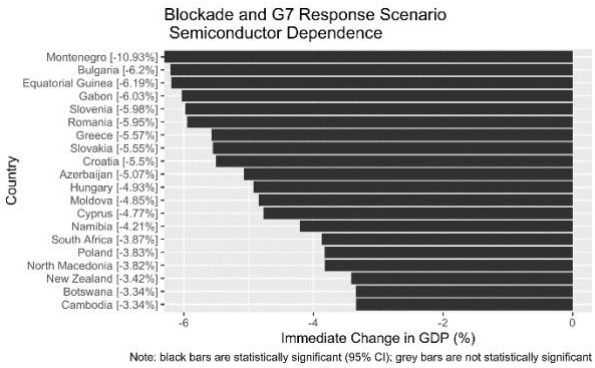




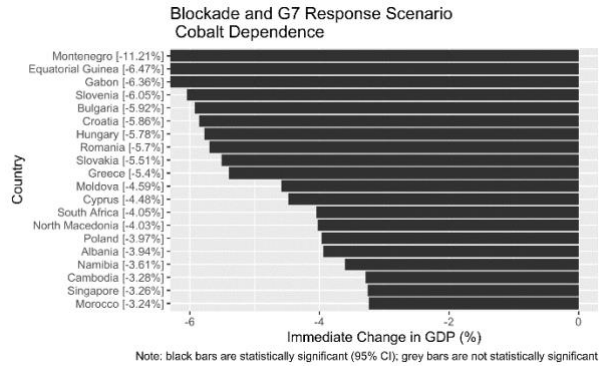
The panel graphs in Table 13 focus on the top 20 responses to Scenario V impulses, with consideration for disruptions in the trade of specific goods. After the baseline scenario, the other panels pertain to additional pulses to the respective trade in specific goods, with countries weighted by their trade in the respective good. By accounting for disruptions to specific goods, we observe some changes in the estimated severities of the economic declines, with higher severities observed when there are disruptions to the semiconductors and nickel markets. However, we only observe a few changes in the lists and orderings of the most-affected economies. This suggests the baseline models are already accounting for how shocks to the economies of Taiwan, the PRC, and the G7 (as well as Australia and South Korea) will lead to disruptions in these specific markets.

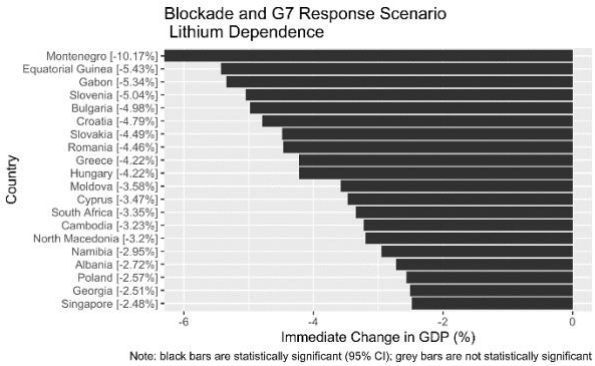
Baseline	Semiconductors





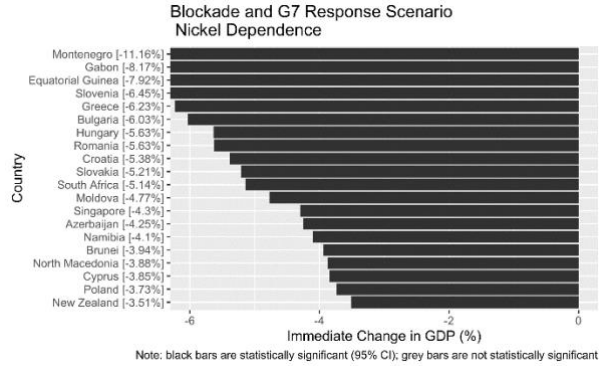
Cobalt	Lithium

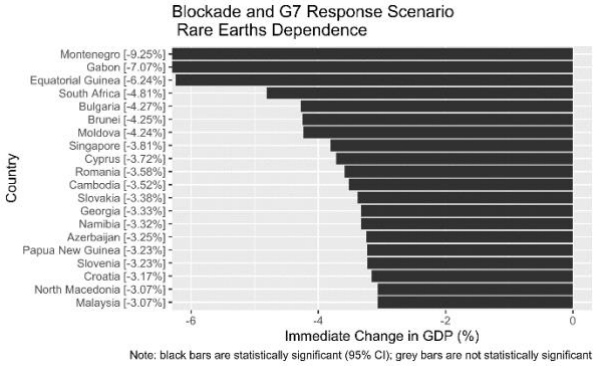




Nickel

Rare Earths





9. Annex 3. Methodological Notes on Network Analysis

We use descriptive analysis of network measures, including node-level characteristics, weighted in-and-out degrees, eigenvector centrality, and network efficiency.

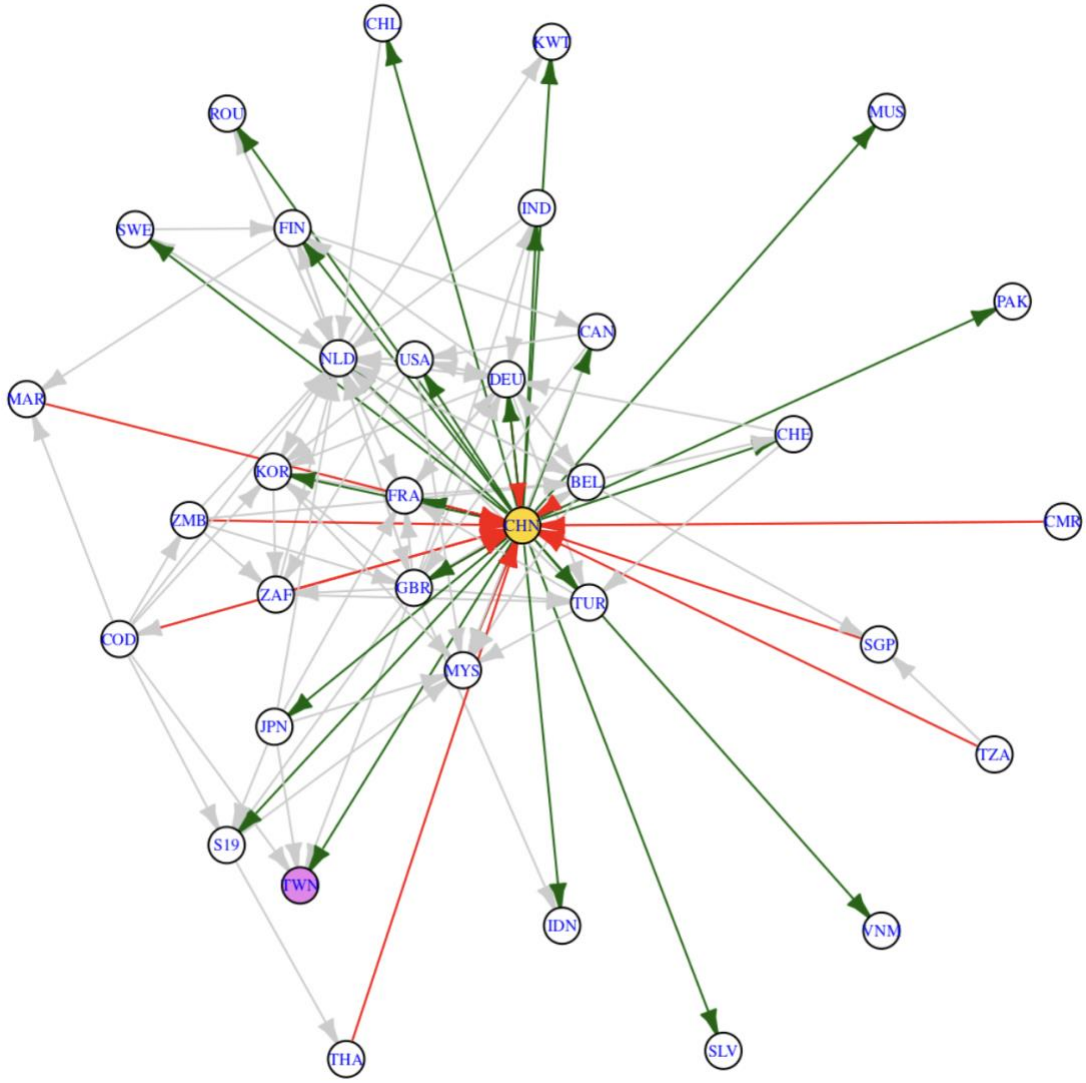
Weighted In-and-out degrees indicate the number of incoming or outgoing ties a network has, corresponding to the number of markets a particular country imports from or exports to, weighted by total volume. Eigenvector centrality indicates influential nodes in the network, those that are well-connected to other nodes.

We also provide a network-level measure, network efficiency. This is used to assess how much less efficient a network becomes after removing one or more nodes. Network efficiency measures how far on average each pair of nodes are from each other in the network. A less efficient network means that commodities must travel longer, on average, to reach their destinations. In this context, this could take the form of greater shipping costs, re-routing of trade due to sanctions or instability, and more potential for disruption along trade routes. Table 5 earlier in the report summarizes the definition of these measures and their real-world corresponding concepts. We use both 2022 and, whenever appropriate, 2023 data, with the understanding that for some commodities the 2023 may still be updating.

10. Annex 4. Cobalt network analysis

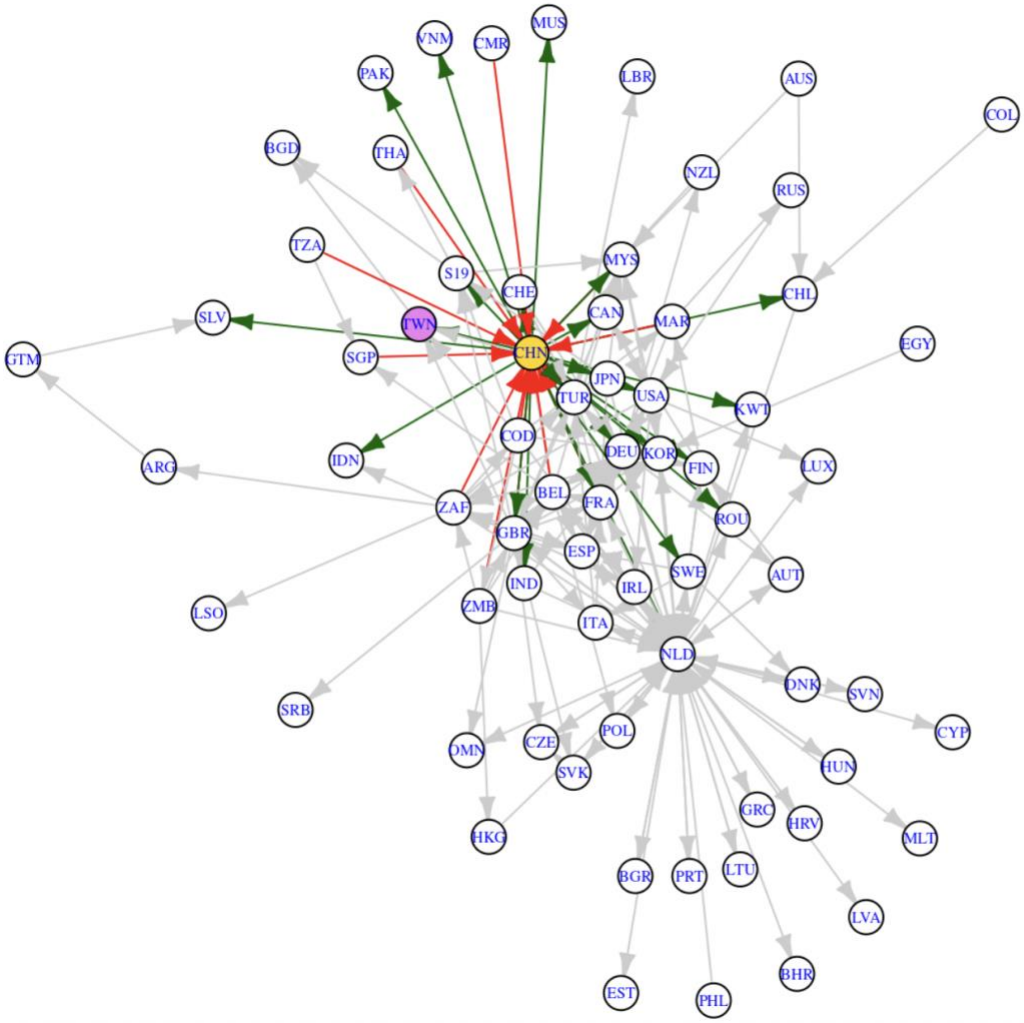
The network figures for the cobalt trade network (total, 1st degree, 2nd degree, and regional networks).

Figure 4. 1st degree connections of PRC-centric cobalt trade network in 2022



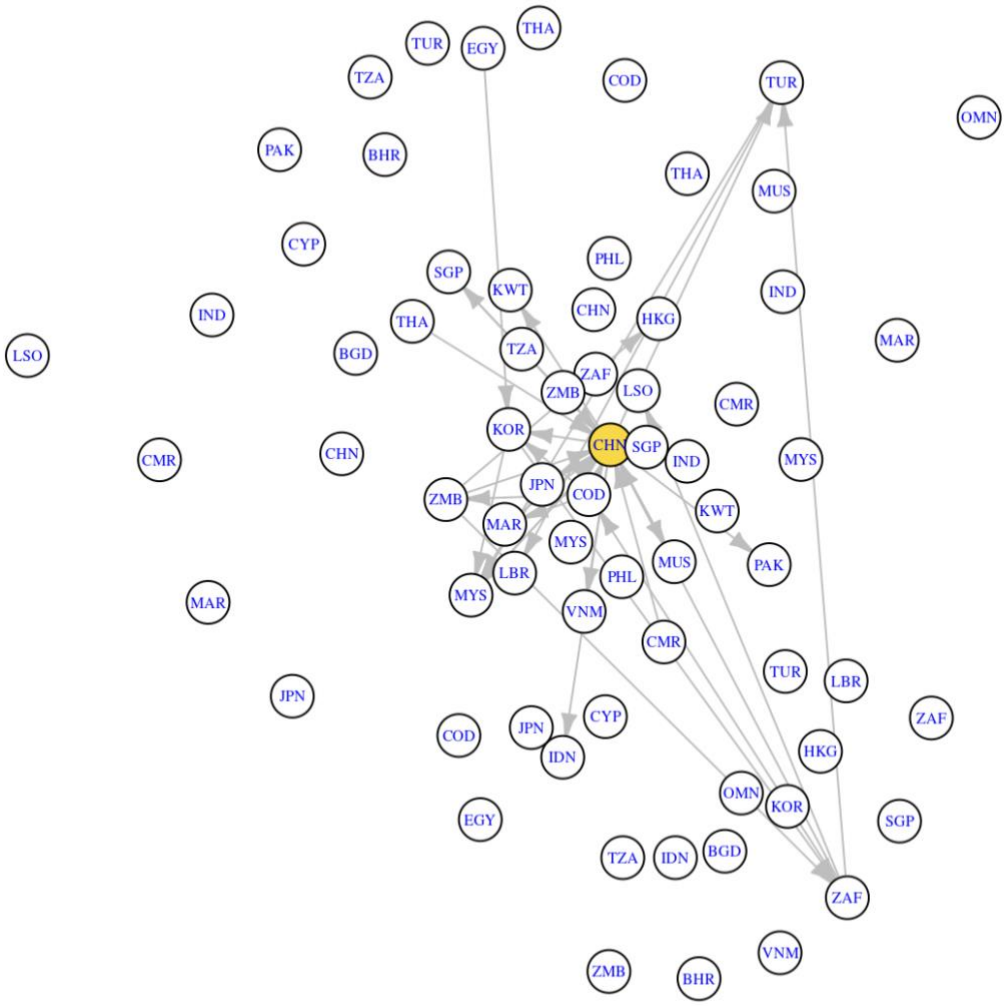
Note: The PRC imports from many countries including the Democratic Republic of the Congo, Zambia, Thailand, Cameroon, Singapore, and Tanzania, and exports to many countries, including the United States, United Kingdom, Germany, India, Canada, Indonesia, Korea, France, Turkey, and Switzerland.

Figure 5. 1st and 2nd degree connections of PRC and Taiwan cobalt trade network in 2022



Note: 1st and 2nd degree connections of PRC and Taiwan cobalt trade network in 2022. The most notable node is the Netherlands (bottom right), which imports cobalt from the PRC and then exports to many European countries, including Poland, Czechia, Bulgaria, Portugal, Lithuania, Greece, and Hungary, which are further connected to more countries.

Figure 6. Asia and Africa Cobalt Networks in 2022



Note: Subgraph (Asia and Africa) of the 2022 cobalt trade network. This graph shows countries in Asia and Africa, and countries with many connections including South Africa and Turkey.

11. Annex 5. Tie Formation Analysis

Section 5.2 outlines the importance of the PRC and Taiwan in the international trade network for various commodities. However, it is also helpful to understand the probability that alternative trade ties are formed to see if the spillover effects of a conflict could be mitigated. Thus, we employ the exponential random graph models (ERGM), to predict the likelihood of future ties. ERGMs are used to explain factors affecting the topology of a network. ERGMs also allow for inferences on predicting links between nodes.

Predicting link formation between unconnected network nodes provides a useful perspective into markets and sources of commodities countries may turn to as alternatives if access to PRC market and resources is constrained in a conflict scenario, whether due to sanctions, maritime restrictions, or decreased Chinese economic capacity. ERGM provides a set of coefficients that would allow us to assess the likelihood that two nodes would establish a link by using fitted coefficients and input that could be set externally.

We can use the coefficients and given inputs to calculate the probability of ties between two given nodes. For example, we calculated that the likelihood of a link forming between Malaysia and Indonesia in trade in semiconductors is 74.9 percent, when accounting for GDP growth rates, inflation rates, and political stability.

Undoubtedly, this value is subject to changes in other values, such as GDP growth rate, inflation level, and political stability. A conflict between the PRC and Taiwan is also likely to change these countries' GDP growth rate, inflation level, and political stability. For example, we assume changes in these values after the PRC-Taiwan conflict, such as a 10 percent decrease in GDP growth rate, 20 percent increase in inflation, and 15 percent decrease in political stability and Freedom House's Freedom in the World Index score as leaders crack down on dissents. Holding the semiconductor trade values and coefficients constant, these changes are likely to lead to a 0.47 percent likelihood of a trade increase between these two countries.

The are limitations to utilizing ERGM in our context, which is why we include this analysis in the Annex. First, the data we use for node attributes are obtained primarily from the World Bank, the International Monetary Fund, and the United Nations. Taiwan is absent from these datasets, and the networks used to obtain coefficients therefore do not include it. This is less problematic for commodity networks such as nickel or cobalt, where Taiwan plays very minor roles. However, it is less appropriate for semiconductors and high-technology products. Thus, the coefficients obtained for those networks should be used with this caveat in mind. Relatedly, ERGM is unable to handle missing data for node attributes. Whenever missing data occurs, depending on the variable, we either impute the missing data with the mean of the variable from other observations, or we set it to 0. Lastly, an assumption must be made that the factors driving the underlying connections do not change when we interfere with the network.

We use the 2022 trade network data for each of the commodities to estimate coefficients. It is a more parsimonious model, both due to data constraints and efficiency. We include two network features, the number of links in the network and the number of reciprocal dyads in the network. As trade occurs more frequently between democracies than mixed-regime dyads, at the dyad level, we include regime

similarity, proxied by Freedom House's Freedom in the World Index. At the node level, we include GDP growth (%), inflation rate (%), and political stability.[44]

Table 14 shows the coefficients obtained through ERGM. The coefficients are in log-odds. We extracted a backbone network, one that comprises of the most important nodes and linkages, for each of the commodities to conduct ERGM analysis.

Table 14. Coefficients Obtained through ERGM

Coefficients (critical minerals)						
	Nickel	Stainless steel	Cobalt	Refined cobalt	Lithium	Lithium cells and batteries
Edges	-3.804132	-4.2309900	-3.939817	-4.183520	3.104034	-4.0230664
Mutual links	2.246952	3.0896919	2.798064	2.846741	1.779004	2.9540813
GDP growth	0.049197	-0.0222338	-0.002009*	0.032121	-0.038285	-0.0065443*
Political stability	0.384893	0.4307170	0.289663	0.347131	0.185583	0.3582163
Inflation	-0.007790*	-0.0001566*	0.002784*	0.001821*	0.001100*	-0.0009126*
Diff. in FHI	0.001358*	0.0006215 *	0.004881	0.009045	-0.032766	-0.0045709

Coefficients (semiconductors)			
	Semiconductors	Cellphones	Delivery trucks
Edges	-4.0517731	-4.3874930	-4.1764187
Mutual links	3.7622709	2.8705140	2.8737870
GDP growth	-0.0015964	0.0015623 *	0.0129253
Political stability	0.1166157	-0.2192743	-0.0846377
Inflation	0.0027978	0.0009004 *	-0.0007106 *
Diff. in FHI	-0.0031902	0.0006883 *	-0.0025746

**Not statistically significant*

We can use the coefficients and given inputs to calculate the probability of ties between two given nodes. For example, if we wanted to calculate the likelihood of a link forming between the Philippines and Vietnam in the delivery trucks network, we use the following formula:

-4.176 * (change in the number of ties) + 2.874 * (change in the number of reciprocal ties) + 0.013 * (PHL GDP growth + VNM GDP growth) - 0.085 (PHL political stability + VNM political stability) - 0.002 (absolute difference between PHL and VNM FH score)

Because the coefficients are in log odds, we then need to convert it to probability with this formula:

[44] We do not control for some variables that may influence determining trade, such as regulatory quality or government effectiveness, because these are highly correlated with political stability.

exp(−3.982)1+exp(−3.982) = 1.83%exp−3.9821+exp−3.982 = 1.83%

The scenarios inform us of how different inputs may or will behave. Combining the insights from previous sections' analysis with tie formation allows us to estimate the likelihood that an alternative market or trading partner may be available. This would enable better planning and calculation of potential losses from cross-strait conflict on a commodity level.

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