Firm Adaptation in Production Networks: Evidence from Extreme Weather Events in Pakistan

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Introduction

- Increased frequency and severity of extreme weather events are key manifestations of projected climate change (IPCC 2021)
- Firms impacted directly (Indaco et al 2021) and via exposure of supply chain partners (Barrot & Sauvagnat 2016, Carvalho et al 2021)
- How costly these changes will be, and appropriate policy responses, depend on whether and how firms and economic systems adapt
- Firms' position in production networks may affect disaster exposure via network nodes (supply partner firms) and links (supply routes)
- Adaptive responses may involve complex network effects
- Adjustments may reflect both direct disruptive impacts of disasters and forward-looking decisions over future risk exposure

Key Questions

- Do firms adapt by changing production and network linkage decisions following natural disaster events?
  - What are the key margins of adaptation?
  - What mechanisms underlie these adaptive responses?
  - How important are adaptive decisions for aggregate outcomes?

Approach

- Examine firm responses to floods in Pakistan and their network effects
- Impacts on firm operations and road transport
- Adaptive adjustments to mitigate future flood risk
- Georeferenced microdata on firm networks from 2011-18
  Monthly data on near universe of firm-to-firm sales
- GPS tracker data on truck supply routes and disruptions
  Natural disaster and hazard exposure data
- Isolate forward-looking adaptive behavior from direct impacts using identification permitted by firm and route level flood disruption

Results

- Floods cause temporary disruption to firm operations and road usage
- Network effects key: 28% firms flooded, 78% experience supply partner flood, 46% buyer-seller pairs experience transport route flood
- Persistent adaptive adjustments to own, supplier and route flooding
  - Relocate to less flood-prone locations
  - Diversify supplier base (cf Castro-Vincenzi 2022)
  - Shift towards less flood-prone suppliers (cf Pankratz & Schiller 2021)
  - Shift towards suppliers reached via less flood-prone routes
  - Responses reflect forward-looking actions to reduce vulnerability
  - Identify changes in firm beliefs over flood risk
  - Evidence consistent with persistent learning mechanism

Thoughts I

- The adaptation is very quick? Does this mean something for adaptation channels? Could it be that same old suppliers are helping their purchasers source from other suppliers?
  - ▸ Diversification
- What is evidence in the literature in general on frictions to adaptation or just general optimizing frictions? Kleven and Waseem (2013) optimizing frictions?
- External Validity: Could it be that these Pakistani manufacturing firms are producing very basic goods and therefore it is easy to adjust? If you are producing more complex goods, it is harder to adjust as you would need very specific suppliers i.,e case of transistors in global supply chain disruptions?
- Forward looking adaptation hard to show empirically given data limitation but they do reasonably good job.

Thoughts II

- They disentangle forward looking adaptation from mechanical adaptation by showing that they are also shifting away from other non-flooded suppliers who have flood risk? But can this also be mediated by the mechanical adaptation since now you employ different routes or you just choose a group of suppliers instead of each supplier separately? It is hard to show this since they do not observe goods supplied by a given supplier but just the PKR amount of purchases from that supplier.
- The mechnical adaptation also has many channels such as it could be just that your old supplier cannot supply or that prices and economic environment has changed and hence you re-optimize? Importantly, they show firms respond to their own shocks and hence when your suppliers get a shock they also change their operations?
- People also asked how does a flood shock compare to other shocks such as financial shocks?

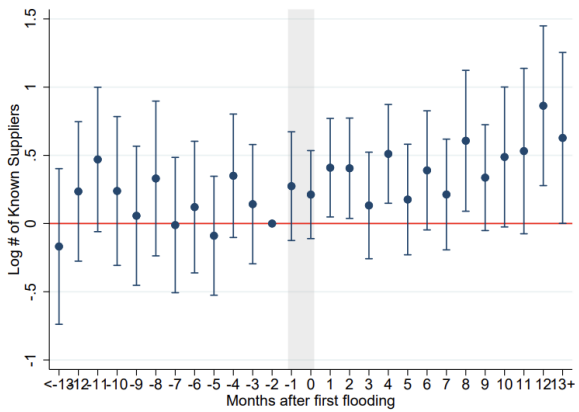
Thoughts III

- Similarly, where is this adjustment coming from? Are they trading off resilience to some other shocks in order to be more resilient to flood shocks?
- Technically firms could also search for new buyers or customers in response to shocks to places where they make sales? They do not study this!
- Similarly, what are effects on the firms up the supply chains? Low power to study this!
- What is governmet's response in terms of investments in flood shock resilient infrastructure?
- It would be good to study characteristics of new destinations and new suppliers.

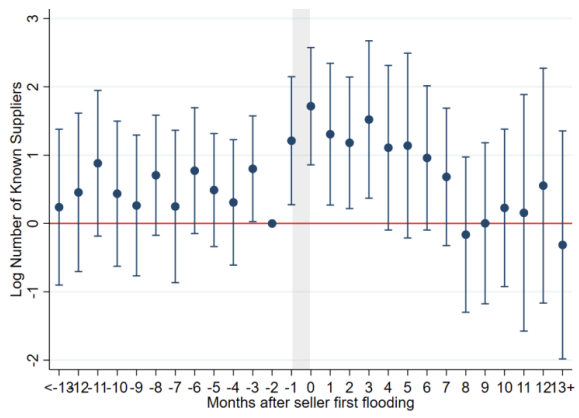
Appendix I

Flood-affected firms diversify suppliers temporarily

Direct exposure



Indirect exposure



(cross-reported links)

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Appendix II

Flood-affected firms shift activity towards safer suppliers

	Dependent Variable: Change in Supplier Risk	
	(1)	(2)
Own Max Flood Ext.	0.0158	-0.0685
	(0.0334)	(0.0923)
3m Suppliers Max Flood Ext.	-0.589***	-0.634***
	(0.0293)	(0.173)
Time FE	Yes	
District × Time FE		Yes
R^2	0.0030	0.0111
N	146,740	146,643

Standard errors in parentheses, clustered at the district-event (month) level.

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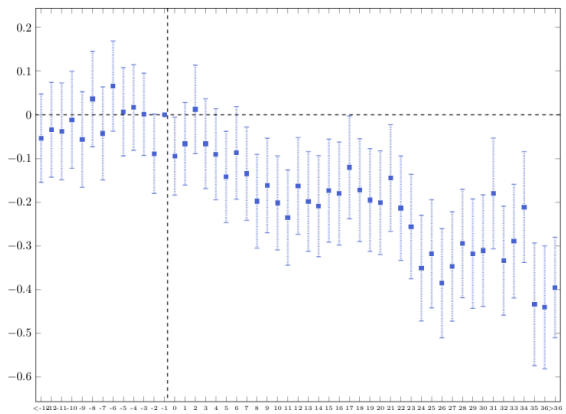
Appendix III

Temporary road flooding disrupts transactions persistently

- Short-lived flood disruption of transport routes between buyer-seller pairs $\Rightarrow$ persistent cessation of transactions between them



- Substitution away from supply partners reached by flooded routes driven by transactions ceasing rather than intensive margin reductions

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