Tropical cyclones and economic growth : the importance of considering small island developing states

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MOTIVATION

Tropical cyclones are arguably one of the most damaging and threatening natural disasters for human systems. Among other examples, the 2005 Hurricane Katrina caused the displacement of approximately 650,000 people and destroyed more than 200,000 homes along the US Gulf Coast. A number of empirical studies have explored the short and long-run economic relationship between tropical cyclones and national growth rates, but no general conclusion can be drawn from them so far. While negative effects are found in samples of exposed countries worldwide, cyclone shocks also show no significant influence in other national-level analyses. This suggests that, beyond inequalities in the exposure to cyclonic risk between countries, there is also inequality regarding these extreme weather events' impacts.

LITTÉRATURE REVIEW

Felbermayr & Groschl (2014), Hsiang & Jina (2014) or Krichene & al. (2021) find evidence of negative and persistent effects of tropical cyclones on economic growth using universal datasets. In other national level analyses, Strobl (2011) or Zhou & Zhang (2021) show that these extreme events are not disruptive enough to be reflected in national economic growth rates in the US or in Hong-Kong respectively. Apart from the geographic dimension, another aspect to consider is the level of development. In the more general framework of natural disasters, developing countries are almost always found to be more adversely affected than advanced economies (Kahn, 2005 ; Noy, 2009 ; Fomby & al., 2013).

PAPER'S OBJECTIVE AND CONTRIBUTION

This paper explores key dimensions across which one might expect the economic impact of cyclone shocks on economic growth to be heterogeneous. First, since cyclone events are primarily localized along coastal areas, they may only affect a reduced share of national economies. Another aspect to consider is the level of development, as developing countries tend to have agricultural-based economies, they may experience stronger effects from cyclone shocks. In fact, cyclones can trigger a number of catastrophes like floods or landslides, potentially causing losses of crops that spread to the rest of the economy. According to these criteria, the sub-group of Small Islands Developing States (SIDS) is distinguished from the world sample and is specifically analysed. Splitting the initial sample in such a way reveals that in addition to economic development, country size provides another shield against growth losses due to storm shocks.

DATA

The raw data on cyclone events come from the *Tropical Cyclone Exposure Database* (TCE-DAT; Geiger & al., 2018), which provides consistent pixel-event-level data on cyclone intensity and exposure from 1950 to 2015. Data on precipitation and temperature levels were obtained from the *Climatic Research Unit gridded Time Series* database (CRU TS; Harris & al., 2020). Information on per capita GDP come from the *United Nations Statistics Division* (UNSD, 2020).

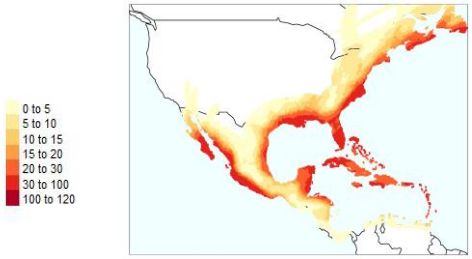

Figure 1: Annual average maximum wind speed (in km/h) from 1950 to 2015 at pixel level for North Atlantic and North East Pacific tropical cyclone basin

RESULTS

Worldwide estimations are led by SIDS, and hence, national growth responses to cyclone events are heterogeneous given the size and the development level of the country. **The estimated immediate effect of one additional unit of cyclone exposure is to decrease growth rates in SIDS by -0.016 percentage point, and this negative effect drops to -0.024 percentage point after 15 years.** The quasi-constant slope indicates that SIDS manage to avoid an intensification of negative effects, but do not manage to counteract them either. In contrast, point estimates tend to show that **non SIDS countries** experience an increased growth in the short-run, which plummets in the long-run, but these results are **not statistically significant** and no conclusion can be drawn from them.

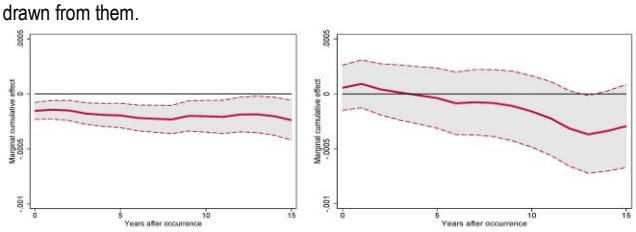

Figure 2: Measures of the marginal cumulative effects over fifteen years of cyclone events on per capita GDP growth for SIDS (left) and non SIDS (right).

TRANSMISSION CHANNELS AND PUBLIC POLICY IMPLICATIONS

Negative impacts in SIDS appear to be driven by an increased dependence on foreign economic conditions, insufficient reconstruction capacities and difficulties to implement adaptation policies. Policy implications regarding the urge to invest in economic preparedness or early warning systems in SIDS shall emerge from this study.

MÉTHODOLOGY

This study aims to assess the short to long-term impact of cyclone events on per capita GDP growth rate using an exogenous and scale-invariant predictor of cyclone events, adding controls for temperature and precipitation. Panel data regression is used with time and country fixed effects, and the purpose is to study the marginal cumulative effect over 15 years after a cyclone strike.

Cyclone exposure indicator:

$$\overline{Cyc}_{i,t} = \frac{\sum_{p} \max_{p}\{Wind_{p,i,t}\} * Area_{p}}{LandSize_{i,t}}$$

Equation of interest:

$$g_{i,t} = \alpha + \sum_{j=0}^{15} \beta_{j,1} \overline{Cyc}_{i,t-j} + \sum_{j=0}^{15} \beta_{j,2} \left(\overline{Cyc}_{i,t-j} \times SIDS\right) + \sum_{j=0}^{15} \gamma_{j} \overline{Temp}_{i,t-j} + \sum_{j=0}^{15} \delta_{j} Prec_{i,t-j} + \mu_{i} + \eta_{t} + \varepsilon_{i,t}$$

Marginal cumulative effect:

$$\Omega_{L} = \sum_{j=0}^{L} \beta_{j}, L \in [\![0; 15]\!]$$

ROBUSTNESS CHECKS

Results obtained for SIDS are consistent with the neoclassical growth theory in the very short-run as it predicts an immediate negative impact on economic growth. Three core aspects are highlighted by the table below. It confirms the exogeneity of the cyclone indicator as estimates are of same magnitude given 95 % confidence bands. Then, it confirms that lag structures are not particularly influential and short-term impacts are most decisive. Third, the negative sign associated with the lagged value of per capita GDP shows that the economy is still converging towards its steady state level after the cyclone strike.

	Main Model Specification (1)	Additional Fixed Effects (2)	Additional Control Variables (3)
Model with no cyclone lag: immediate effect			
$ln(GDPpc)_{i,t-1}$			-0.01216***
			(0.00312)
$\overline{Cyc}_{i,t}$	0.00012	0.00018	0.00008
	(0.00011)	(0.00012)	(0.00011)
$\overline{Cyc}_{i,t} * SIDS$	-0.00028**	-0.00027***	-0.00024**
	(0.00012)	(0.00012)	(0.00012)
$ln(Population)_{i,t-1}$			0.02637***
			(0.00424)
$ln(Trade\ Openness)_{i,t-1}$			0.00752***
			(0.00187)
$ln(Investment\ per\ capita)_{i,t-1}$			0.00393**
			(0.00185)
Observations	3584	3565	3536
Adjusted R^2	0.25	0.28	0.28
Cyclone's immediate effect in SIDS	-0.00016***	-0.00015***	-0.00016***
	(0.00004)	(0.00005)	(0.00004)
Model with 1 cyclone lag:			
Marginal Cumulative Effect in SIDS	-0.00014***	-0.00013***	-0.00013***
	(0.00005)	(0.00005)	(0.00004)
Marginal Cumulative Effect in non SIDS	0.00017	0.00025*	0.00014
	(0.00012)	(0.00013)	(0.00012)
Model with 5 cyclone lags:			
Marginal Cumulative Effect in SIDS	-0.00018***	-0.00012*	-0.00013**
	(0.00006)	(0.00007)	(0.00006)
Marginal Cumulative Effect in non SIDS	0.00019	0.00035**	0.00010
	(0.00015)	(0.00016)	(0.00015)
Model with 10 cyclone lags:			
Marginal Cumulative Effect in SIDS	-0.00022***	-0.00017*	-0.00013*
	(0.00008)	(0.00009)	(0.00008)
Marginal Cumulative Effect in non SIDS	-0.00003	0.00017	-0.00016
	(0.00018)	(0.00020)	(0.00018)
Model with 15 cyclone lags:			
Marginal Cumulative Effect in SIDS	-0.00024**	-0.00015	-0.00013
	(0.00011)	(0.00011)	(0.00010)
Marginal Cumulative Effect in non SIDS	-0.00029	-0.00050**	-0.00045**
	(0.00022)	(0.00025)	(0.00022)

Notes: Outlier-robust regression estimates. Standard errors are in parentheses. Time and individual fixed effects, as well as temperature and precipitation controls are included in all specifications. Additional fixed effects model refers to the inclusion of Region*Year and SIDS*Year fixed effects.
Significance levels : *** 1 % ; ** 5 % ; * 10 %.