The evolution of global production networks after extreme weather events: an out-of-equilibrium approach

Antoine Mandel
Camilla Pelosi
Université Paris 1 Panthéon-Sorbonne

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1 Introduction and motivation

The adverse effects of climate change on economic systems and human communities are becoming increasingly evident, manifesting through more frequent and severe extreme weather events [IPCC, 2022]. This has prompted a growing body of literature to explore how these impacts propagate through socio-economic networks ([Barrot and Sauvagnat, 2016], [Carvalho et al., 2021]). However, while these studies typically consider how climate shocks propagate based on existing economic structures, they do not address how such shocks may influence the evolution of production networks themselves. This research addresses this gap by adopting a bottom-up approach to assess the dynamic impacts of extreme weather events on supply chain structures.

2 Methodology

I build on the multi-sector disequilibrium agent-based model introduced by Mandel and Veetil [2020], which features interrelationships between buyers and sellers and is designed to assess how businesses react to disturbances, eventually affecting aggregate variables. The model is extended by incorporating a nested CES production function, which allows for a clearer distinction between substitution away from a specific supplier of an intermediate good after a shock and substitution away from the intermediate good itself.

In this new setting, extreme weather events are represented as realizations of a stochastic process that directly impact the supply of labor and capital services in the affected regions, with propagation effects influencing the global economy. More specifically, extreme weather events are simulated with plant-level resolution, based on known frequencies for each time period in the simulation. Using vulnerability functions derived from the literature, the direct economic impact on production facilities is calculated. The propagation of these impacts through supply chain disruptions is then tracked, enabling firms to seek alternative suppliers when their existing ones are affected by environmental hazards. The key idea behind the substitution mechanism is that when the production levels of suppliers of intermediate inputs decline, their clients experience shortages. If these shortages surpass a specified threshold—indicated by missed deliveries—clients will actively seek out alternative suppliers.

3 (Preliminary) results

Preliminary results from simulations highlight two key findings. First, there is no direct correlation between output behaviour and the trend of direct losses. Although direct losses stabilize over time, output continues to decline steadily throughout the simulation period. This discrepancy indicates that factors beyond direct losses—such as propagation mechanisms, market dynamics driven by myopic expectations, and feedback loops—play a significant role in influencing output.

Second, relying solely on average values for risk assessment can lead to underestimating the actual risks. Averages tend to smooth out extreme variations and fail to capture the full extent of potential catastrophic scenarios. Similarly, the distribution of direct losses per firm shows that while most firms experience small to moderate losses, some face disproportionately higher losses. These extreme cases, combined with the fat-tailed nature of extreme weather distributions (Weitzman [2011]; Pindyck [2013]), underscore the need for a more nuanced approach to risk assessment that accounts for the full range of possible outcomes, rather than relying on averages alone.

4 Expected contributions

This research makes two key contributions. First, it elucidates how substitution dynamics following environmental shocks influence the evolution of input-output networks, projecting how global value chains may spatially reconfigure in response to climate-related disruptions. Second, by aggregating the effects of disruptions across production nodes, the study develops a bottom-up metric to assess the impact of extreme weather events on global GDP and production, providing a more granular understanding of economic vulnerabilities within supply chains.

References

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