The Effect of Tropical Cyclones on Economic Sectors Worldwide

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Impacts World 2017 – C1: Costs of CC and the Loss & Damage Mechanism

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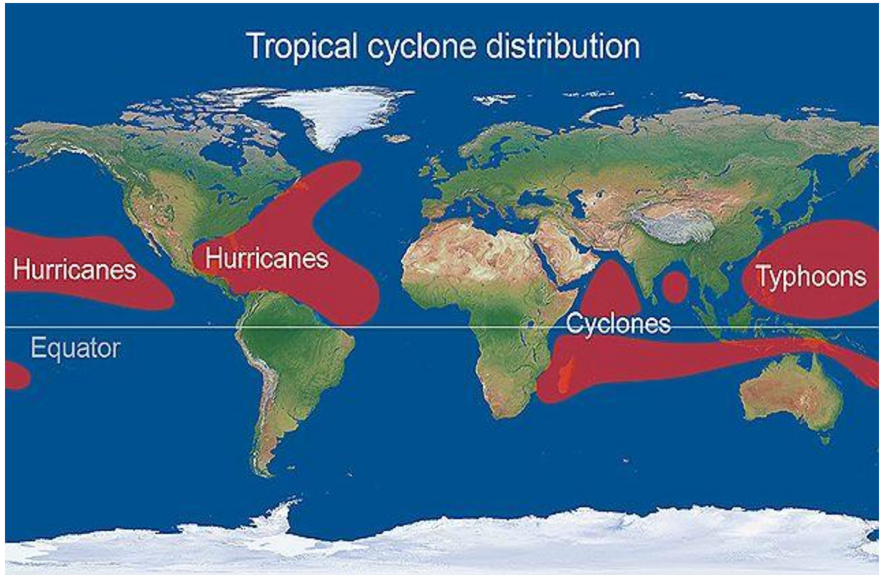
Tropical Cyclones

- Large rotating wind systems (tropics and subtropics)
- Damages: damaging winds, storm surges, heavy rainfalls
- Enormous destructive:
  - ➢ 150 billion U.S. dollars damages in USA (2004 & 2005)

    ≈ 0.6 % of GDP (2004 & 2005)
  - ➢ 6,300 deaths by typhoon Haiyan in the Philippines (2013)

Source: NOAA



Source: UK Met Office

Source: BBC

Source: Reuters

Tropical Cyclones

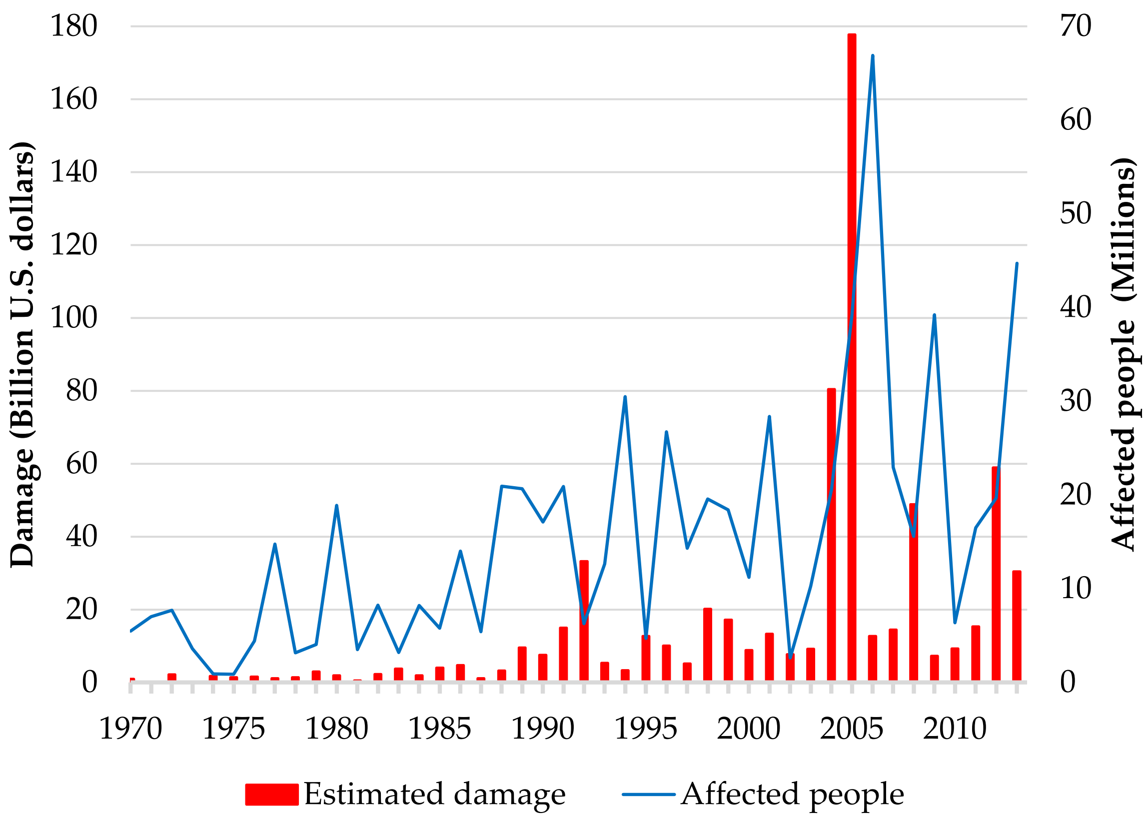


Figure: Estimated damage and affected people from tropical cyclones, 1970-2013
Source: EM-DAT (2015)

- Increase in damage and affected people
  - Higher intensity – Global warming
  - Higher exposure
- International community has also recognized this urgency:
  - Loss & Damage Mechanism: Area 1 – better understand vulnerability
  - Sendai Framework for Disaster Risk Reduction:
    - Calls for "build-back-better in recovery, rehabilitation, and reconstruction" of the economy
- Literature:
  - Effects found in empirical studies ambiguous
  - Data source of most of the older studies: EM-DAT
    - Pos. correlated with econ. & pol. situation → Endogeneity
  - Most studies just look at aggregated measures like GDP growth

Contribution of the Paper

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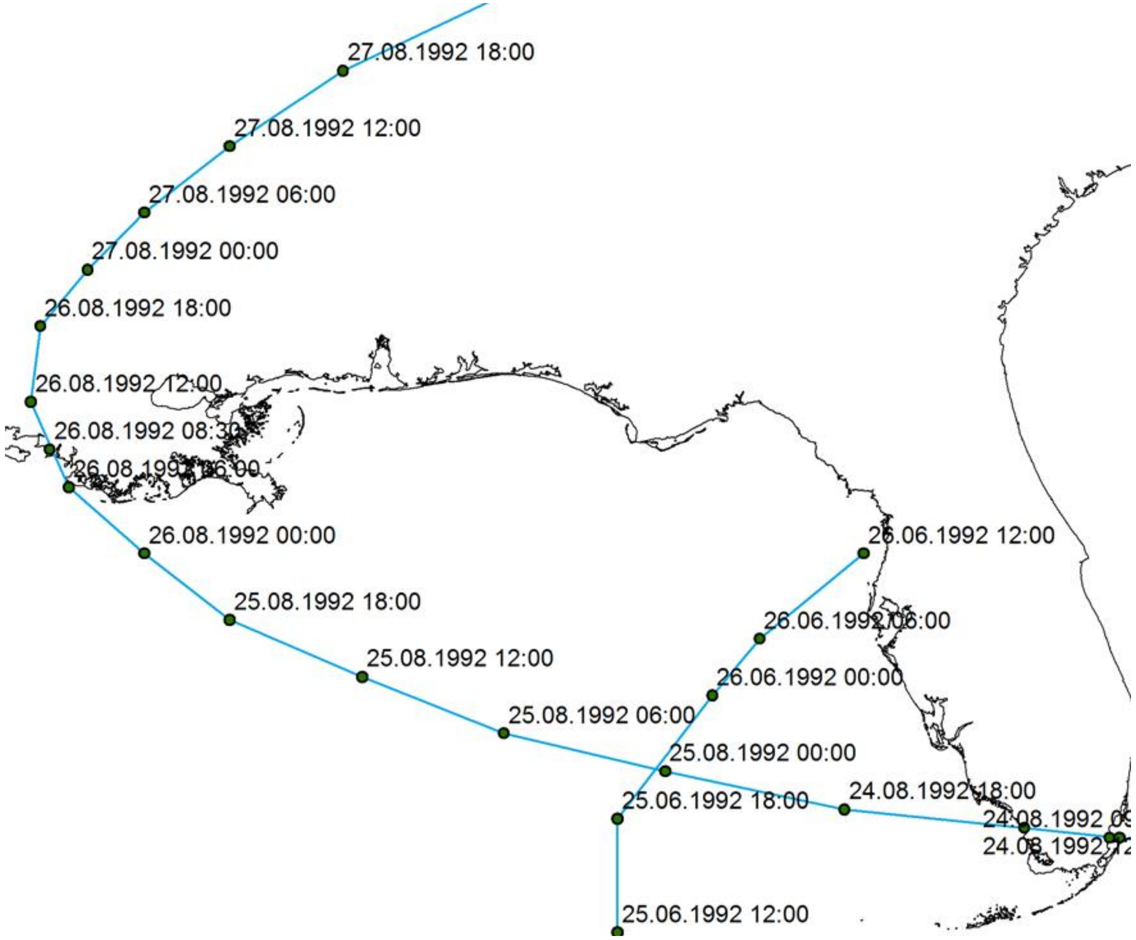
- Open up the black box and look at the damages on a disaggregated level (sectoral growth rates) and at the same time use a credible causal identification strategy.
- Use of meteorological data (wind field damage model) – as exogenous variation for the effects of tropical cyclones.
- Research questions:
    - ➢ What is the effect of tropical cyclones on annual sectoral growth worldwide?
    - ➢ What is the temporal structure of this sectoral growth effect?
    - ➢ Do tropical cyclones change the input-output structure of the sectors?

Tropical Cyclone Data

- International Best Track Archive for Climate Stewardship (IBTrACS) from NOAA
  - Unification of data provided by different weather agencies (satellites, ships, aviation, surface measurement)
  - Six-hourly measurement of tropical cyclones:
    - location, wind speed, pressure



Tropical Cyclone Data: Wind Field Model

- However, the measurement points give no indication of the size of the tropical cyclones.
- To simulate the size and intensity of the tropical cyclones, I make use of the climada model developed by Bresch (2014).
- Depending on the position, the forward speed, and the wind speed the model calculates asymmetric wind fields for the whole storm track.

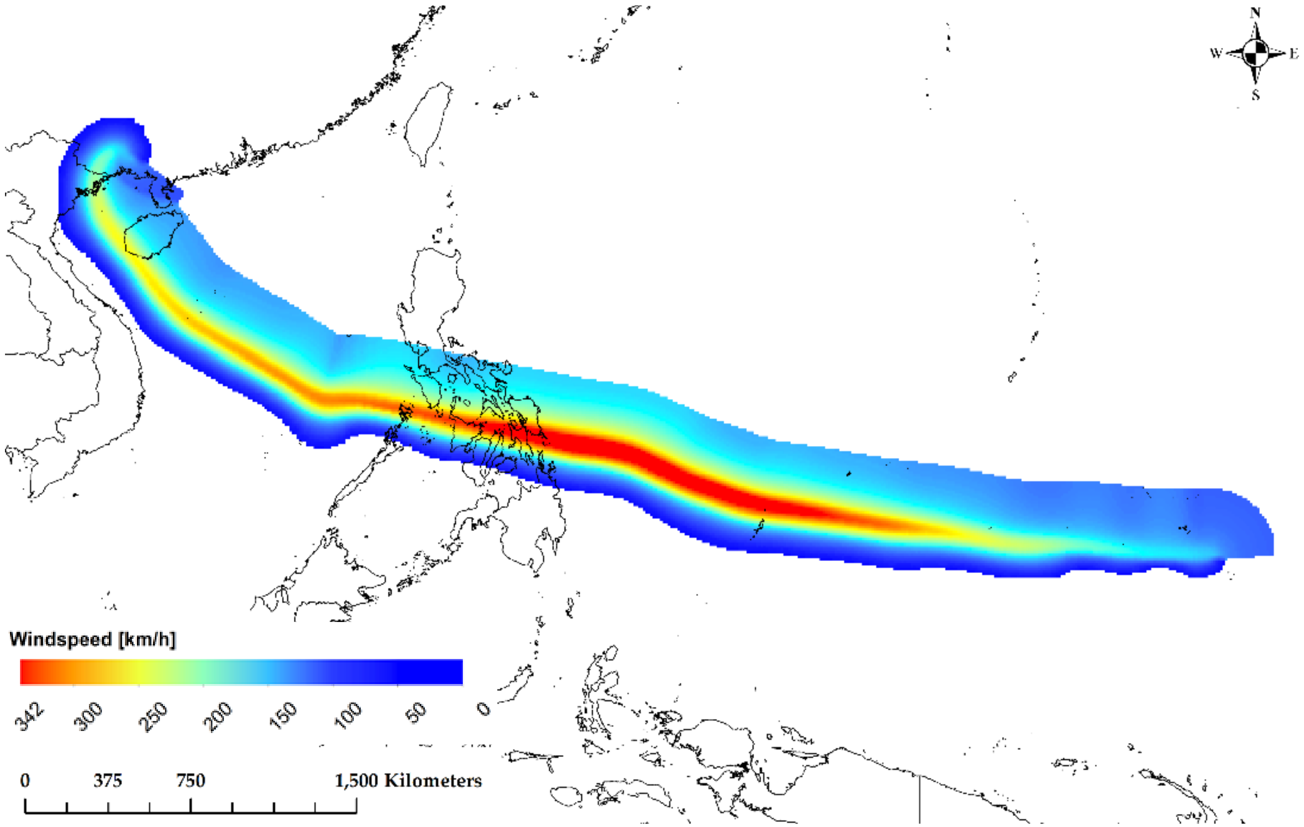
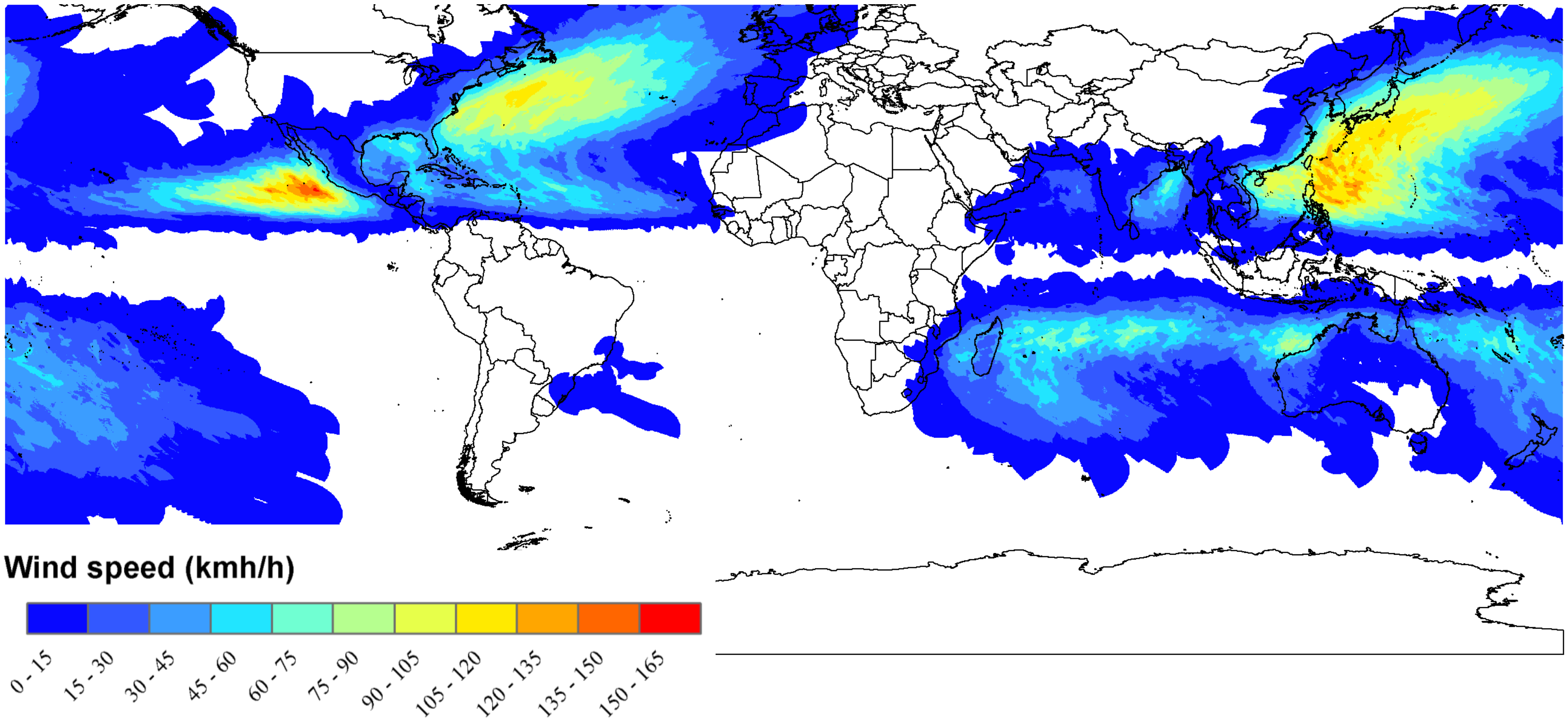


Figure 5: Windfield Model Typhoon Haiyan 2013.

Maximum Wind Speed of Tropical Cyclones (Average, 1970-2013)



Tropical Cyclone Data: Intensity Measure

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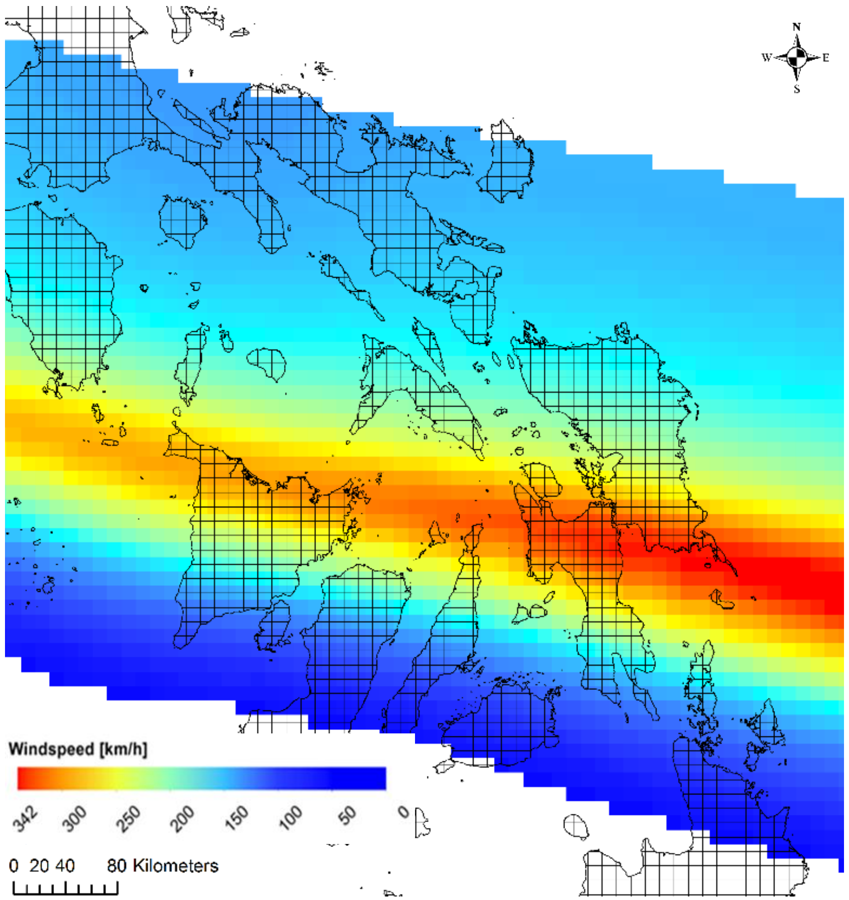
Variable for tropical cyclone intensity on a country-year level:

- Separation into 0.1°x0.1° grid net
- Following Hsiang & Jina (2014):

I aggregate for each country *i* and year *t*, the *maximal occuring wind speed* in a grid point *p* weighted by the *area of the exposed grid point* relative to the *overall size of each country*:

$$WIND_{i,t} = \frac{\sum_{p \epsilon i} \max wind_{p,t} * area_{p,t}}{total\ area_i}$$

→ Area-weighted measure for tropical cyclone intensity



Tropical Cyclone Intensity: Variation for the 20 Most Exposed Countries

- Tropical cyclone intensity variable spreads considerably, even for the 20 most exposed countries.
- Points to a sufficient exogenous variation of the main explanatory variable.

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Panel data regression for j sectors (1971-2015, 213 countries):

$$GROWTH^{j}_{i,t-1\to t} = \alpha^{j} + \beta^{j}\, WIND_{i,t} + \delta^{j}_{t} + \theta^{j}_{i} + \varepsilon^{j}_{i,t}$$

	Dependent variables: Growth rate pc in sector							
	Total output	A&B: Agriculture, hunting, forestry, fishing	C&E: Mining, utilities	D: Manu-facturing	F: Construction	G-H: Wholesale, retail trade, restaurants, hotels	I: Transport, storage, communi-cation	J-P: Other activities
	(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$WIND_t$	-0.0067**	-0.0304***	-0.0093	-0.0090	0.0102	-0.0105**	-0.0075*	-0.0031
	(0.0030)	(0.0062)	(0.0152)	(0.0069)	(0.0127)	(0.0045)	(0.0042)	(0.0027)
	[0.0262]	[0.0000]	[0.5429]	[0.1936]	[0.4212]	[0.0214]	[0.0727]	[0.2472]
Observations	8,907	8,865	8,739	8,868	8,911	8,861	8,865	8,905
No. of countries	213	212	210	213	213	212	212	213
Adj. R^2	0.0434	0.0102	0.0024	0.0146	0.0178	0.0256	0.0153	0.0181
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: OLS regression results with clustered standard errors by countries in parentheses (), and p-values in brackets []. Asterisks indicate p-values according to: *** p<0.01, ** p<0.05, * p<0.1.

Empirical Method and Results

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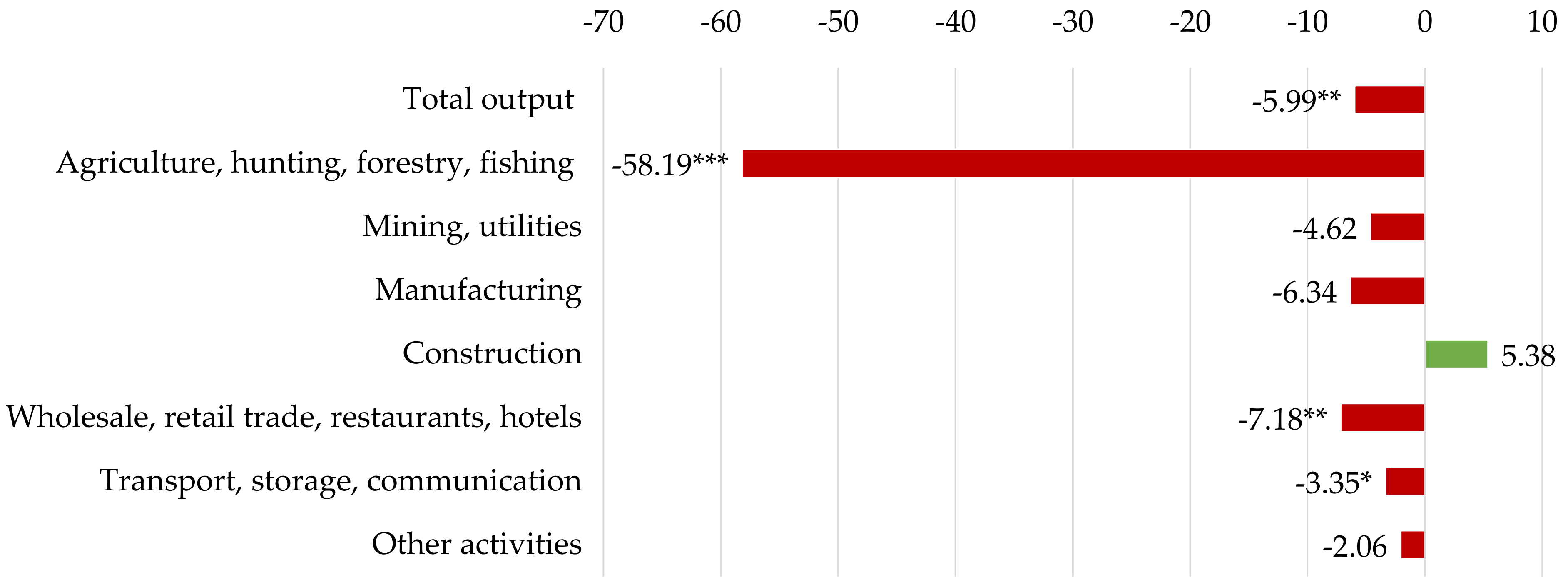
$$GROWTH^{j}_{i,t-1\rightarrow t} = \alpha^{j} + \beta^{j}\, WIND_{i,t} + \delta^{j}_{t} + \theta^{j}_{i} + \varepsilon^{j}_{i,t}$$

Effect of a median tropical cyclone (15.4 km/h) on average p.c. sectoral GDP growth [%]

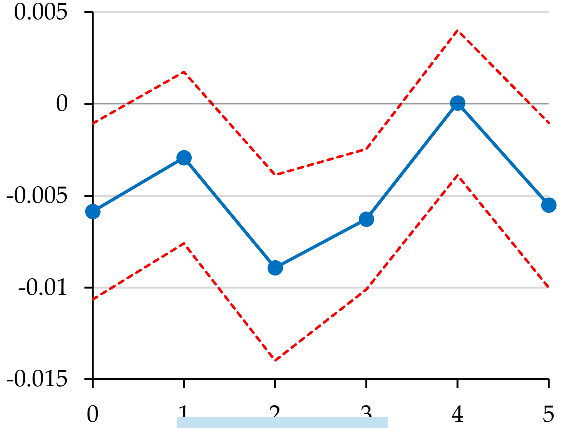


Losses/ Surpluses [Mio. US Dollars] in terms of sample average
-175.3
-28.4
-15.6
-38.4
+17.1
-37.3
-16.6
-36.4

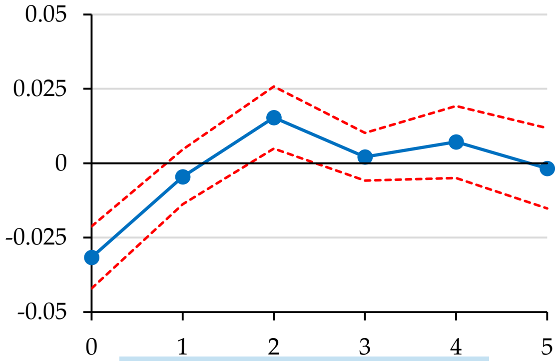
Past Influence of Tropical Cyclones (Point Estimates with 90 % Confidence Bands)

$$GROWTH^{j}_{i,t-1\rightarrow t} = \alpha^{j} + \sum_{L=0}^{5} (\beta^{j}_{L} * WIND_{i,t-L}) + \delta^{j}_{t} + \theta^{j}_{i} + \varepsilon^{j}_{i,t}$$

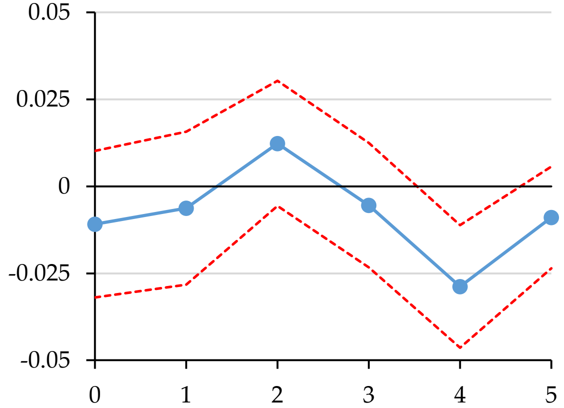
Total Output



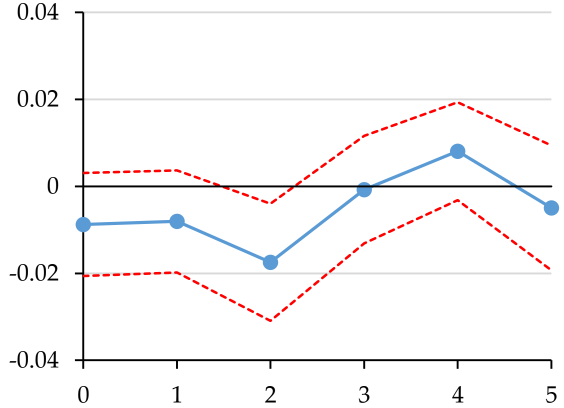
Agriculture, hunting, forestry, fishing



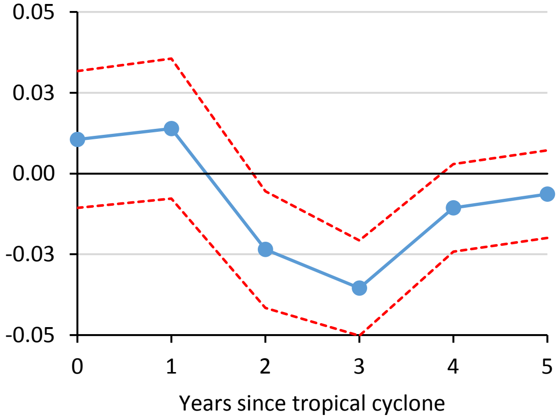
Mining, utilities



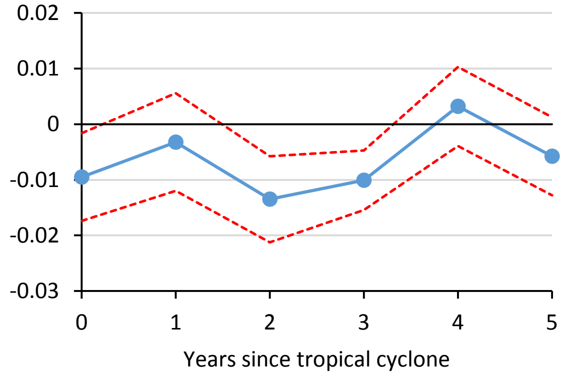
Manufacturing



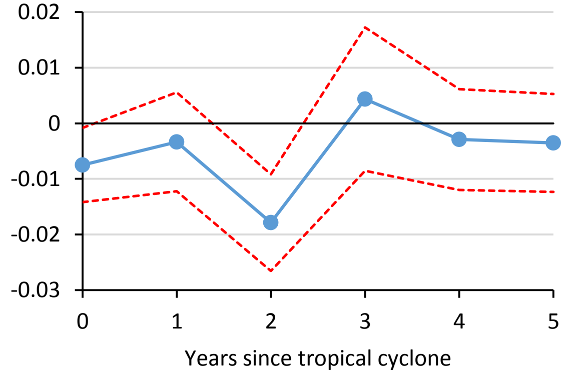
Construction



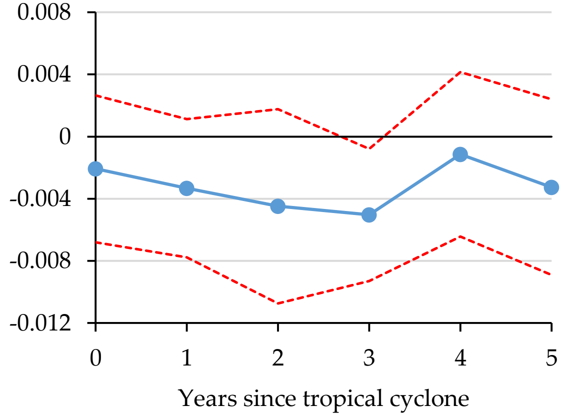
Wholesale, retail trade, restaurants, hotels



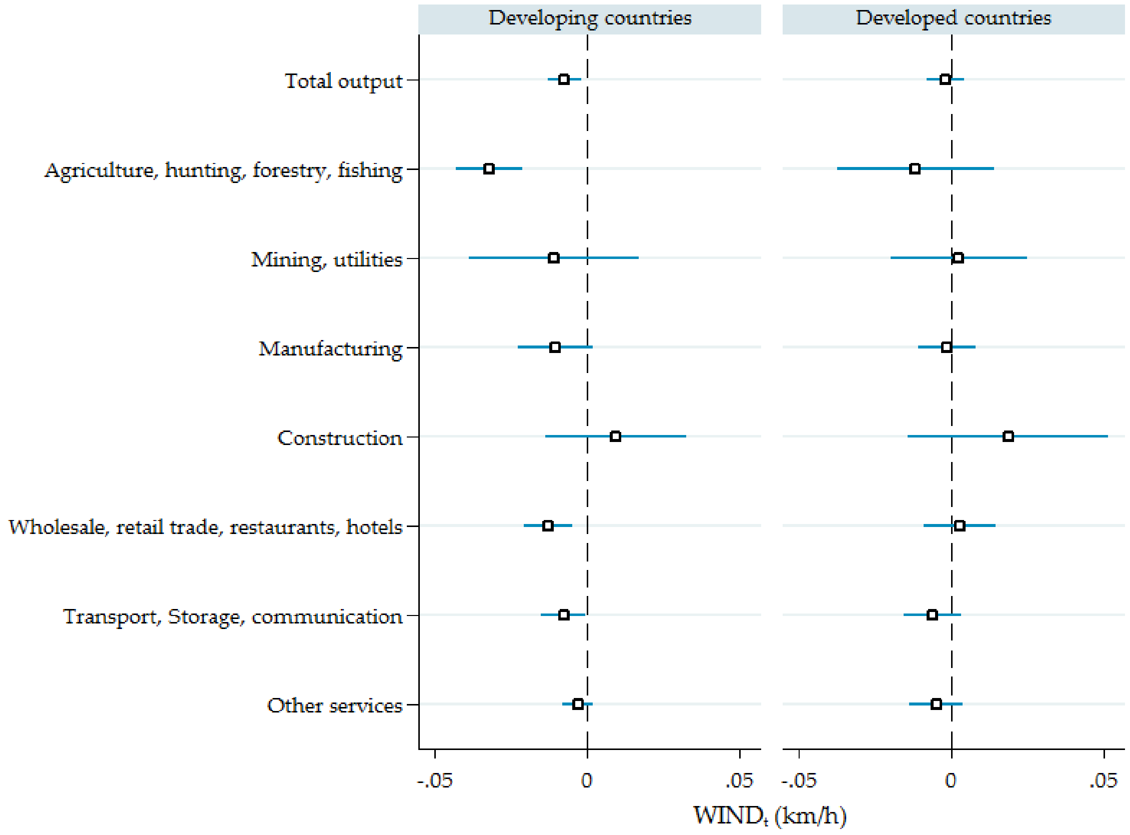
Transport, storage, communication



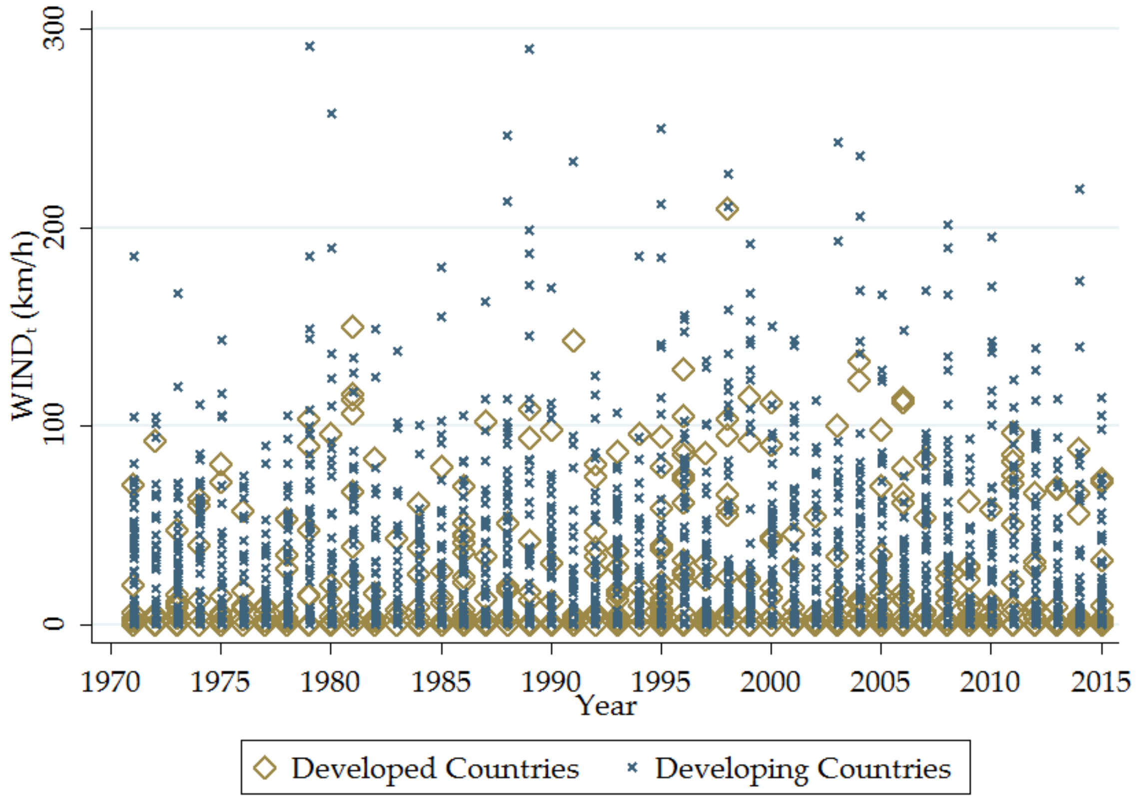
Other activities



Heterogenous Effects: Developing and developed Countries



Coefficient estimates of the variable WIND$_t$ (km/h) (blue squares), together with the 90% confidence bands (blue line).



Distribution of the tropical cyclone intensity variable WIND$_t$ for developed and developing countries from 1971-2015.

Conclusion

- There exist a difference in vulnerability of the economic sectors to tropical cyclones

Sector	**Contemp. effect**	**Lagged effect**
Agriculture, hunting, forestry, fishing	Negative	No effect
Mining, utilities	No effect	Negative
Manufacturing	No effect	Negative
Construction	No effect	Negative
Wholesale, retail trade, restaurants, hotels	Negative	Negative
Transport, storage, communication	Negative	Negative
Other activities	No effect	Negative

- Strong evidence for delayed negative effects for nearly the whole economy
- Evidence for the no-recovery hypothesis
- Developing countries seem to drive the results
- Results can be used as a guideline for international organizations or can help to specify existing climate cost models

Thank you for your attention!

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