A Bridge over Troubled Water: Flooding Shocks and Supply Chains

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The views expressed in this presentation are those of the authors and do not necessarily reflect the views of the National Bank of Belgium

Roadmap

Introduction

- Climate change as a global threat to living conditions and economic growth
  - Mitigation efforts insufficient to prevent damaging effects
  - Part of the costs of climate change related to extreme weather events

Introduction

- Number of days with very heavy precipitation over Europe has increased by 45% comparing 1981-1983 with the decades before (Fischer and Knutti, 2016)
- Probability of storms in coastal counties in the US has risen fourfold with the 1C increase in temperature (Bilal and Ross-Hansberg, 2023)

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- Production of goods and services organized around complex supply chains
  - Disruptions to the orderly flow of goods and services as a source of aggregate risk
  - Firm-level or regional shocks can propagate to have large adverse macroeconomic consequences

Economic Impact Natural Disasters

- Important to know what economic impact is of disasters
- Economic effects extreme weather events both local and propagated through supply chain

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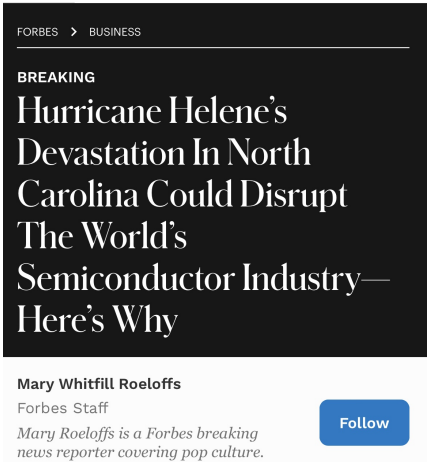
- Local:
  - Destruction production facilities
  - Destruction transport infrastructure
  - Workforce and human capital dislocated/hurt
- Supply chain effects outside the region
  - US affiliates of Japanese firms witnessed as well strong drop in output in response to Japanese earthquake in 2011
  - Just now: hurricane Helene in the US

Case in Point: Hurricane Helene



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BREAKING

Hurricane Helene's Devastation In North Carolina Could Disrupt The World's Semiconductor Industry—Here's Why

Mary Whitfill Roeloffs

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Follow

- Spruce Pine hard hit by hurricane Helene
- Home to large quartz mine (Sibelco)

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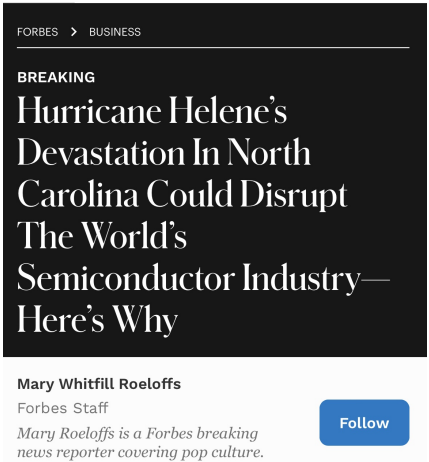
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- *"It is rare, unheard of almost, for a single site to control the global supply of a crucial material. If you want to get high-purity quartz—the kind you need to make those crucibles without which you can't make silicon wafers—it has to come from Spruce Pine."* *(Conway, 2023)*

This paper

- Look at natural disaster in Belgium: 2021 floods
- Make explicit distinction between:
  - Direct effects
  - Ripple effects through supply chain
- Explore important sources of firm heterogeneity
- Investigate supply chain responses

Roadmap

Related Literature

- Literature on macroeconomic effects of natural disasters (Noy 2009, Strobl 2011, 2012, Faccia et al. 2021, ...)

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  - Challenge idea that micro shocks cannot have large macro impact
  - Idiosyncratic shocks can affect production of other firms/sectors and have sizable aggregate effects

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  - Challenge idea that micro shocks cannot have large macro impact
  - Idiosyncratic shocks can affect production of other firms/sectors and have sizable aggregate effects
- Small literature that combines production networks models/data with natural disaster events (Boehm et al. 2019, Carvalho et al. 2021, Balboni et al. 2024)

Roadmap

2021 Floods

- July 2021: extreme rainfall caused severe flooding across Western Europe
  - Over 200 fatalities
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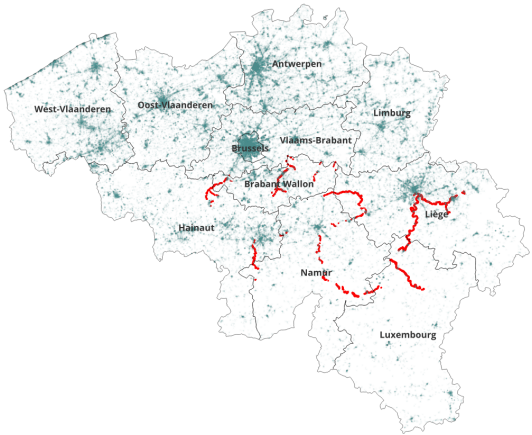
- July 2021: extreme rainfall caused severe flooding across Western Europe
  - Over 200 fatalities
  - Estimated cost of 10 billion EUR
- Belgium has been hard hit
  - Record rainfall around Liege (over 250mm per m^2 on some places)
  - 48,000 buildings flooded and 100,000 people affected
  - Damage to transport infrastructure

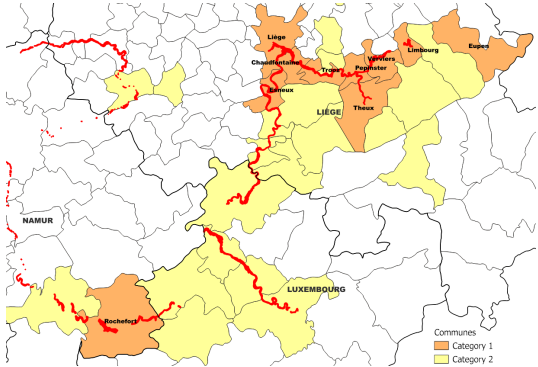
Floods 2021



- Firms active in/around flooded areas likely to be affected
  - Companies flooded
  - Damage to road infrastructure, employees absent, ...
- Figure maps firms and flooded rivers

Floods 2021

- Focus on most severely hit communes (category 1)
- Mostly located in the Vesdre valley



Roadmap

Data

- Combination of different data sources
  1. VAT database: sales on a quarterly base
  2. B2B database: yearly transaction value between Belgian firms
  3. Crossroad database: info on establishments
- Flooded firms:
  1. Operating in category 1 commune AND
  2. On a radius of 500 meters of a flooded area AND
  3. At least half of the establishments were located in flooded area

$\rightarrow$ $1,249$ **flooded firms present 4 quarters before and after event**

▸ Flooded Firms ▸ Summary Statistics

Roadmap

Empirical Strategy Direct Effects

- Difference-in-difference design
- Compare outcomes of flooded firms over time with outcomes non-flooded firms

$$y_{ist} = \alpha_i + \alpha_{st} + \sum_{\tau \neq 0} (\beta_\tau \times \text{Flooded}_i \times \text{quarter}_\tau) + \sum_{\tau \neq 0} (\delta_\tau \times \boldsymbol{X}_{i0} \times \text{quarter}_\tau) + \varepsilon_{ist}$$

- β_τ coefficients measure change in dependent variable since base year, compared to the control group
- Dependent variables: log sales and exit

Upstream and Downstream Effects

- Propagation of shock through supply chain
- Measure of exposure to upstream suppliers:

$$\text{Upstream}_i^{(1)} = \frac{\sum_{j \in \mathcal{S}_i}(\text{Purchases}_{ij,\tau_0} * \text{Flooded}_j)}{\sum_{j \in \mathcal{S}_i}(\text{Purchases}_{ij,\tau_0})}$$

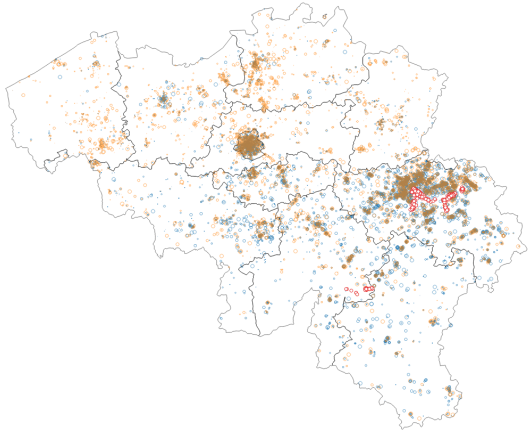
- Measure of exposure to downstream buyers:

$$\text{Downstream}_i^{(1)} = \frac{\sum_{j \in \mathcal{B}_i}(\text{Sales}_{ij,\tau_0} * \text{Flooded}_j)}{\sum_{j \in \mathcal{B}_i}(\text{Sales}_{ij,\tau_0})}$$

- Can add higher order linkages as well (later)

▸ Exposure Values

Supply Chains Matter



The red dots represent the flooded firms as described in Section 2.1. The blue dots represent the connected buyers of this set. The orange dots represent the connected suppliers.

Propagation Effects

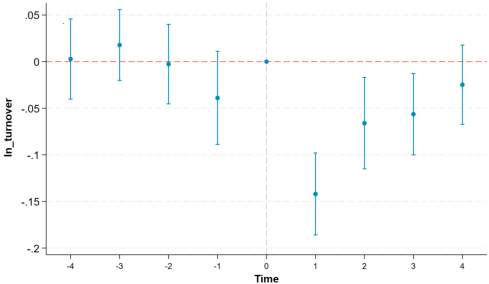
- Similar specification as for the direct effects but now with upstream/downstream exposure
- Flooded firms excluded from estimation sample

$$y_{ist} = \sum_{\tau \neq 0} \left(\beta_{\tau}^{U(1)} \times \text{Upstream}_{i}^{(1)} \times \text{quarter}_{\tau} \right) + \sum_{\tau \neq 0} \left(\beta_{\tau}^{D(1)} \times \text{Downstream}_{i}^{(1)} \times \text{quarter}_{\tau} \right) + \sum_{\tau \neq 0} \left(\delta_{\tau} \times \mathbf{X}_{i0} \times \text{quarter}_{\tau} \right) + \alpha_i + \alpha_{st} + \varepsilon_{ist}$$

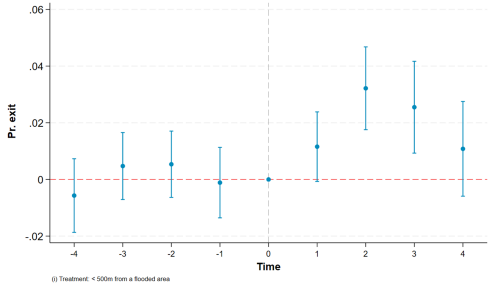
Roadmap

Direct Effects

Log Sales



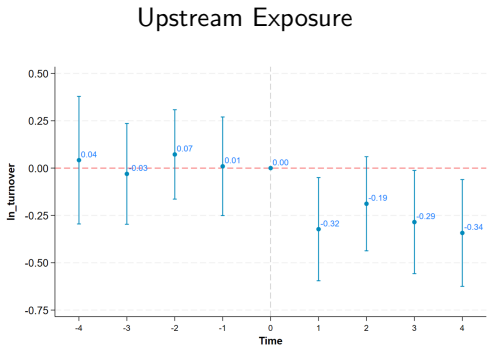
Exit Probability



- Initial drop in sales of around 15%. Negative effects last for 3 quarters
- Significant increase in exit probability after the floods

Propagation Effects: Upstream

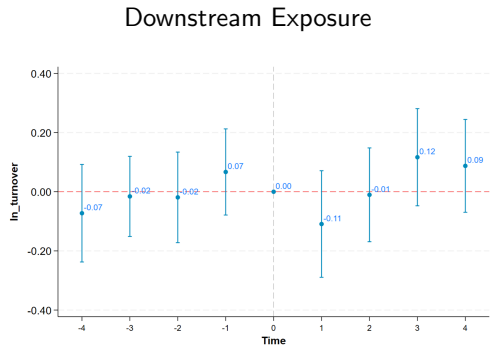
- Focus on buyer-supplier relations that started at least 2 years before the shock
- Significant negative effects of upstream exposure on sales
- There are 10,795 firms with a positive value for upstream exposure. Firm at the 90th percentile (exposure $= .17$) witnesses a drop of $.17 \times .32 = 5.4\%$ in sales.
- Results change when also short term relations taken into account



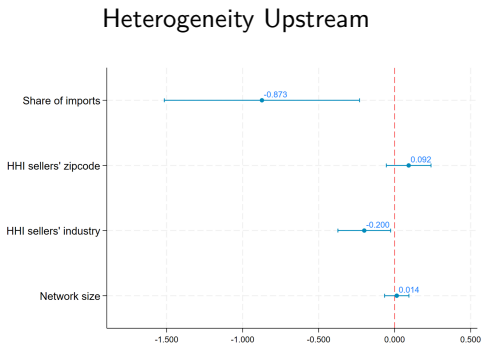
▸ Short Term

Propagation Effects: Downstream

- Focus on buyer-supplier relations that started at least 2 years before the shock
- Downstream exposure to buyers active in flooded areas
- In contrast to upstream exposure, there appears to be no effect of connection to buyers in flooded areas



Heterogeneous Effects



- See if impact varies with firm characteristics:
  - International activity → share of imports/exports
  - Network diversity → HHI sellers/buyers in sector/zip code
  - Network size → total number of buyers and sellers
- Import share seems to exacerbate impact of upstream exposure
- Higher upstream industry concentration leads to larger impact

▸ Downstream Heterogeneity

Roadmap

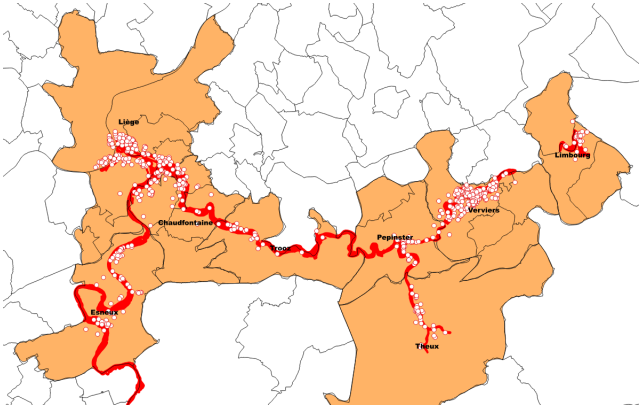
Conclusions

- Floods in 2021 had a significant negative economic impact
- Flooded firms witnessed a direct negative impact on their sales which lasted for 3 quarters
- Negative shock propagates through the network as buyers of flooded firms are negatively impacted as well
- Next steps:
  - Introduce model which would allow predictions of what would happen with future disasters
  - Look in detail at network formation after the floods
  - Other sources of heterogeneity

Roadmap

Appendix

Flooded Firms

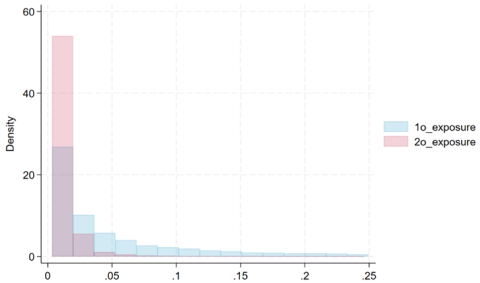


Red sections are the flooded zones. The white dots are the firms identified as flooded. Orange filling indicates communes in Category 1.

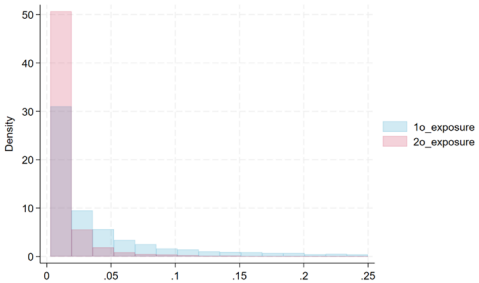
Return

Exposure Measure

Upstream Exposure



Downstream Exposure



Return

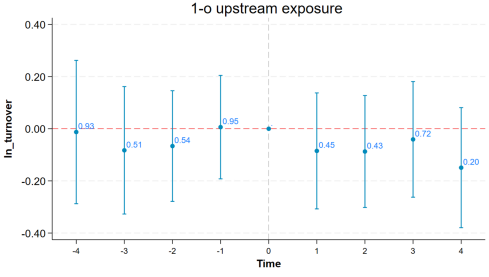
Summary Statistics

	Flooded		Non-flooded	
	< 500m	$< 5{,}000$m	Rest of Wallonia	Rest of Belgium
Log Sales	11.29	11.13	11.21	11.22
	(1.37)	(1.41)	(1.45)	(1.56)
Log No. Employees	1.07	1.05	1.11	1.19
	(1.02)	(1.03)	(1.11)	(1.20)
Firm's age	18.76	17.92	17.50	18.02
	(14.88)	(15.22)	(14.04)	(14.32)
# Establishments	0.25	0.29	0.24	0.29
	(0.42)	(0.52)	(0.84)	(4.73)
Manufacturing	0.10	0.08	0.08	0.07
	(0.30)	(0.27)	(0.27)	(0.25)
Services	0.11	0.11	0.08	0.09
	(0.31)	(0.31)	(0.27)	(0.28)
Retail	0.11	0.13	0.10	0.10
	(0.31)	(0.33)	(0.30)	(0.30)
# Unique firms	1,249	5,757	44,982	231,669

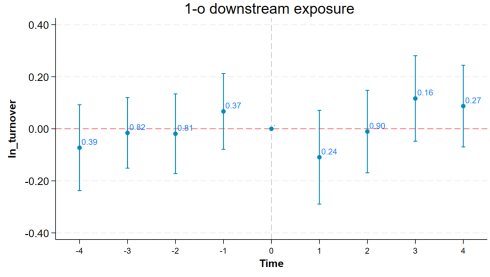
▸ Return

Short Term Relations Included

Upstream



Downstream



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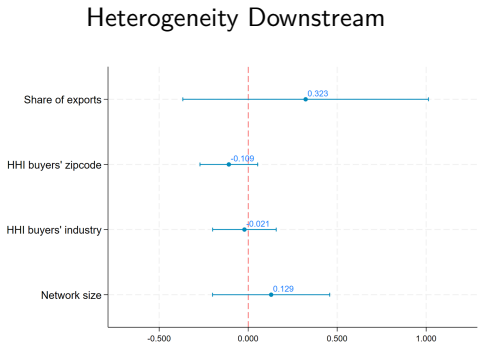
Downstream Heterogeneity



- No clear effects of firm heterogeneity

Return