

Introduction

Background

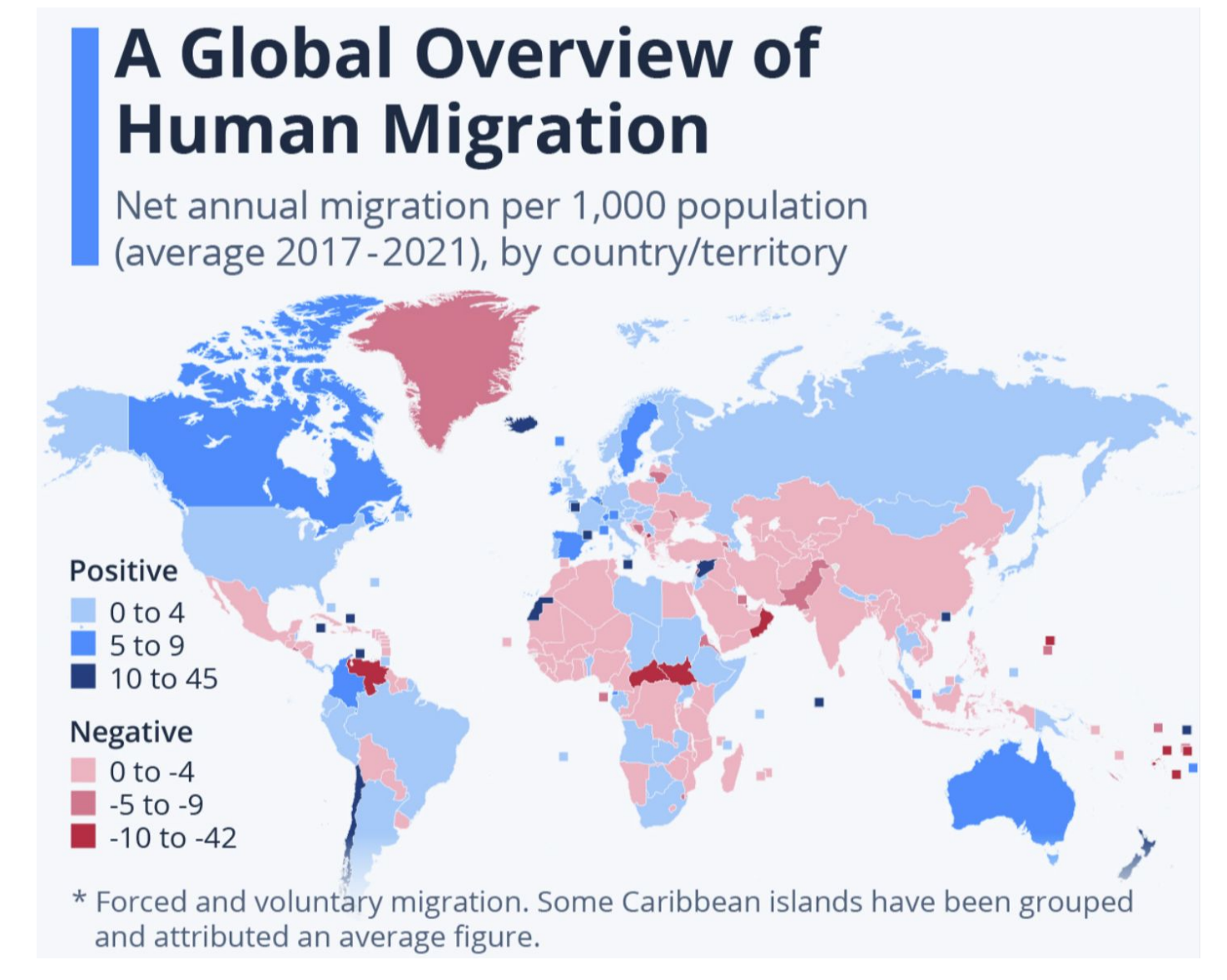
- Natural disasters displace millions of people each year, and climate change continues to elevate global hazards
- Migration is quite expensive, and extreme events like disasters destroy people's assets including housing and valuables, immobilizing the most vulnerable

Past Research

- A U.S. study demonstrating flood damages sorted outbound migration by income, showing trends of higher income levels migrating, while lower income levels were trapped
- Previous Geo-Social lab work used Granger-Causality models for data recorded over time, which works on using migration mechanics to assess predictive patterns

Problems to Solve

- Existing research on displacement caused by natural disasters, especially on the difference in effects across income levels, remains limited in global reach and general impact
- Past research has been limited by bad data, caused by factors such as forced conflict escapes and seasonal baselines causing migration data to be hard to interpret



Research Objectives

Research Question: How are changes in countries' migration trends associated with disaster frequency, and how does income of those countries affect those changes during high disaster periods?

Hypotheses:

- Lower income populations face mobility constraints, so disasters may cause higher increases in emigration rates in high income countries whose residents can afford to move compared to lower income countries
- As the frequency of disasters per month increases, the outward migration will increase, though it may have a cap on this increasing outward migration as the number of disasters per month increases

Objectives: Build monthly migration metrics for 180 countries (2019–2022) while removing forced migration and seasonality from the data. Then, test in what ways disasters influence migration, and compare disaster month vs normal month migration across different income levels.

Methodology

1. Data Collection and Transformation

- Two original datasets:
 - EMDAT natural disaster
 - Global migration flows dataset from Meta x Humdat
- Transformed migration data into new dataset with:
 - The country's name and month of data collection
 - Number of outward and inward migrants
 - Population
 - Emigration rate (out migration rate)

$$\text{Out-Migration Rate} = \frac{\text{Number of Out-Migrants}}{\text{Total Population}} \times 1,000$$

$$\text{Migration Efficiency Ratio} = \frac{\text{In-migrants} - \text{Out-migrants}}{\text{In-migrants} + \text{Out-migrants}} \times 100$$

Migration Flows Data			
country_from	country_to	migration_month	num_migrants
AD	AE	2019-01	12
AD	AE	2019-02	2
AD	AE	2019-03	1
...	...	...	...
BO	UY	2022-11	13
BO	UY	2022-12	18

Disasters Data			
country	start_date	end_date	people_affected
Ecuador	2022-04-25	2022-04-25	85121
Kenya	2021-03-06	2021-03-31	270143
Afghanistan	2022-08-31	2022-08-31	1304600
...	...	...	...
Uruguay	2020-06-22	2020-06-23	15097
Bosnia and Herzegovina	2020-06-22	2020-06-24	36024

2. Cleaning & Controls

- Remove data influenced by factors other than disasters (i.e. wars)
- Deseasonalize the migration data

3. Income and Distance

- Split countries into GDP-per-capita quartiles
- Compare disaster- vs normal-month migration
- Test the across-income trend
- Measure migration distances

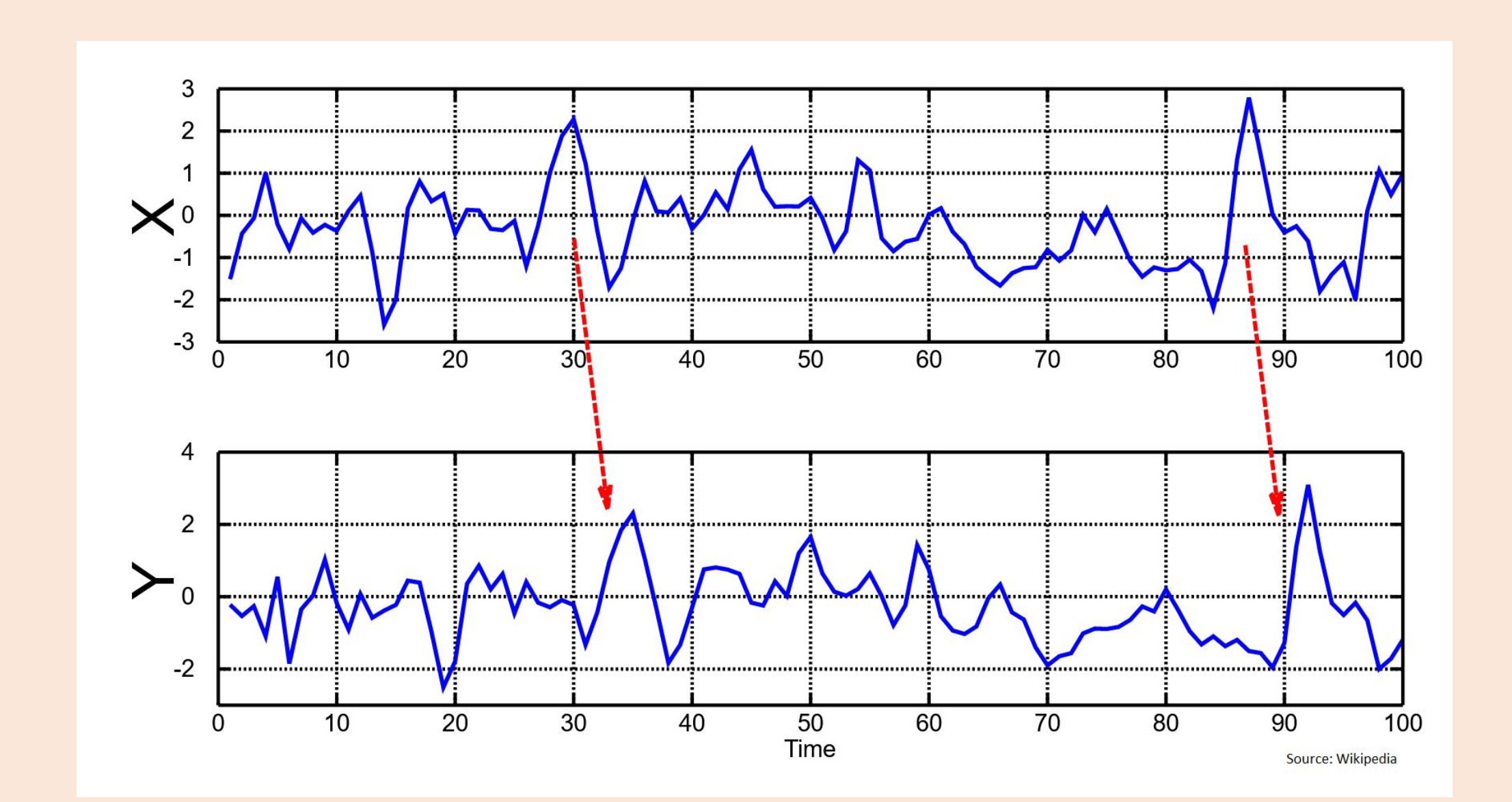
4. Granger-Causality

- R²-score and AIC based model comparison for selecting best lag

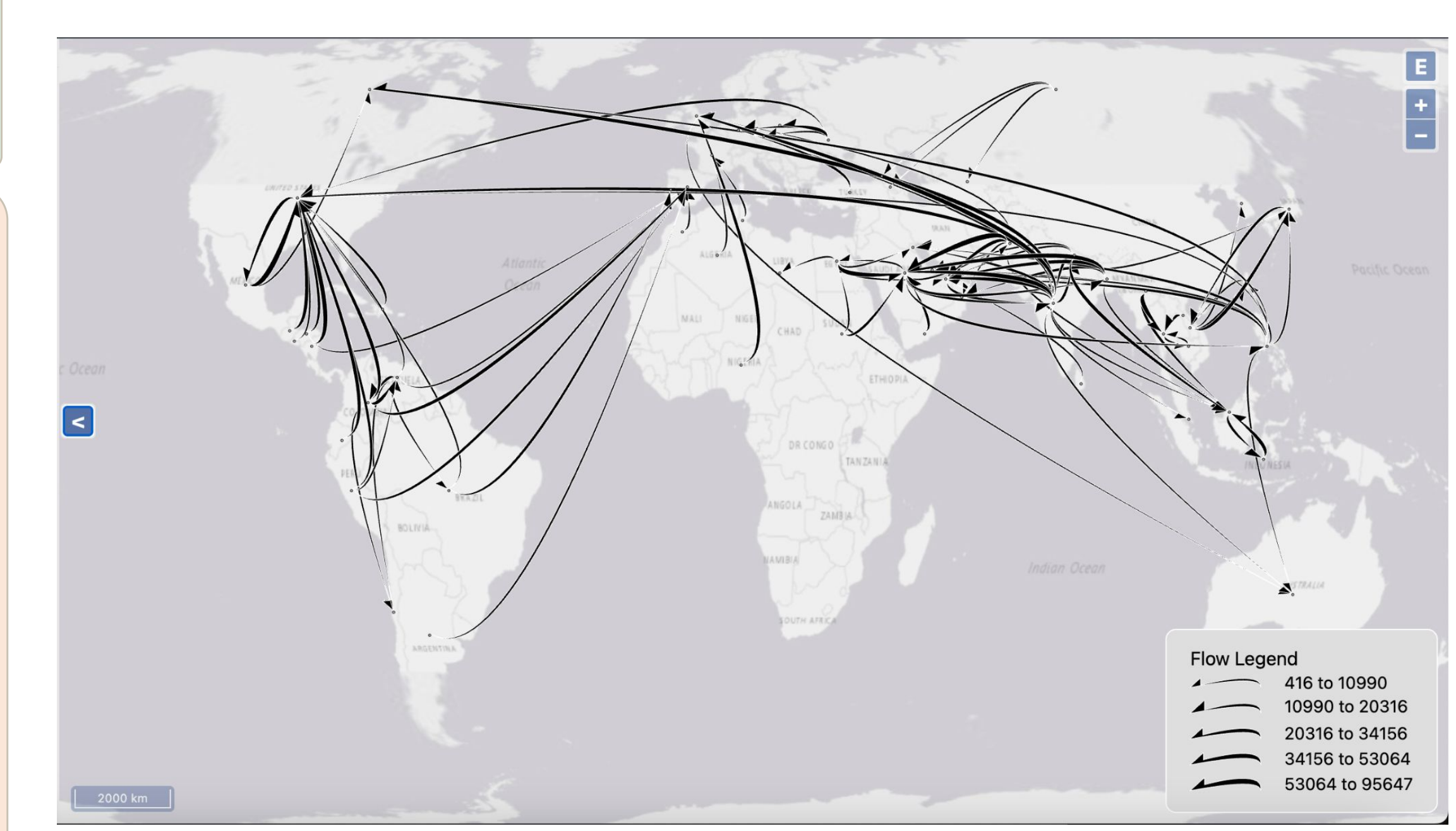
$$R^2 = 1 - \frac{\sum_i^N (y_i - \hat{y}_i)^2}{\sum_i^N (y_i - \bar{y})^2}$$

$$AIC = -2 \ln(L) + 2k$$

- Granger-Causality Test & Lag Selection (time series relationships)



Top 100 Largest Migration Flows



Conclusion and Discussion

Conclusions

- Disasters have a heavy influence on increasing international migration month-to-month, an influence also following disaster timing rather than only coinciding with it
- Income determines disaster response, as richer countries are more likely to migrate and in greater numbers, while only around half of the poorer countries respond, also showing a suppression in their ability to migrate
- The relationship between disaster frequency and migration is non-linear, as although the migration rate goes up during months with 1-2 disasters, it goes back down, even further below normal, at higher disaster frequencies

Impact

This is the first global, monthly test of how disaster frequency relates to international migration, including income as a moderator, on fully open data. This research brings awareness to the necessity of aid towards countries with people who are trapped by natural disasters, and can act as a first step towards even stronger research to identify more migration patterns relating to the environment.

Future Work

The most important is to analyze data over longer stretches of time (past 48 months), allowing for extended Granger-Causality tests. Subnation migration data can provide further insight on countries with a lack of disaster-provoked migration and help us understand what might trap them aside from income.

Acknowledgements

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Key References

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Results

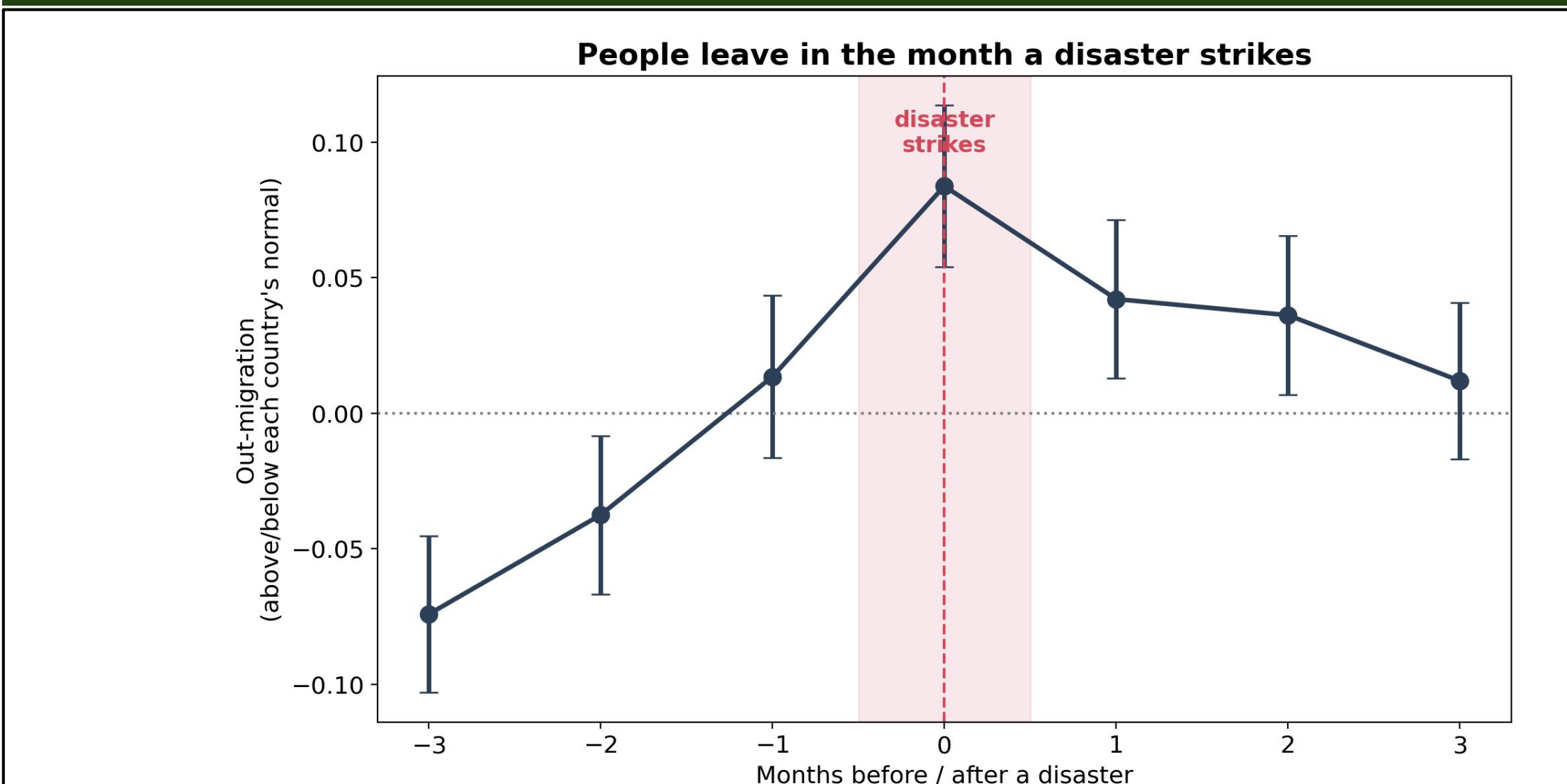


Figure 1: In terms of relationship to disaster timing, the emigration rate sits below each country's normal before a disaster, peaks in the exact month it strikes, then decays over the next ~3 months. Granger F-tests (restricted vs. unrestricted models, ADF-stationary series, AIC-selected 1–3 month lags) confirm disasters add predictive power beyond migration's own history.

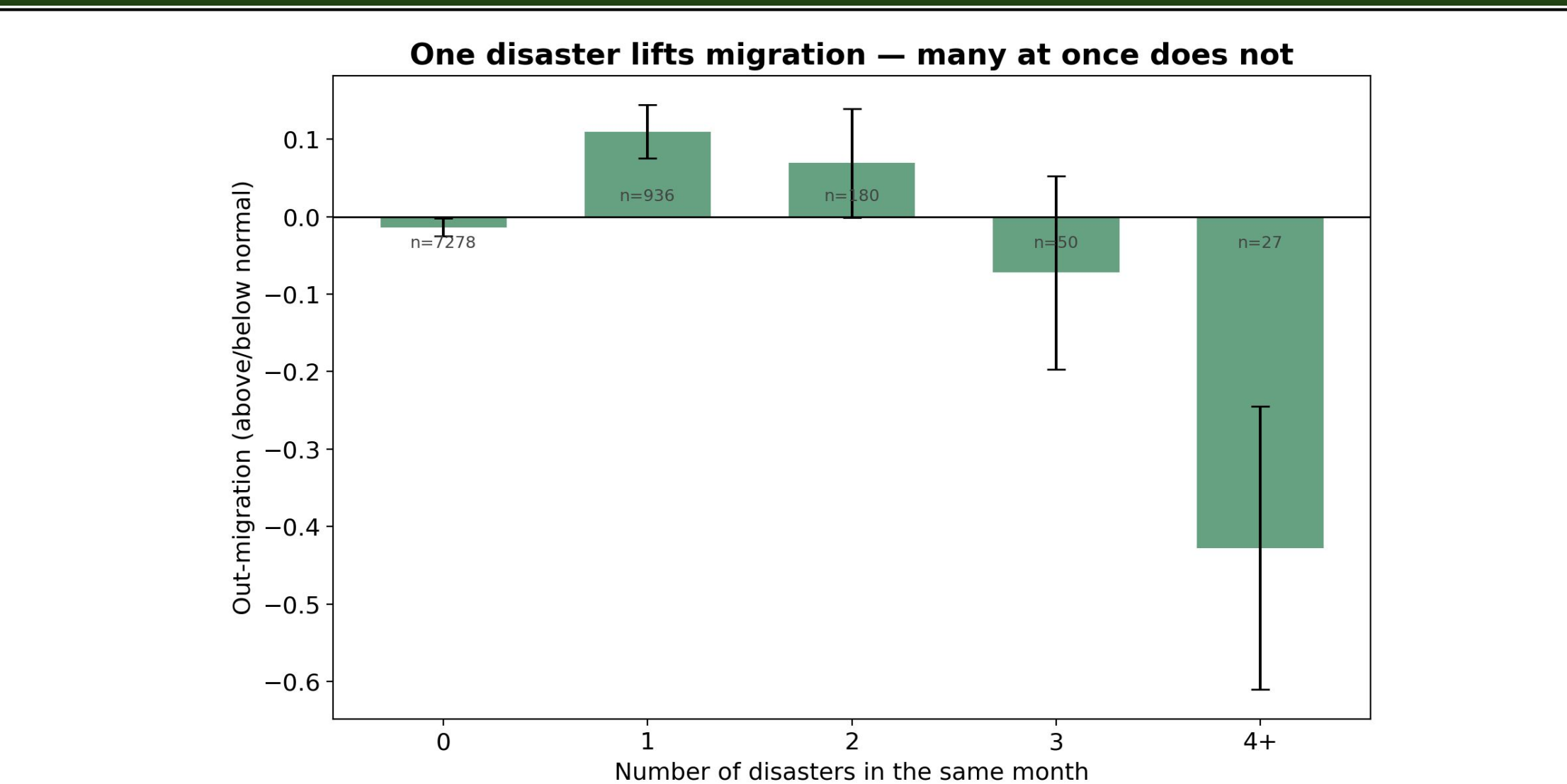


Figure 2: The out-migration rate increases with 1–2 disasters, but decreases when disaster frequency reaches high counts, showing high disaster frequency traps people while general disasters provoke migration out of a country. A single disaster lifts standardized out-migration to +0.11, but the effect turns negative at 3 and 4+, a signature of trapped populations.

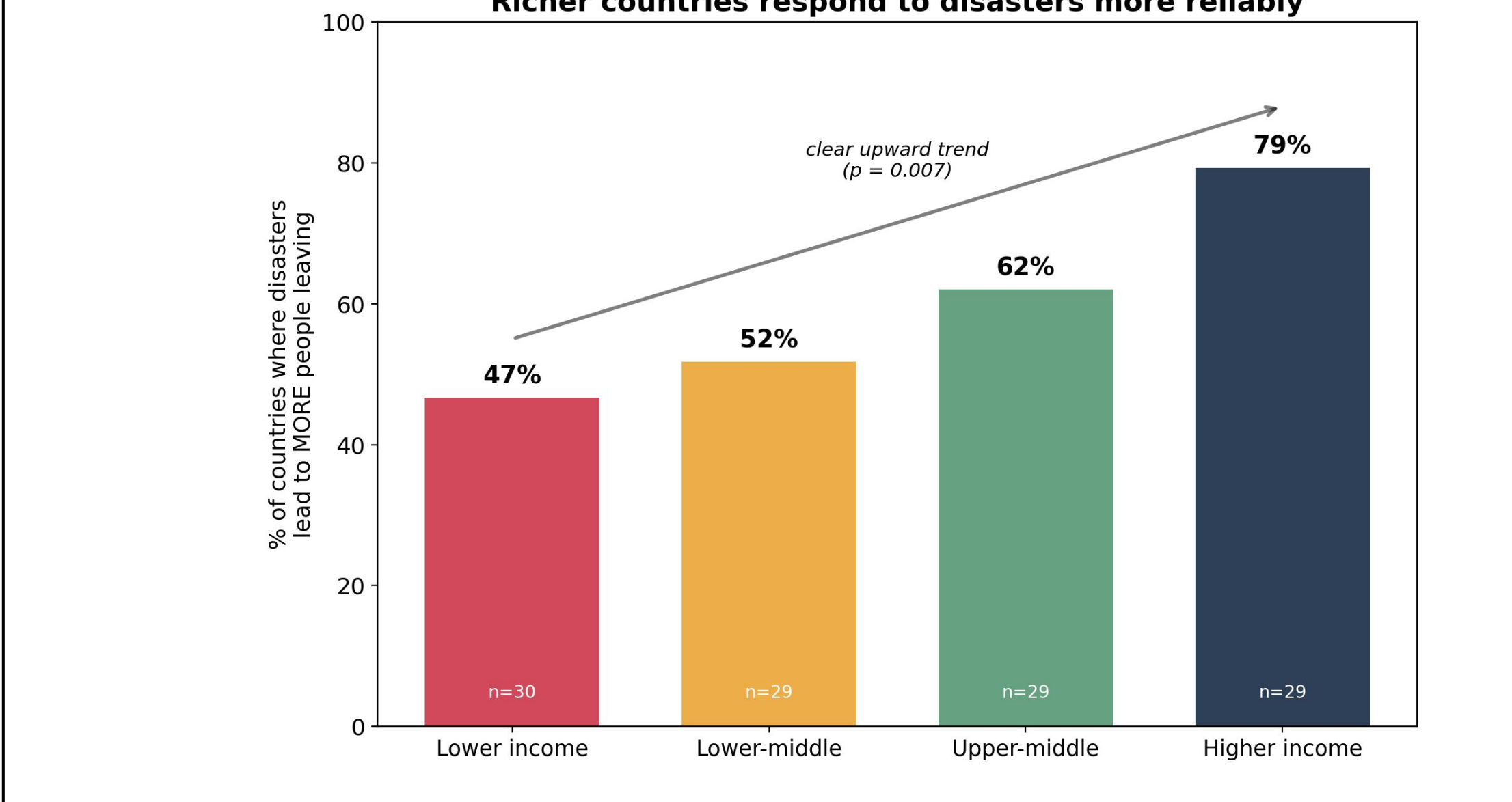


Figure 3: A clear relationship can be seen where higher income levels mean higher migration rates when a disaster occurs. The share of countries where out-migration climbs across income quartiles, and the median country's response rises the same way. Based on this, the probability and magnitude of leaving scale with income.

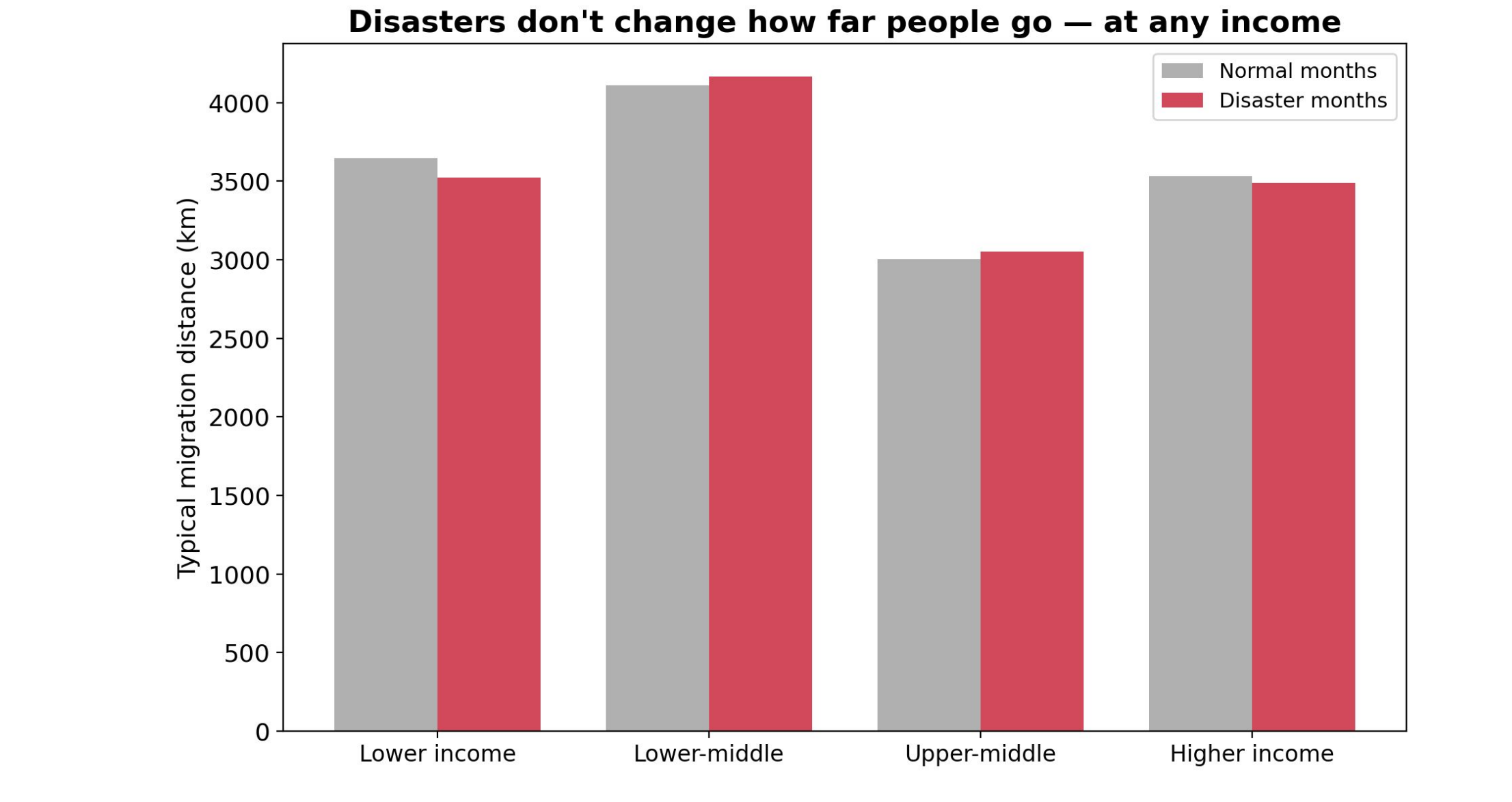


Figure 4: For each income level, the typical migration distance doesn't change between normal months and disaster months, with income also not showing any trend with how far people migrate, so how many people migrate. Distance shows no income relationship ($p \approx 0.04$) and shifts only ~1% in disaster months — it likely depends on geography, not income or disasters.