Climate change, economic activity, and the role of internet access: Evidence from the Pacific Island region

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Motivation

- Global implications of climate change:
  - Historical context: temperature increased by 0.4°C to 0.8°C over the last 100 years
  - Forecast for the next century: Predicted increase between 1.4°C and 5.8°C (Portner et al., 2022)
- Susceptibility of the Pacific Island region to climate change:
  - More vulnerable due to unique geographical, ecological, and socio-economic factors (Hanna and McIver, 2014; McIver et al., 2016)
  - Key sectors like agriculture and fisheries feel the immediate impact

Motivation

- Scarcity of empirical research assessing economic impacts of climate change in the Pacific:
  - Major reason: scarcity of relevant data
  - Crucial data like temperature and economic performance over time is not available
  - Many countries lack systems for data collection and storage due to financial and technical limitations
- Could country-level data offer a remedy?
  - Pacific region has vast geographical diversity; climate impacts vary across areas
  - Illustrative case: Examining subnational divergences – Papua New Guinea

⏩ Figure

Research Questions

- **Research question 1:** What are the effects of warmer temperature on economic activity in the Pacific?
  - Focus on 12 specific Pacific Island countries (Cook Islands, Fiji, Federated States of Micronesia, The Marshall Islands, Nauru, Palau, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu, and Samoa)
  - Using nightlight data to measure economic activity (Hodler and Raschky, 2014; Henderson et al., 2012; Donaldson and Storeygard, 2016)
- **Research question 2:** How does the internet help against the negative effects of rising temperatures?
  - Better communication during natural disasters
  - Helps people adjust to climate change
- **Research question 3:** How agriculture is affected by climate change:
  - Most people depend on agriculture and fishing
  - 80% of households rely mainly on agriculture
  - Agriculture is central to the economy

Data

Nightlight

- Used as a proxy for economic activity
- Why Nightlight Data?
  - Brighter areas indicate more economic activities
  - Direct correlation with human settlement and industries
  - Useful where traditional economic data is limited or unreliable
- Available datasets:
  - Defense Meteorological Satellite Program (DMSP): Yearly data, available up to 2013
  - Visible Infrared Imaging Radiometer Suite (VIIRS): Monthly data, available from 2012 to present (Chosen for our analysis)
- Measurement:
  - Nightlight measured in log form
  - Higher values = more concentrated economic activities

Data

Weather data

- ERA5 satellite reanalysis data
  - Provided by the European Centre for Medium-Range Weather Forecasts Reanalysis 5 (ECMWF)
  - Widely recognized and used in economic studies (Trinh et al., 2022; Churchill et al., 2022a,b)
- Features of ERA5 data:
  - Hourly estimates of climate variables
  - Resolution: 0.25° longitude x 0.25° latitude
  - Data available since 1979
- Our measures:
  - Air temperature and precipitation (monthly averages)
  - Area-weighted averages for regional data (Kalkuhl and Wenz, 2020; Heyes and Saberian, 2022)

Data

Internet data

- Collins Bartholomew's Mobile Coverage Explorer
  - Offers detailed global mobile network coverage (3G and 4G)
  - Data grid: 1km x 1km ⏩ Papua New Guinea
  - Data from 2011 to present
  - Coverage: Fiji, Micronesia, Palau, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu

Data

Agricultural activities

- Utilize Normalized Difference Vegetation Index (NDVI) as a proxy for agricultural activities
  - Landsat program (United States Geological Survey), launched in 1999
  - Data grid: 30 × 30 meters resolution
  - Calculation method (Goldblatt et al., 2020):

$$NDVI = \frac{NIR - red}{NIR + red} \tag{1}$$

  - Index value range: -1 to 1 (Higher values indicate more vegetation)
  - Limitation: NDVI data available only for Papua New Guinea

Empirical strategy

(1) Fixed-effects model (Liu et al., 2023):

$$Y_{csmt} = \beta_1 T_{csmt} + \beta_2 P_{csmt} + \alpha_c + \alpha_s + \alpha_t + \epsilon_{i,t} \tag{2}$$

where:

- Y_{csmt} is the economic activity for subnational unit s in country c in month m at year t
- T_{csmt} is the average temperature (Celsius), P_{csmt} is the average precipitation
- Country FEs (α_c), subnational areas FEs (α_s), year FEs (α_t)
- clustered standard errors at subnational level

(2) Long-differences model (Burke and Emerick, 2016):

$$\Delta Y_{csmt} = \gamma_1 \Delta T_{csmt} + \gamma_2 \Delta P_{csmt} + \alpha_c + \varepsilon_{i,t} \tag{3}$$

Results

Effect of Rising Temperatures Using Panel Specification

Dependent variable:	Nightlight (log)		
	OLS	FE model No control	FE model With control
	(1)	(2)	(3)
Temperature	-0.013***	-0.013***	-0.015***
	(0.001)	(0.001)	(0.001)
Rainfall			-4.535***
			(0.433)
Subnational FEs		✓	✓
Year FEs		✓	✓
Observations	52,272	52,272	52,272
R-squared	0.336	0.368	0.369
Nightlight mean	0.274	0.274	0.274

Notes: Robust standard errors in parentheses. Standard errors are clustered at the subnational level. ***p$<$0.01, **p$<$0.05, *p$<$0.1.

Results

Effect of Rising Temperatures Using Long Difference Specification

Dependent variable:	Nightlight difference (log)		
	OLS	Fixed-effects model No control	Fixed-effects model With control
	(1)	(2)	(3)
Temperature difference	-0.165***	-0.129***	-0.124***
	(0.047)	(0.044)	(0.044)
Rainfall difference			1.789
			(3.097)
Country FEs		✓	✓
Observations	484	484	484
R-squared	0.025	0.059	0.059
Nightlight mean	0.240	0.240	0.240

Notes: Robust standard errors in parentheses. Standard errors are clustered at the subnational level. ***p$<$0.01, **p$<$0.05, *p$<$0.1.

Results

Effect of Rising Temperatures on Economic Activities – Internet as Moderator

Dependent variable:	Nightlight (log)			
	Fixed-effects (1)	Long Difference (2)	Fixed-effects (3)	Long Difference (4)
Temperature	-0.040***	-0.252***	-0.006***	-0.014***
	(0.008)	(0.066)	(0.001)	(0.005)
Temperature*Internet 3G	0.003***	0.011***		
	(0.000)	(0.003)		
Temperature*Internet 4G			0.045***	0.041***
			(0.000)	(0.001)
Subnational (Country) FEs	✓	✓	✓	✓
Year FEs	✓		✓	
Control for rainfall	✓	✓	✓	✓
Observations	28,296	262	25,056	193
R-squared	0.742	0.023	0.392	0.065

Notes: Robust standard errors in parentheses. Standard errors are clustered at the subnational level. ***p<0.01, **p<0.05, *p<0.1.

Results

Effect of Rising Temperatures on Economic Activities – Agriculture as Mechanism

Dependent variable:	Nightlight (log)	Agriculture index)	Nightlight (log)
	(1)	(2)	(3)
Temperature	-0.148***	-0.007***	-0.024***
	(0.014)	(0.001)	(0.003)
Agriculture index			4.025***
			(0.206)
Subnational FEs	✓	✓	✓
Year FEs	✓	✓	✓
Control for rainfall	✓	✓	✓
Observations	651	651	651
R-squared	0.937	0.246	0.419

Notes: Robust standard errors in parentheses. Standard errors are clustered at the subnational level. ***p$<$0.01, **p$<$0.05, *p$<$0.1.

Results

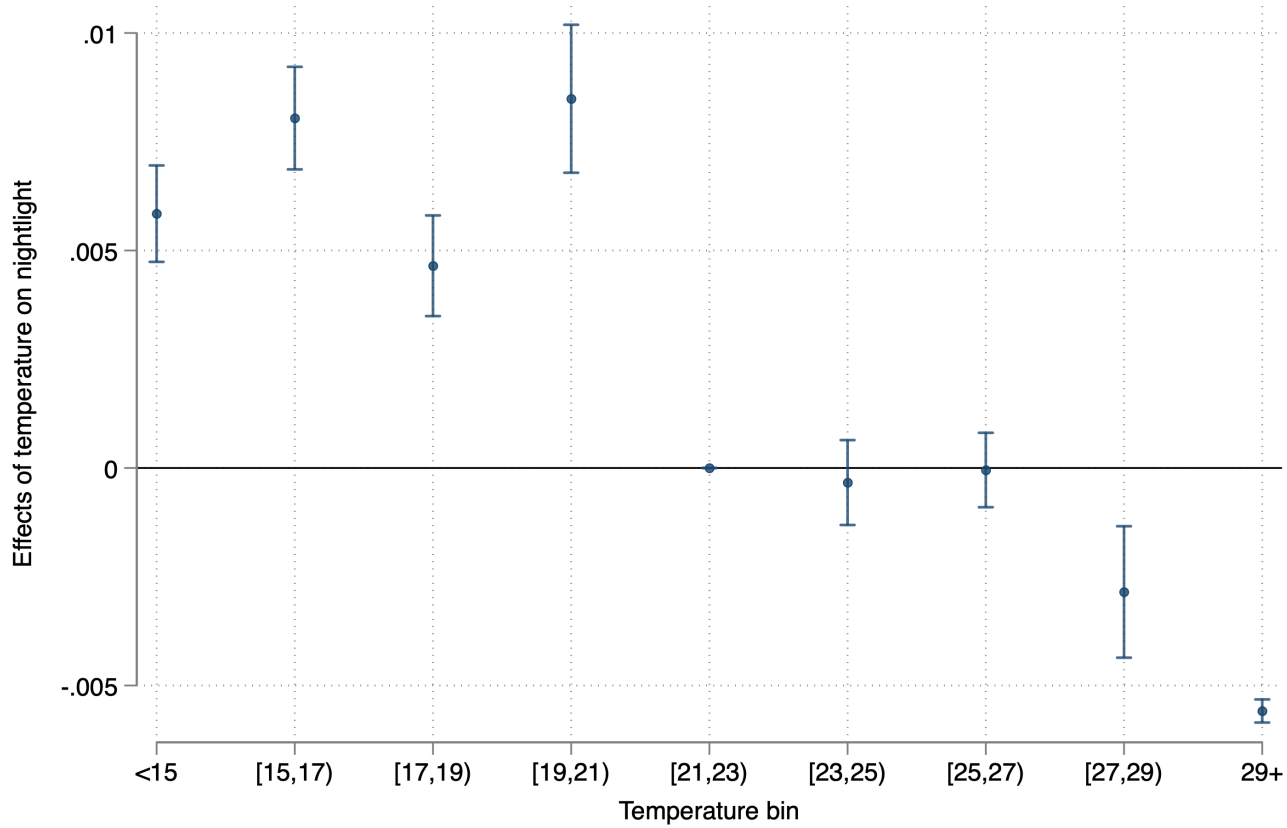
Effect of Rising Temperatures on Economic Activities – Robustness checks

Dependent variable:	Nightlight (log)			
	Linear-time trend (1)	+ temperature difference (2)	+ temperature squared (3)	+ temperature interaction term (4)
Temperature	-0.014***	-0.015***	0.419***	0.424***
	(0.001)	(0.001)	(0.010)	(0.010)
Temperature difference		0.017***	0.050***	-0.180***
		(0.005)	(0.005)	(0.045)
Temperature squared			-0.010***	-0.010***
			(0.000)	(0.000)
Temperature*Temperature difference				0.009***
				(0.002)
Subnational FEs	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓
Control for rainfall	✓	✓	✓	✓
Observations	52,272	51,788	51,788	51,788
R-squared	0.37	0.37	0.393	0.394

Notes: Robust standard errors in parentheses. Standard errors are clustered at the subnational level. ***p<0.01, **p<0.05, *p<0.1.

Results

Effects of temperature on economic activities – Non-linear effects of temperature



Conclusion

- Pacific Island countries especially vulnerable due to their unique characteristics
- Limited studies specifically on Pacific Island region despite its high vulnerability
- Used satellite data to measure nighttime light as a proxy for economic activity at the subnational level
- Findings: Rising temperatures correlate with economic activity decline, with agriculture playing a significant role
- Internet access can reduce the negative impact of rising temperatures on economic activity
- Investment in high-speed internet can aid in climate change adaptation.

Thank you!

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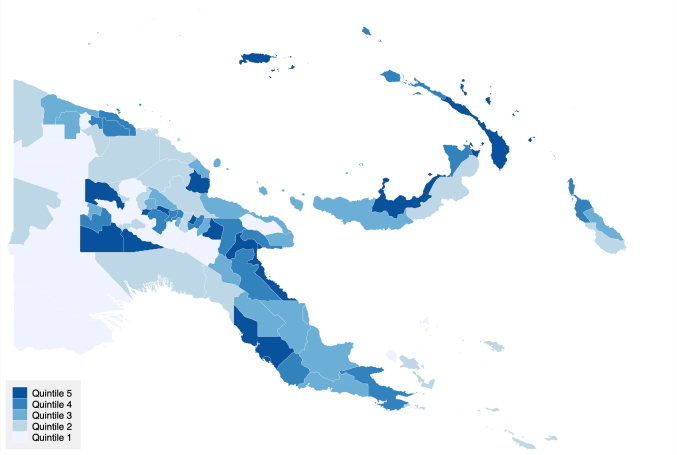
Appendix

Subnational variation – Papua New Guinea

back

Panel A: Economic activities



Panel B: Average temperature

Appendix

3G coverage – Papua New Guinea

back