T20 Policy Brief

G20 BRASIL 2024

T20 Brasil 2024 Let's rethink the world

Task Force 04

TRADE AND INVESTMENT FOR SUSTAINABLE AND INCLUSIVE GROWTH

A Call for Granular Supply Network Data for Navigating the Climate Transition

Mathilde Bossut, Doctoral researcher, Frankfurt School of Finance & Management (Germany)

Christian Diem, Senior Scientist, PostDoc, Complexity Science Hub (Austria)

Johannes Stangl, Doctoral researcher, Complexity Science Hub (Austria)

Anton Pichler, Postdoctoral Researcher, Vienna University of Economics and Business (Austria)

Stefan Thurner, President, Complexity Science Hub (Austria)

Ulf Moslener, Professor, Frankfurt School of Finance & Management (Germany)

Catherine Marchewitz, Senior Researcher, DIW Berlin (Germany)

Karsten Neuhoff, Professor, TU Berlin, and HEad of Department Climate Policy, DIW Berlin (Germany)

David N. Bresch, Professor, ETH Chair of Weather and Climate Risks (Switzerland)

TF04

Abstract

Recently, a series of crises, such as the COVID-19 pandemic, the global chip shortage, or the disruptions in the Suez and Panama Canal, have highlighted interdependencies and vulnerabilities of international supply chains (SCs). Those events demonstrated that isolated incidents can have significant repercussions on global trade. Under global warming, such disruptions are expected to become more frequent and more intense, increasing pressures on supply chains. In this policy brief, we point out that the current state of (national and international) supply chain data leaves us unequipped to identify, quantify and mitigate climate risk exposure in supply networks.

We identify three main ways the G20 can lead efforts to make the global economy more resilient. First, the G20 should encourage individual countries to collect and manage national supply network data to strengthen local resilience. Second, the G20 should establish an institutional framework for international cooperation to quantify, monitor, and identify global supply network risks. Finally, the G20 should take advantage of the acquired knowledge to increase the global supply network's resilience to climate change and better plan adaptation and mitigation efforts.

Keywords: supply chain, supply networks, climate resilience, green transition, bottlenecks, shock propagation, climate risks

Diagnosis of the Issue

Understanding the Impact of Climate Change on Value Chains

Supply chains, the backbones of our economies, can amplify economic shocks. The ability of modern economies to produce goods and services depends on an intricate web of national and global supply chains. As a consequence, international trade accounts for no less than 63% of global GDP (World Bank, 2023). These supply chains are created and operated by an estimated 300 million firms that are connected through a network of 12 billion supply chain relations (Pichler et al., 2023). Natural disasters, disease outbreaks, conflicts, or policy changes - more present under global warming - cause supply and demand shocks to firms that propagate along this supply network, leading to substantial indirect and economic and social costs.

Climate change is posing major challenges to supply chains. Under the current carbon emission trajectory, global average temperature is expected to increase by 2.9°C by 2050 (UNEP, 2023). Consequently, severe repercussions on weather patterns, climate extremes, biodiversity, ecosystems and human livelihood as well as efforts in climate mitigation and adaptation will raise significant challenges for firms and people worldwide (IPCC, 2023). As a result, disruptions in production and trading routes might emerge from destroyed and obstructed capital (e.g., production sites, warehouses, power plants) and infrastructure (e.g., ports, roads, power grid) while uncertainty and decrease in resource availability (e.g., water, energy, raw materials), output (e.g, crop yields) and labour performance will impact productivity. In addition, transition risks, such as regulations (e.g., quotas, tariffs, carbon taxes) and the rapid roll-out of green technologies might lead to asset stranding and reduced firm competitiveness and profitability in carbon-intensive sectors. If firms fail to adapt, such climate risks can be vastly amplified by shock propagation along the global supply network.

Climate shocks generate supply and demand shocks affecting companies located upstream and downstream in the supply network. Shocks impact the economies directly and indirectly, whereby the indirect effects can be drastically larger than the direct ones (Hallegatte, 2008). In the aftermath of the 2011 Tsunami in Japan, not only did 4th tier suppliers and customers of the directly affected firms face significant losses in revenue across Japan (Carvalho et al., 2021), but the shock propagated further to the US where it caused an approximate drop of 1% in total manufacturing and almost 2% in durable goods production (Boehm et al., 2019).

Supply chain dynamics might amplify shocks from physical and transition risks. Firms affected by climate-related disasters show signs of worsened competitiveness (Pankratz, 2023), increasing their probability of default. In conjunction with stock and price fluctuations, delays and disruptions, such physical climate risks can lead to a substantial restructuring of global supply chains. In contrast, the advent of green technologies will render a variety of products and businesses outdated, along with some of their direct and indirect suppliers. Similarly, currently discussed proposals on Scope 3 emissions regulations would lead firms to drop carbon-intensive (in-)direct suppliers, while creating demand for carbon-efficient ones. These dynamics will rewire the existing supply network and form new critical dependencies. The potential second-order effects of shock propagation and the rewiring of supply chains remain a blind spot of significant economic risk.

The current lack of granular supply chain data prevents a comprehensive assessment of climate and transition risks in supply chains and their (in-)direct impact on economic stability. The G20 should spearhead overcoming this fundamental lack of data and assessment. G20 countries can lead the collection of data, agree on standards, and join data for critical supply chains (e.g., food, medicine), to enable policies for enhancing resilience in supply chains against climate change.

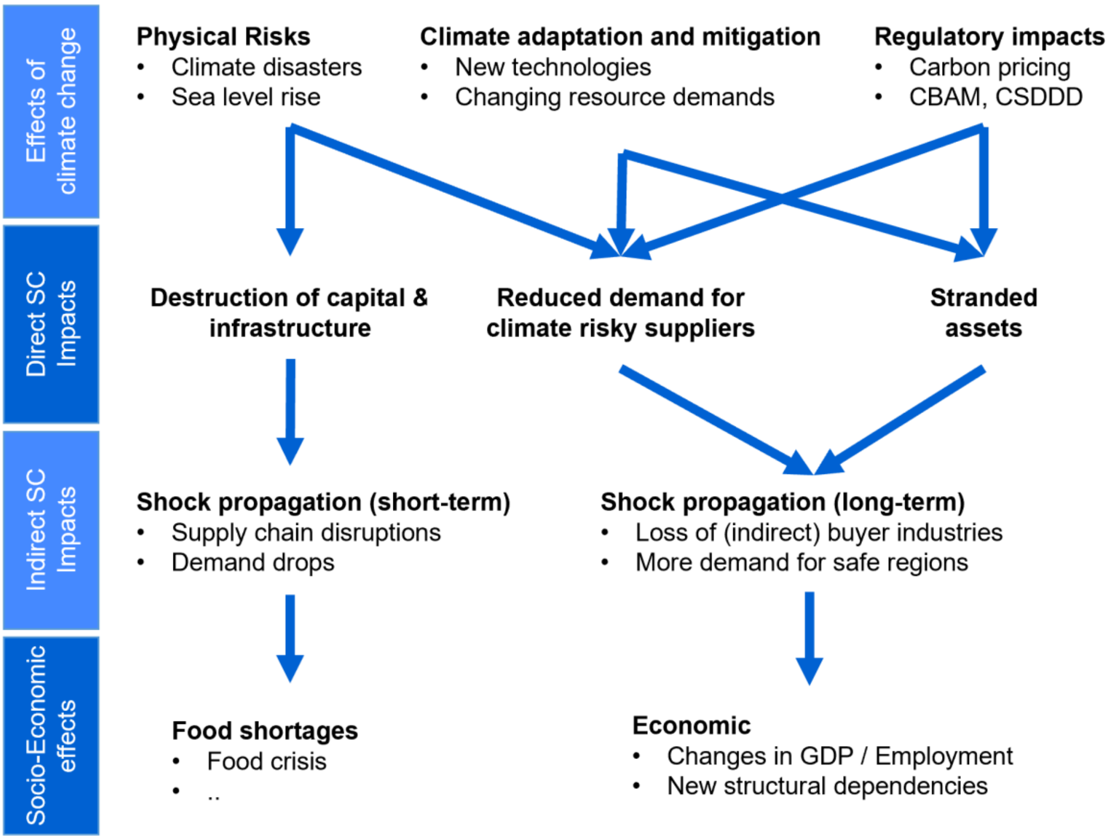

FIGURE 1: Supply chain exposure to climate change and cascading effects

Recommendations

Improved Supply Chain Network Data for Increased Climate Resilience

1. The G20 should encourage national mapping of supply networks for climate risks exposure assessment.

The non-negotiable basis for quantifying supply chain-mediated climate risks is comprehensive granular supply network data. Each country shall start by reconstructing a map of its own national supply networks. This can be achieved through using value-added tax data, payment flow data, or commercial data providers. Dozens of countries – such as Brazil, Spain, India, Mexico and Japan – hold unexploited comprehensive datasets where almost all domestic supplier-buyer relationships between firms in a country are known in a time-resolved manner (Pichler, 2023). Complementarily, G20 countries should encourage firm-level disclosure of their suppliers, as e.g., major customer disclosure in firms' SEC filings. We encourage the Task Force on Climate Related Financial Disclosures (TCFD) group to explicitly integrate such assessment in their recommendations.

Nationwide firm-level supply network datasets enable countries to assess how local supply network disruptions will unfold under climate change and climate transition scenarios. The corresponding methods are readily available to appraise the economic losses stemming from post-disaster supply chain contagion (Inoue & Todo, 2019, Diem et al., 2024) and to quantify economic systemic risks (Diem et al., 2022). Resilience to natural disasters could be assessed by overlapping firms' physical assets with hazard maps resulting from probabilistic models (Aznar-Siguan and Bresch, 2019 and Ciullo et al., 2021). Examining changes in economic output under various climate scenarios will provide additional insights. Similarly, national governments can pre-emptively assess the effects of climate policies, e.g., a CO_2 price, on supply networks to estimate and minimise stress on firms, costs (Stangl et al, 2024), and financial losses (Tabachova et al., 2023) and identify firms with significant default risk.

Granular supply network data informs decision-making and economic planning for climate adaptation and green transition. Policy makers can actively engage to diversify supply chains and minimise systemic risks. This involves fostering the suppliers' diversification of customers, employee retraining, and up-skilling in high-risk sectors, as well as investing in climate adaptation projects that are specifically tailored to high-concentration, high-risk, and highly relevant sectors.

Methodologies should consider international exposures to quantify dependencies on climate shocks that originate abroad. As a first approximation, countries can simulate "imported" external shocks with predefined climate scenarios (NGFS, 2023; Ballesteros, 2023). A more advanced way of quantifying climate risks is to extend national supply network data by linking them to customs data to see direct import and export dependencies of individual firms (Dhyne et al., 2021). However, only efforts towards cooperation in understanding cross-country firm-level dependencies will muster a complete picture.

2. The G20 should join efforts to obtain a complete picture of international supply networks to identify, quantify and monitor climate-related risks.

There are limits to national supply network data sets. National supply networks are exposed to firms in other countries sometimes multiple tiers away upstream and/or downstream. These can face heterogeneous physical and transition risks and will not be visible in a national supply network and customs data of a single country. Therefore, it is of utmost importance to gradually create a cohesive map of the global supply network (Pichler, 2023).

Joining national datasets vastly improves the assessment of climate risks of individual countries. The G20 should lead collaborative efforts to obtain a better picture of inter-regional firm-level supply networks and conduct coordinated risk assessments. Solutions like distributed computing and federated learning are ways to calculate and communicate exposures.

Standardisation of national supply network data collection facilitates collaborative efforts on cross-border climate risk mitigation. The G20 represents a vast share of the global supply network. Agreeing on data standards and usage will be a cornerstone in overcoming the current supply network data shortage and a foundation for minimally invasive climate mitigation strategies. It will allow countries to improve and coordinate their national and cross-country climate risk strategies in fair, transparent and mutually beneficial ways.

New international institutions become necessary to guarantee transparent, fair and trustworthy collection, integration, sharing, interpretation, and maintenance of the established data bodies.

3. The G20 should adopt data-driven policy measures to increase the international supply network resilience.

G20 should identify critical weaknesses through a comprehensive assessment of climate risk exposures in the global supply network. Key nodes in the network (e.g., specific firms or production facilities) and high-risk hotspots (e.g., critical production inputs; high geographical concentration of imported goods) could be identified and highlighted as “too relevant to fail” (Bresch et al., 2014).

International efforts should mitigate systemic risks emerging from key players in the global supply network. Recent research has shown that a total of US$122 billion of economic activity per year is at risk of ports’ exposure to climate extremes alone (Verschuur, 2023). In the aftermath of the 2008 financial crisis, G20 countries identified financial companies that were “too big to fail” and adopted the Basel III reforms to improve stability in the global financial network. To ensure economic resilience despite increased climate hazards, there is a need for a similar initiative for managing systemic risks in the global supply network - this time preventively.

G20 should engage in collaborative efforts for supply chain monitoring of critical and essential goods and services. In particular, food security and medical supply distribution are particularly vulnerable to climate change and losses in ecosystems and biodiversity (Ortiz, 2021). First, we recommend engaging in coordinated science-guided risk analysis on the exposure of supply chains critical for essential provisioning to climate shocks, employing methods like simulating multiple breadbasket failures (Gaupp, 2019). Second, based on nationally linked and monitored global supply networks, G20 should implement internationally operating early warning systems for acute disasters and encourage affected countries to simulate how these situations play out within their national supply networks.

G20 should initiate an international dialogue to support efficient economic crisis planning at the global scale. G20 policy makers should consider coordinating strategic geographic diversification at the firm- and industry level, resolving bottlenecks in key green transition relevant supply chains and devising efforts to resolve these bottlenecks (e.g., lithium, rare earths) as well as investing in climate resilience in vulnerable highly relevant nodes, with benefits ultimately trickling down to other parts of a densely connected global supply network.

	1 DATA COLLECTION	2 ASSESSMENT	3 ACTIONS
National governments	✓ Supply chain disclosures ✓ National supply network datasets ✓ firm-level physical exposures	✓ Climate hazards vulnerabilities ✓ Climate and net zero transition modelling	✓ Diversification strategies ✓ Retraining and Upskilling ✓ Targeted climate-resilient infrastructures
G20	✓ International standards for supply chain data ✓ TCFD framework encompassing supply chain disclosures ✓ Datasets on the global supply network	✓ Coordinated risks assessment ✓ “Too relevant to fail“ firms identification	✓ Adapted financial stability rules ✓ Early warning system ✓ Coordinated strategic geographic diversification ✓ Targeted investment in climate resilience and adaptation

Table 1. A call for action: building climate-relevant supply chains at the national and international scale

Scenario of outcomes

Climate change will have disruptive effects on national and global supply chains. A better and systematic data-driven understanding of international supply network dynamics is a crucial cornerstone to foster increased resilience and adaptation to mitigate climate impacts and plan a socially acceptable green transition.

Countries knowing their domestic supply network and proactively assessing their exposure to international disruptions will have a competitive advantage in the wake of increasingly more severe supply chain-mediated climate risks. Countries that can identify firms highly vulnerable to climate risks are better equipped to strategize and plan for climate resilience (ECA working group, 2009). Not only can they initiate dialogues with vulnerable critical firms to strengthen their resilience efforts and build an economy robust to shocks. They can also capitalise on the structural changes inherent in transitioning towards a more sustainable and climate-resilient economy. Early identification of the most affected branches and firms enables countries to retrain, and up-skill affected employees. This will enhance firm performance and foster growth, while also resulting in lower unemployment and improved livelihoods of citizens

International cooperation on standardised supply network data will greatly improve countries' abilities to assess exposures to climate risks located in other parts of the global supply network. This increased visibility of risks should allow for more resilient economies that can transition smoother with less unemployment. The identification of high systemic risk firms and infrastructure sites based on an international supply network dataset will allow for better targeted investments in resilience-enhancing measures (e.g., which firms need infrastructure diversification, where should critical production sites be placed not only geographically, but also within the supply network).

This can reduce costs and leverage climate adaption budgets, which is relevant for poorer countries with limited resources. Demonstrating that the economic losses of critical supply chain node failures can have global repercussions, may incentivize countries to collaborate in protecting these critical points. Increased levels of resilience can decrease food supply shortages and avoid peaks in food prices. The cooperation to mitigate bottlenecks in the green transition can lower prices for critical products while facilitating a faster and more effective transition.

International supply chains will amplify economic losses resulting from climate change-induced disruptions. Managed properly, international supply chain players could capitalise on regional differences in climate impacts to minimise vulnerability to climate change (Janssens, 2020; Janssens, 2021). Overcoming the current supply network data gap is essential for making the international supply network more resilient and allowing for a socially acceptable minimally invasive green transition. This requires establishing national databases, international data collaborations, and implementing systematic assessments of expected supply chain-mediated climate risks.

Recommendations	Climate Change Risks & Impacts	Climate Transition
Understanding of national supply networks'exposure to climate risks.	✓ Understanding and preventing indirect economic effects arising with climate change ✓ Identifying high-risks sectors and geographic areas.	✓ Building national competitivity advantages ✓ Minimising economic and social costs of the green transition
Provide a complete picture of the global supply network	✓ Targeted investment in climate resilience and adaptation ✓ Identifying „too relevant to fail“ firms exposed to climate hazards	✓ Identifying and mitigating bottlenecks in the green transition ✓ Identifying „too relevant to fail“ firms to accompany in planned green transition
Adopt data-driven climate adaptation and mitigation measures	✓ Preventing food and other critical goods shortage	✓ Capitalizing on regional climate differences as an adaptation mechanism

Table 2. Understanding supply chains dynamics leads to efficient climate resilience and green transition

References

Aznar-Siguan, G., and Bresch, D. N., CLIMADA v1: a global weather and climate risk assessment platform, *Geosci. Model Dev.*, no. 12, (2019) 3085–3097, ,https://doi.org/10.5194/gmd-12-3085-2019.

Ballestero, F., et. al. , Scenario Anaysis for Net Zero: The Applicability of Climate Neutrality Studies for Transitioning Firms - German Building Sector and Energy-Intensive Industry, (2023) Discussion Papers 2048, 32S, 2023, https://shorturl.at/jvBMQ

Boehm, C. E., Flaaen, A. , and Pandalai-Nayar, N., 'Input Linkages and the Transmission of Shocks: Firm-Level Evidence 2011 Tōhoku Earthquake'. *The Review of Economics and Statistics* 101, no. 1 (1 March 2019): 60–75. https://doi.org/10.1162/rest_a_00750.

Bresch, D. N., Berghuijs, J., Egloff, R., and Kupers, R., A resilience lens for enterprise risk Management. In „Turbulence", ed. Kupers, Amsterdam University Press. (2014) https://shorturl.at/xzAB9

Carvalho, V.M., Nirei, M., Saito, Y.U., and Tahbaz-Salehi, A., 'Supply Chain Disruptions: Evidence from the Great East Japan Earthquake*'. *The Quarterly Journal of Economics* 136, no. 2 (1 May 2021): 1255–1321. https://doi.org/10.1093/qje/qjaa044.

Ciullo, A., Martius, O., Strobl, E. and Bresch, D., N., 2021: A framework for building climate storylines based on downward counterfactuals: European Union Solidarity fund. *Climate Risk Management*, **33**, 100349, https://doi.org/10.1016/j.crm.2021.100349

Dhyne, E., Kikkawa, A. K., Mogstad, M., & Tintelnot, F. (2021). Trade and domestic production networks. *The Review of Economic Studies*, *88*(2), 643-668. https://doi.org/10.1093/restud/rdaa062

Diem, C., Borsos, C., Reisch, T., Kertész, J., and Thurner, S., 'Estimating the Loss of Economic Predictability from Aggregating Firm-Level Production Networks'. *PNAS Nexus* 3, no. 3 (1 March 2024): pgae064. https://doi.org/10.1093/pnasnexus/pgae064.

———. 'Quantifying Firm-Level Economic Systemic Risk from Nation-Wide Supply Networks'. *Scientific Reports* 12, no. 1 (11 May 2022): 7719. https://doi.org/10.1038/s41598-022-11522-z.

ECA working group, Climate-resilient development: A framework for decision-making, 2009, https://shorturl.at/biHMV

IPCC, 2023: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 25 July 2023. https://doi.org/10.59327/IPCC/AR6-9789291691647.

Gaupp, F., Hall, J., Hochrainer-Stigler, S., and Dadson S., 'Changing Risks of Simultaneous Global Breadbasket Failure'. *Nature Climate Change* 10, no. 1 (January 2020): 54–57. https://doi.org/10.1038/s41558-019-0600-z.

Hallegatte, S. 'An Adaptive Regional Input-Output Model and Its Application to the Assessment of the Economic Cost of Katrina'. *Risk Analysis* 28, no. 3 (2008): 779–99. https://doi.org/10.1111/j.1539-6924.2008.01046.x.

Inoue, H., and Todo, Y. 'Firm-Level Propagation of Shocks through Supply-Chain Networks'. *Nature Sustainability* 2, no. 9 (September 2019): 841–47. https://doi.org/10.1038/s41893-019-0351-x.

Janssens, C., Havlík, P., et al. 'Global Hunger and Climate Change Adaptation through International Trade'. *Nature Climate Change* 10, no. 9 (September 2020): 829–35. https://doi.org/10.1038/s41558-020-0847-4.

———. ‘International Trade Is a Key Component of Climate Change Adaptation’. *Nature Climate Change* 11, no. 11 (November 2021): 915–16. https://doi.org/10.1038/s41558-021-01201-8.

NGFS Scenarios Portal. ‘NGFS Scenarios Portal’. Accessed 30 March 2024. https://www.ngfs.net/ngfs-scenarios-portal/.

Ortiz, A. M. D., Outhwaite, C.L., Dalin, C., and Newbold, T. ‘A Review of the Interactions between Biodiversity, Agriculture, Climate Change, and International Trade: Research and Policy Priorities’. *One Earth* 4, no. 1 (January 2021): 88–101. https://doi.org/10.1016/j.oneear.2020.12.008.

Pankratz, N. M. C., and Schiller, C. ‘Climate Change and Adaptation in Global Supply-Chain Networks’, 25 June 2021. https://doi.org/10.2139/ssrn.3475416.

Pichler, A., Diem, C., et al. ‘Building an Alliance to Map Global Supply Networks’. *Science* 382, no. 6668 (20 October 2023): 270–72. https://doi.org/10.1126/science.adi7521.

Stangl, J., Borsos, A., Diem, C., Reisch, T., and Thurner, S. ‘Firm-level supply chains to minimize unemployment and economic losses in rapid decarbonization scenarios’. arXiv (24 April 2024) https://doi.org/10.48550/arXiv.2302.08987.

Sun, Y., Zhu, S., Wang, D. et al. Global supply chains amplify economic costs of future extreme heat risk. Nature 627, 797–804 (2024). https://doi.org/10.1038/s41586-024-07147-z

Tabachová, Z., Diem, C., Borsos, A., Burger, C., and Thurner, S. ‘Estimating the Impact of Supply Chain Network Contagion on Financial Stability’. arXiv, 4 May 2023. https://doi.org/10.48550/arXiv.2305.04865.

UNEP. ‘Emissions Gap Report 2023’, 11 August 2023. http://www.unep.org/resources/emissions-gap-report-2023.

Verschuur, J., Koks, E.E. and Hall, J.H. 'Systemic Risks from Climate-Related Disruptions at Ports'. *Nature Climate Change* 13, no. 8 (August 2023): 804–6. https://doi.org/10.1038/s41558-023-01754-w.

World Bank Open Data. 'World Bank Open Data'. Accessed 30 March 2024. https://data.worldbank.org.

G20 BRASIL 2024
BUILDING A JUST WORLD
AND A SUSTAINABLE PLANET

T20 Brasil 2024
Let's rethink the world

Let's
rethink
the world

CEBRI
Rethink Tank

FUNDAÇÃO
ALEXANDRE
DE GUSMÃO

ipea
Instituto de Pesquisa
Econômica Aplicada