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RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

The Effects of Temperatures on Behavior

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RESEARCH SYMPOSIUM
MEASURING & REDUCING SOCIETAL IMPACTS

UCLA Luskin Center for Innovation

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Split Personalities? Behavioral Effects of Temperature on Financial Decision-making

Split Personalities?
Behavioral Effects of Temperature on Financial Decision-making

Despina Gavresi, Anastasia Litina, Christos A. Makridis

This Paper

Given what we know from behavioral finance, how do personality traits moderate the effects of idiosyncratic shocks on financial decisions?

This Paper

Given what we know from behavioral finance, how do personality traits moderate the effects of idiosyncratic shocks on financial decisions?

We answer this question by exploiting plausibly exogenous variation in the exposure to temperature across countries and time, tracing out the investment response.

- 28 European countries + Israel from 2004 to 2018 + over 140,000 individuals
- Financial investments in bonds, stocks, mutual funds, and retirement accounts
- Geocoded locations at the NUTS1 level within a country → temperature link

Our identifying variation comes from tracing out the response of the same individual to fluctuations in temperature in their country after controlling for all shocks that are common within a given country X year (and other demographics)

Background

We contribute to two primary literatures:

Personality characteristics and financial decision-making:

- Barber and Odean (2001), Durand et al. (2008), Grinblatt et al. (2011), Becker et al. (2011), Donnelley et al. (2012), Hirshleifer et al., (2016), Hirshleifer et al. (2020), Maggiori et al. (2021)

Weather and economic growth:

- Bloom and Sachs (1998), Rodrik et al. (2004), Robinson and Acemoglu (2012)

Weather and financial decision-making:

- Sanders and Brizzolara (1982), Hirshleifer and Shumway (2003), Goetzmann and Zhu (2005), Goetzmann et al. (2014), Baylis (2020), Makridis and Schloetzer (2021)

Roadmap

Data and Measurement Strategy

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Data and Measurement – Individual

Our primary data comes from six waves of the Survey of Health, Aging, and Retirement (SHARE) in Europe from 2004 to 2018 across 140,000 individuals ages 50 or older and 28 European countries + Israel.

- Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Germany, Finland, France, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Sweden, Slovenia, Slovakia, Spain, Switzerland, and Israel
- Financial investments: bonds, stocks, mutual funds, and retirement accounts
- Demographics: age, gender, location of residence, job situation
- Personality traits: “what are your hopes for the future,” “in the last month, have you been sad or depressed,” “have you felt enjoyment recently,” “general interest”

Data and Measurement – Country

We use the European Centre for Medium-Range Weather Forecasts, which is an independent intergovernmental organization that produces global numerical weather predictions even disaggregating within the same country over time.

→ We use the mean annual temperature measured in Celsius equal to the average mean monthly temperature at the NUTS1 regional level

→ We also use precipitation as the average mean monthly precipitation

We also gather some country*year characteristics from the World Bank.

Table 1: Descriptive Statistics, 2004-2018

	Pooled Sample		Optimists		Pessimists	
	mean	sd	mean	sd	mean	sd
financial investments						
investments in bonds	0.03	0.17	0.03	0.18	0.01	0.11
investments in stocks	0.1	0.3	0.1	0.3	0.0	0.1
investments in mutual funds	0.06	0.24	0.07	0.26	0.02	0.13
investments in retirement accounts	0.1	0.3	0.1	0.3	0.0	0.2
amounts in financial investments						
amount invested in bonds	45596.94	72485.29	46535.57	73585.56	35230.61	58153.96
amount invested in stocks	41103.5	86946.0	41642.2	87850.4	33327.8	71812.6
amount invested in mutual funds	58767.45	95607.67	58776.67	94360.83	56377.02	108686.62
amount invested in retirement accounts	41902.5	77087.9	43529.8	78320.0	25808.3	64402.9
personality						
optimism	0.86	0.35	1.00	0.00	0.00	0.00
depression	0.6	0.5	0.6	0.5	0.4	0.5
happiness	0.82	0.38	0.87	0.33	0.69	0.46
interest	0.9	0.3	0.9	0.3	0.8	0.4
trust others	6.81	2.39	6.95	2.33	6.16	2.53
risk aversion	0.82	0.39	0.80	0.40	0.90	0.30
health quality	0.56	0.50	0.63	0.48	0.35	0.48
demographics						
male	0.44	0.50	0.45	0.50	0.42	0.49
age at interview	67.52	9.95	66.51	9.59	69.93	10.57
employed	0.23	0.42	0.25	0.43	0.13	0.34
property value	200786.97	188239.27	211036.02	190386.94	138327.99	158932.25
country sentiment						
population growth	0.26	0.62	0.34	0.57	0.23	0.56
services value	62.77	5.15	63.14	5.01	61.89	5.02
total agriculture value	1.95	0.93	1.78	0.86	2.21	0.89
gdp per capita	34526.27	17471.82	37462.86	16959.48	28058.82	13448.59
weather						
temperature	10.00	3.99	10.36	3.89	10.38	3.75
precipitation	11.91	3.09	12.01	2.81	11.98	2.86
Observations	206743		127375		21376	

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Identification Strategy

We relate financial investment with logged temperature interacted with personality characteristics, but we focus on optimism as the primary dimension:

$$y_{ijt} = \gamma TEMP_{jt} + \phi c_{ijt} + \xi\left(TEMP_{jt} \times c_{ijt}\right) + \eta_c + \lambda_t + \epsilon_{ijt}$$

where

y = indicator (or logged amt) of investment in bonds, stocks, mutual funds, retirement

TEMP = logged average annual temperature

c = indicator of personality characteristics (i.e., optimism)

η and λ = fixed effects on country and year

In an even stricter specification, we add person and country*year fixed effects.

Threats to Identification

To identify a causal effect of temperature on investment activity, we need unobserved determinants of investments to be uncorrelated with changes in temperature/traits.

Concern #1: Unobserved heterogeneity correlated with optimism could also be correlated with financial investment behavior (e.g., positive selection).

Concern #2: Changes in weather could alter an individual’s stated mood.

Concern #3: Time-varying unobserved country-specific shocks, like macro events.

Threats to Identification

To identify a causal effect of temperature on investment activity, we need unobserved determinants of investments to be uncorrelated with changes in temperature/traits.

Concern #1: Unobserved heterogeneity correlated with optimism could also be correlated with financial investment behavior (e.g., positive selection).

We introduce person fixed effects.

Concern #2: Changes in weather could alter an individual's stated mood.

Create a time-invariant measure based on their most frequently stated mood.

Concern #3: Time-varying unobserved country-specific shocks, like macro events.

We introduce country*year fixed effects.

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Temperature ++ Bond Investment for Optimists

	Investment in Bonds				
	(1)	(2)	(3)	(4)	(5)
Optimist	-.0436***	-.0095	-.0274***	-.0031	-.0253**
	[.0083]	[.0084]	[.0082]	[.0128]	[.0087]
log(Temperature)	-.0182***	-.0091**	-.0004	-.0071	-.0071
	[.0027]	[.0036]	[.0044]	[.0052]	[.0074]
x Optimist	.0189***	.0068**	.0133***	.0018	.0099**
	[.0031]	[.0031]	[.0031]	[.0048]	[.0034]
R-squared	.02	.03	.04	.55	.55
Sample	89701	89701	89701	61798	61798
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes

Also true for the intensive margin (amount in logs)

	Amounts in Bonds				
	(1)	(2)	(3)	(4)	(5)
Optimist	-.1955***	-.0096	-.0263***	-.0055	-.0239***
	[.0478]	[.0103]	[.0098]	[.0166]	[.0022]
log(Temperature)	-.0395**	-.0242***	-.0073	-.0245***	-.0108
	[.0165]	[.0047]	[.0055]	[.0072]	[.0077]
x Optimist	.0865***	.0074*	.0136***	.0024	.0097***
	[.0179]	[.0040]	[.0038]	[.0063]	[.0012]
R-squared	.01	.91	.91	.95	.95
Sample	90412	90412	90412	62464	62464
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes

Temperature -- Investment in Stock for Optimists

	Investment in Stocks				
	(6)	(7)	(8)	(9)	(10)
Optimist	-.0545***	.0174	-.0098	.0617***	.0341**
	[.0144]	[.0145]	[.0147]	[.0173]	[.0095]
log(Temperature)	.0001	-.0126**	-.0033	.0028	.0098
	[.0047]	[.0057]	[.0070]	[.0066]	[.0059]
x Optimist	.0274***	.0009	.0107*	-.0219***	-.0119**
	[.0055]	[.0055]	[.0056]	[.0066]	[.0041]
R-squared	.06	.12	.12	.71	.71
Sample	89732	89732	89732	61817	61817
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes

Also true for the intensive margin (amount in logs)

	Amounts in Stocks				
	(6)	(7)	(8)	(9)	(10)
Optimist	-.0545***	.0174	-.0098	.0617***	.0341**
	[.0144]	[.0145]	[.0147]	[.0173]	[.0095]
log(Temperature)	.0001	-.0126**	-.0033	.0028	.0098
	[.0047]	[.0057]	[.0070]	[.0066]	[.0059]
x Optimist	.0274***	.0009	.0107*	-.0219***	-.0119**
	[.0055]	[.0055]	[.0056]	[.0066]	[.0041]
R-squared	.06	.12	.12	.71	.71
Sample	89732	89732	89732	61817	61817
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes

Examining the Determinants of Optimism

Are these differences in optimism driven more by:

- Trust in people (i.e., more optimistic people are just more trusting and happy)
- Risk aversion (i.e., attitudes about risk and uncertainty)
- Demographics and health status

Examining the Determinants of Optimism

	Optimist			
	(1)	(2)	(3)	(4)
Trust others	.0086***	.0083***	.0082***	.0080***
	[.0006]	[.0005]	[.0005]	[.0005]
Risk aversion	-.0243***	-.0147***	-.0147***	-.0134***
	[.0026]	[.0025]	[.0025]	[.0025]
Health quality	.0716***	.0551***	.0549***	.0546***
	[.0026]	[.0025]	[.0025]	[.0025]
Age at interview	-.0009***	-.0019***	-.0019***	-.0018***
	[.0002]	[.0002]	[.0002]	[.0002]
Male	-.0019	-.0003	-.0006	-.0003
	[.0024]	[.0023]	[.0023]	[.0022]
Employed	.0105***	.0097***	.0099***	.0084***
	[.0031]	[.0030]	[.0030]	[.0030]
Constant	-.9511***	3.5416***	3.6688***	-1.3135
	[.0586]	[.6197]	[.6216]	[.8928]
R-squared	.09	.20	.21	.22
Sample	65176	65176	65176	65176
Controls	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No
Year FE	No	Yes	No	No
Nuts FE	No	No	Yes	No
Country*Year FE	No	No	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients of determinants of optimism such as the levels of trust, risk aversion and health quality, logged annual temperature for the NUTS1 region (within a country), their interaction, and a vector of precipitation and individual demographic characteristics, which include age, gender and whether individual is employed or not. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations are unweighted.

Risk aversion plays a much larger role than trust in explaining differences in optimism.

Health and state dependence

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No Evidence of Income Effects as Driving Force

	Value of Property				
	(1)	(2)	(3)	(4)	(5)
Optimist	.8484***	.3539**	.3727**	.1772	.2119
	[.1588]	[.1559]	[.1594]	[.2256]	[.1561]
log(Temperature)	.3392***	-.0595	-.0045	-.0387	.0409
	[.0579]	[.0587]	[.0639]	[.0860]	[.0693]
x Optimist	-.2497***	-.0578	-.0658	-.0631	-.0776
	[.0594]	[.0583]	[.0596]	[.0852]	[.0579]
R-squared	.32	.35	.35	.76	.77
Sample	51315	51315	51315	30286	30286
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes

Notes.—Sources: Survey of Health, Ageing and Retirement (SHARE) in Europe (2004-2018). The table reports the coefficients associated with regressions of the respondent's logged self-reported real property value on logged annual temperature for the NUTS1 region (within a country), an indicator for being optimistic, their interaction, and a vector of precipitation and individual demographic characteristics, which include age and gender. Additional country level controls are used such as GDP per capita, population growth, services and agriculture value as a percentage of GDP. Standard errors are robust and clustered at the individual-level. Observations

Effects Are Concentrated in High Trust Countries 1/2

	Investment in Bonds				
	(1)	(2)	(3)	(4)	(5)
Panel A. High					
Optimist	-.0425***	-.0086	-.0236***	-.0095	-.0282*
	[.0091]	[.0092]	[.0090]	[.0140]	[.0110]
log(Temperature)	-.0193***	-.0108***	.0004	-.0106*	-.0065
	[.0030]	[.0039]	[.0048]	[.0058]	[.0078]
x Optimist	.0187***	.0065*	.0120***	.0047	.0115*
	[.0034]	[.0034]	[.0034]	[.0054]	[.0042]
R-squared	.02	.03	.04	.55	.55
Sample	77318	77318	77318	51375	51375
	Investment in Bonds				
	(1)	(2)	(3)	(4)	(5)
Panel B. Low					
Optimist	-.0357*	-.0269	-.0472**	-.0511	-.0058
	[.0198]	[.0196]	[.0204]	[.0763]	[.0674]
log(Temperature)	-.0101	.0009	-.0061	-.0316	-.0021
	[.0065]	[.0088]	[.0108]	[.0398]	[.0440]
x Optimist	.0149*	.0120	.0192**	.0153	-.0055
	[.0077]	[.0076]	[.0078]	[.0342]	[.0273]
R-squared	.01	.02	.03	.57	.59
Sample	12383	12383	12381	1542	1538
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes

Note the interaction effect is only present in Panel A

Effects Are Concentrated in High Trust Countries 2/2

	Investment in Stocks				
	(6)	(7)	(8)	(9)	(10)
Panel A. High Optimist	-.0541***	.0272*	-.0010	.0678***	.0371*
	[.0162]	[.0162]	[.0164]	[.0193]	[.0138]
log(Temperature)	.0020	-.0116*	-.0024	.0040	.0114
	[.0053]	[.0064]	[.0079]	[.0074]	[.0104]
x Optimist	.0273***	-.0028	.0076	-.0239***	-.0128*
	[.0062]	[.0062]	[.0063]	[.0074]	[.0059]
R-squared	.07	.12	.12	.71	.72
Sample	77344	77344	77344	51383	51383
	Investment in Stocks				
	(6)	(7)	(8)	(9)	(10)
Panel B. Low Optimist	-.0218	-.0500*	-.0553**	.0959	.0053
	[.0250]	[.0267]	[.0274]	[.1200]	[.0533]
log(Temperature)	-.0103	-.0104	-.0081	.0263	-.0054
	[.0070]	[.0107]	[.0132]	[.0506]	[.0437]
x Optimist	.0132	.0239**	.0256**	-.0319	.0042
	[.0097]	[.0103]	[.0107]	[.0479]	[.0265]
R-squared	.03	.06	.06	.61	.62
Sample	12388	12388	12386	1544	1540
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	No	No	No
Year FE	No	Yes	No	Yes	No
Person FE	No	No	No	Yes	Yes
Country*Year FE	No	No	Yes	No	Yes

Putting in Perspective w/ Prior Work

In separate work with Jason Schloetzer, we use daily data on temperature within a county to examine the effect on economic sentiment and well-being.

Putting in Perspective w/ Prior Work

In separate work with Jason Schloetzer, we use daily data on temperature within a county to examine the effect on economic sentiment and well-being.

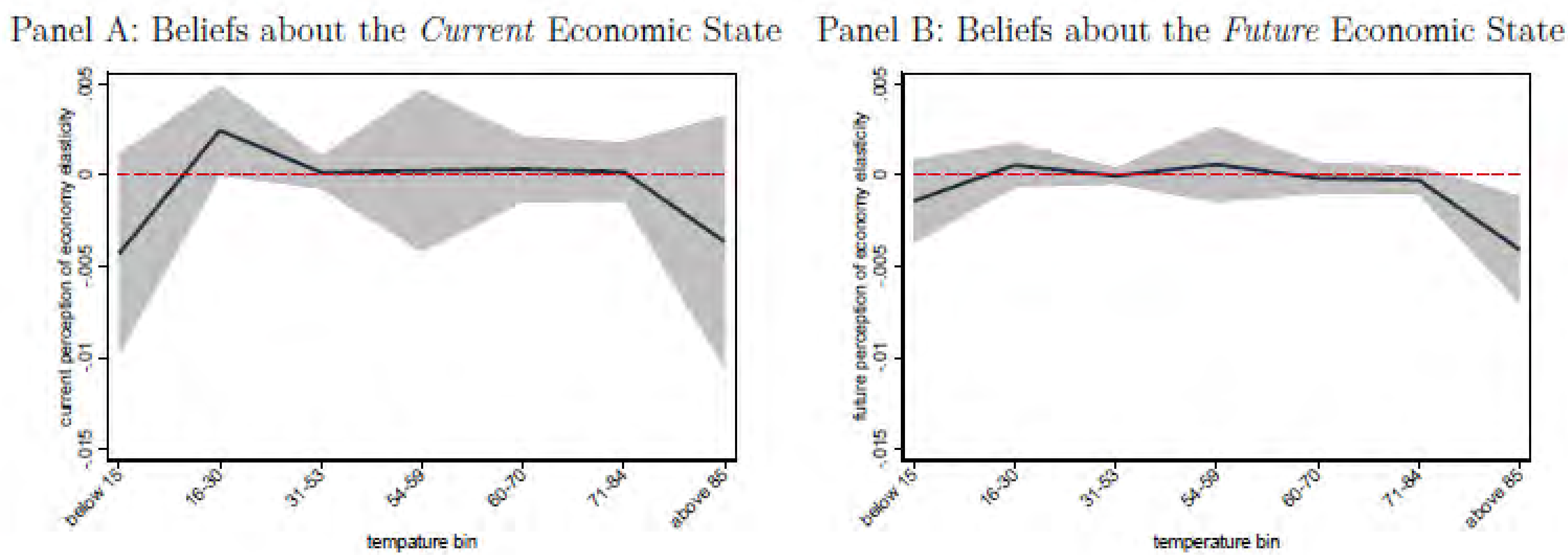

Figure 1: Temperature and Perceptions about the Current and Future States of the Economy

Notes.–Sources: Gallup, PRISM, 2008-2017. The figure plots the coefficients associated with regressions of the z-score of perceptions about the current state of the economy (one to four index) and an indicator for the perception that the future state of the economy is improving on average daily temperature interacted with bins on the temperature range (below 0, 0-15, 16-30, 31-53, 54-59, 60-70, 71-84, and 85+), individual controls, conditional on county historical temperature and precipitation, individual demographics, county and day-of-the-year fixed effects, and county × month × year fixed effects. Individual controls: an indicator for whether the individual is employed, marital status, a quadratic in age, male, education fixed effects, race (black/white). Standard errors are clustered at the county-level and sample weights are used.

And, this was a robust relationship.

Dep. var. =	1[future state of the economy is improving]					
	(1)	(2)	(3)	(4)	(5)	(6)
daily temperature	-.00024***	-.00023***	-.00017***			
	[.00006]	[.00006]	[.00006]			
× 1[extreme temp.]		-.00012*				
		[.00007]				
5-year temperature growth				-.06011***		
				[.00523]		
× 1[age > 65]			-.00036***			
			[.00006]			
sd(daily temperature)					-.00080***	
					[.00030]	
ln(daily temperature)						-.00501***
						[.00190]
R-squared	.09	.09	.09	.09	.09	.09
Sample Size	1536762	1540661	1536762	1361805	1536762	1533201
Controls	Yes	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes.–Sources: Gallup, Quarterly Census of Employment and Wages, Federal Housing Administration, 2008-2017. The table reports the coefficients associated with regressions of the z-score of perceptions about the current state of the economy (one to four index) and an indicator for the perception that the future state of the economy is improving on different measures of temperature fluctuations (in Fahrenheit), conditional on year-to-year county employment and housing price growth, daily precipitation and historical county average, county and month / year fixed effects and individual controls, which include: day of the week fixed effects, an indicator for whether the individual is employed, marital status, a quadratic in age, male, education fixed effects, race (black/white). The different measures of temperature are: daily average temperature, its interaction with an indicator for whether that day has extreme temperatures (below 15 or above 85 degrees), an interaction for whether the individual is in a sensitive age group (defined as over age 65), the five-year growth rate in monthly temperature, the standard deviation of temperature over the year, and logged daily temperature. Standard errors are clustered at the county-level and sample weights are used.

Similar Relationship with Stock Returns

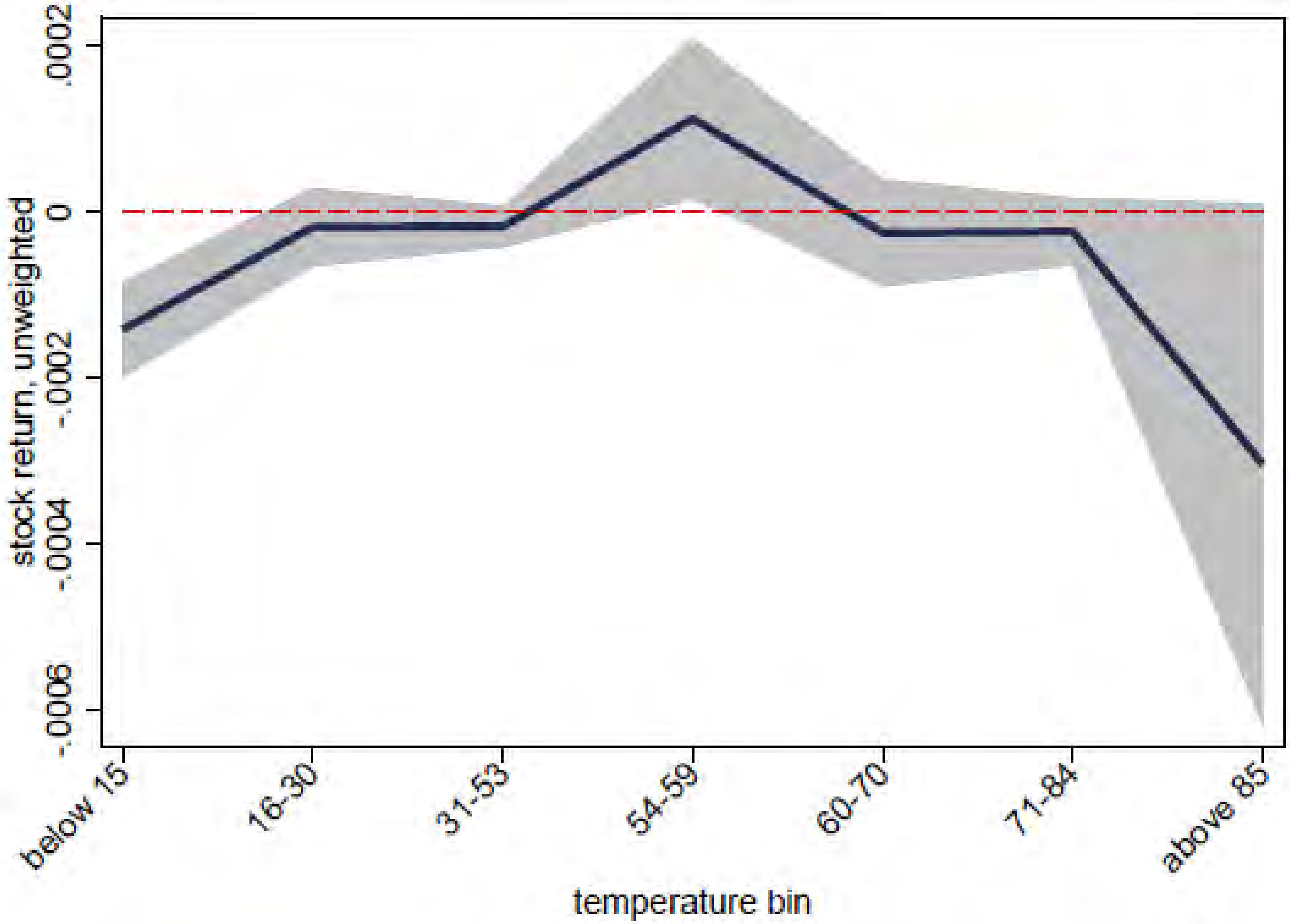

Figure 5: Stock Returns and Temperature Fluctuations

Notes.–Sources: CRSP, 2007-2017. The figure plots the coefficients associated with regressions of the stock return net of dividends on average daily temperature separately across seven temperature bins (below 0, 0-15, 16-30, 31-53, 54-59, 60-70, 71-84, and 85+), county, year, and month fixed effects and daily county precipitation. Stock returns for each company are given the county location of their headquarters based on the result from Coval and Moskowitz [1999] that investors tend to invest more heavily in local stocks. Standard errors are clustered at the county-level and observations are unweighted.

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Conclusion

We know that personality characteristics are closely connected with financial decision-making, but know much less about how they interact with different types of shocks.

We exploit exogenous variation in temperature to assess the effects on investments in different financial assets, allowing for heterogeneity for optimists and pessimists.

Conclusion

We know that personality characteristics are closely connected with financial decision-making, but know much less about how they interact with different types of shocks.

We exploit exogenous variation in temperature to assess the effects on investments in different financial assets, allowing for heterogeneity for optimists and pessimists.

<u>We find that hotter temperatures push optimists towards safer assets and away from more risk assets—but we find null effects for pessimists.</u> This is consistent with models where optimists, or those with stronger expectations, are more responsive.

Our results help discipline models with expectation formation and aggregate behavior by showing how different types of individuals respond to idiosyncratic shocks.

Michelle Escobar

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Temperature and Economic Preferences in Developing Countries

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The Effects of Temperature on Economic Preferences

Michelle Escobar Carias

Prof. David Johnston, Dr. Rachel Knott, Dr. Rohan Sweeney

UCLA Climate Adaptation Research Symposium

September 8th, 2021

GROUP OF EIGHT AUSTRALIA

AACSB ACCREDITED EFMD EQUIS ACCREDITED ASSOCIATION OF MBAS ACCREDITED

BACKGROUND & MOTIVATION

- Our willingness to take risks and our level of patience influence our future well-being:
  - Risky choices like self-employment decrease with risk aversion (Ekelund, et al., 2005)
  - Impatient individuals are less likely to take-up savings products (Ashraf, et al., 2006)

+ In the neoclassical theory preferences on time and risk are assumed to be static (Stigler & Becker, 1977)

Malleability of economic preferences:

- Higher risk-aversion after floods and earthquakes in Indonesia (Cameron & Shah, 2015 JHR)
- Men who experienced greater intensity during 2011 Japan Earthquake became more risk-tolerant, gamble more (Hanaoka et al., 2018 AEJ)
- Exposure to the Indian Ocean Earthquake tsunami increased patience in a sample of Sri Lankan wage workers (Callen, 2015 JEBO)

POTENTIAL CHANNELS

Cognition, sleep, and mood affect economic preferences

+ mathematical skills ➡ - time discounting and - risk aversion (Benjamin, et al., 2013; Falk, et al., 2018)

+ sleep ➡ - discounting rates and - loss aversion (Nofsinger & Shank, 2019)

+ aggression ➡ + financial risk taking and + propensity towards risky driving behavior

(Meier, 2021; Cueva, et al., 2015; Deffenbacher, et al., 2003)

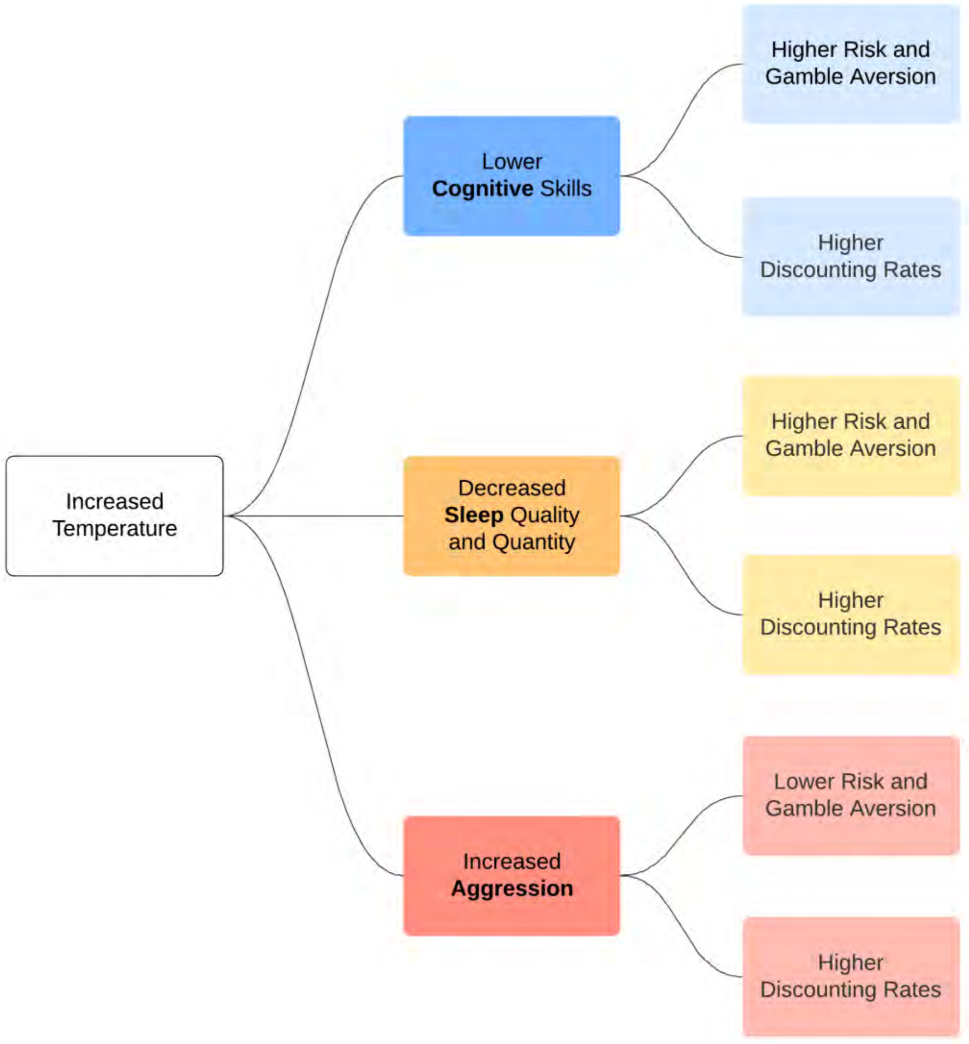
Temperature affects cognition, sleep, and mood

+ number of hot days ➡ - rate of learning and skill formation (Park, et al., 2021)

+ nighttime temperatures ➡ - sleep duration by delaying its onset (Minor, et al, 2020)

+ uncomfortably hot temperatures ➡ + propensity of aggression (Mukherjee & Sanders, 2021)

POTENTIAL CHANNELS



Takeaways

- All channels predict increased impatience (higher discounting rates)
- Cognition and Sleep similar effect on + risk aversion
- Anger would – risk aversion

RELATED LITERATURE

Temperature and economic preferences:

1. Almås, et al. (2020). *Destructive behavior, judgment, and economic decision-making under thermal stress*. NBER Working Paper

Lab experiment with 2,000 participants in Nairobi and USA finds no evidence that heat stress significantly increases risk-taking, rational choice violations, patience, or time inconsistency

2. Wang (2017). *An empirical study of the impacts of ambient temperature on risk taking*. Psychology, 8

High ambient temperatures lead individuals to pursue high-risk and high-yield options

3. Cheema & Patrick (2012). Influence of warm versus cool temperatures on consumer choice. Journal of Marketing Research, 49

Individuals operating in warmer temperatures are a) less likely to gamble, b) less likely to purchase innovative products

RELATED LITERATURE: LAB STUDIES

Strengths

✓ Randomization
- Individuals exposed to high and low temperatures likely very different
- Address Selection Bias

✓ Tight control of other stressors
- Humidity
- Rainfall
- Noise
- Wind

Weaknesses

! Sample Size
- 46 – 2000 individuals

! Sample Composition
- University students, high SES, young

! Timing of Exposure to Treatment
- Day versus nighttime

! Duration of Exposure to Treatment
- 15-20 minutes not long enough

DATA - INDONESIA FAMILY LIFE SURVEY

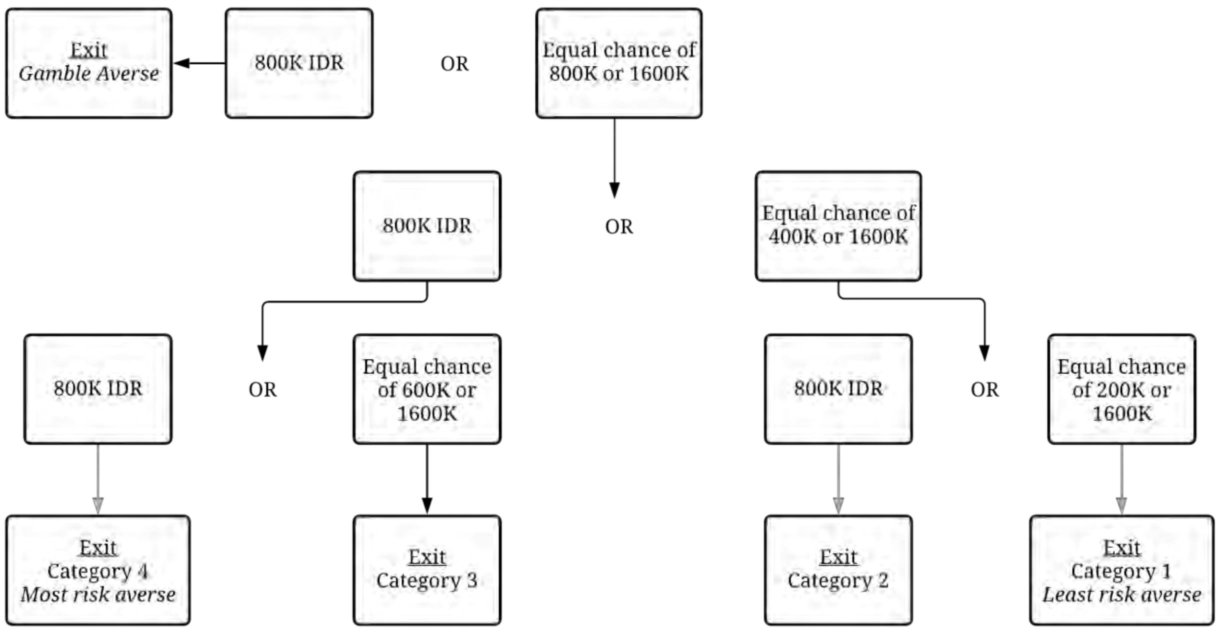
- **A longitudinal survey, representative of about 83% of the Indonesian population**
  - Over 30,000 individuals living in 13/27 provinces
  - IFLS1 was conducted in 1993/94 by RAND, followed by 4 more waves every 3-5 years.

- **Survey info used in this study (51,000 observations from 2 waves):**
  - Adults age 15 – 90 of IFLS4 (2007-2008) and IFLS5 (2014-2015)
  - Staircase instruments measuring risk aversion, gamble aversion, impatience.
    - Mechanism A: Global cognition score, Fluid Intelligence, Mental Intactness, Raven's Matrix, Math
    - Mechanism B: Sleep onset, sleep offset, total time in bed
    - Mechanism C: Mood (angry, stressed, enthusiastic, happy)

  - Restrictions:
    - All IFLS5 adult respondents
    - IFLS4 respondents who did not leave their villages in IFLS5
    - Individuals living within 50 kms of nearest Merra-2 grid

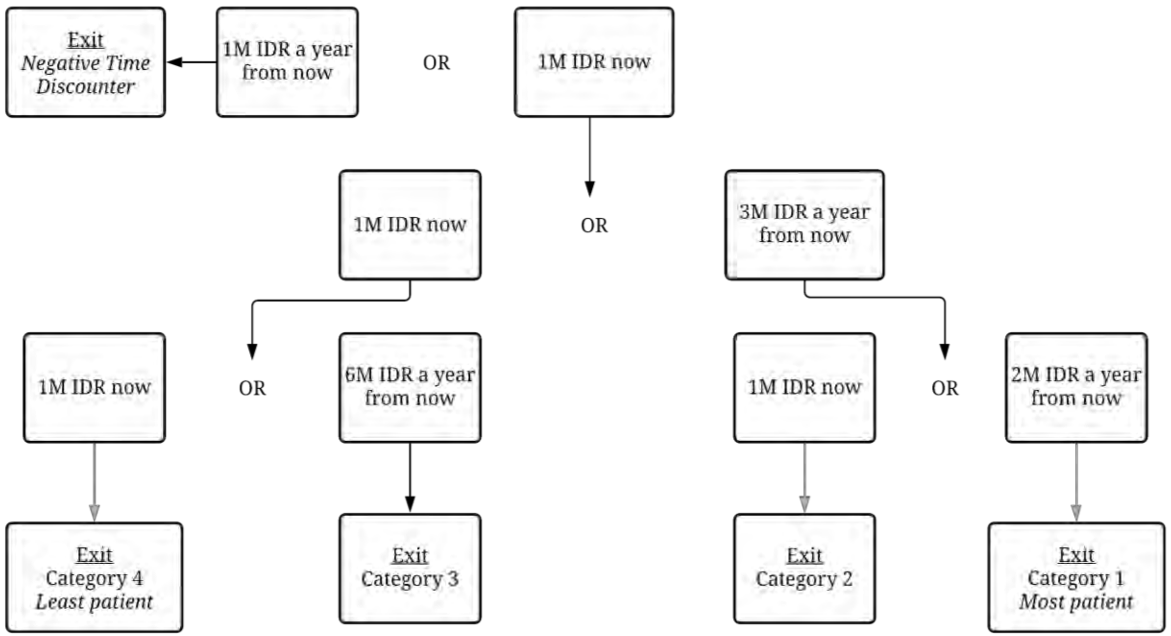
Risk Preferences Flowchart

31%



37%

Time Preferences Flowchart



62%

DATA – VALIDATION OF TIME AND RISK MEASURES

Table 2. Accumulation decisions, risky choices and economic preferences

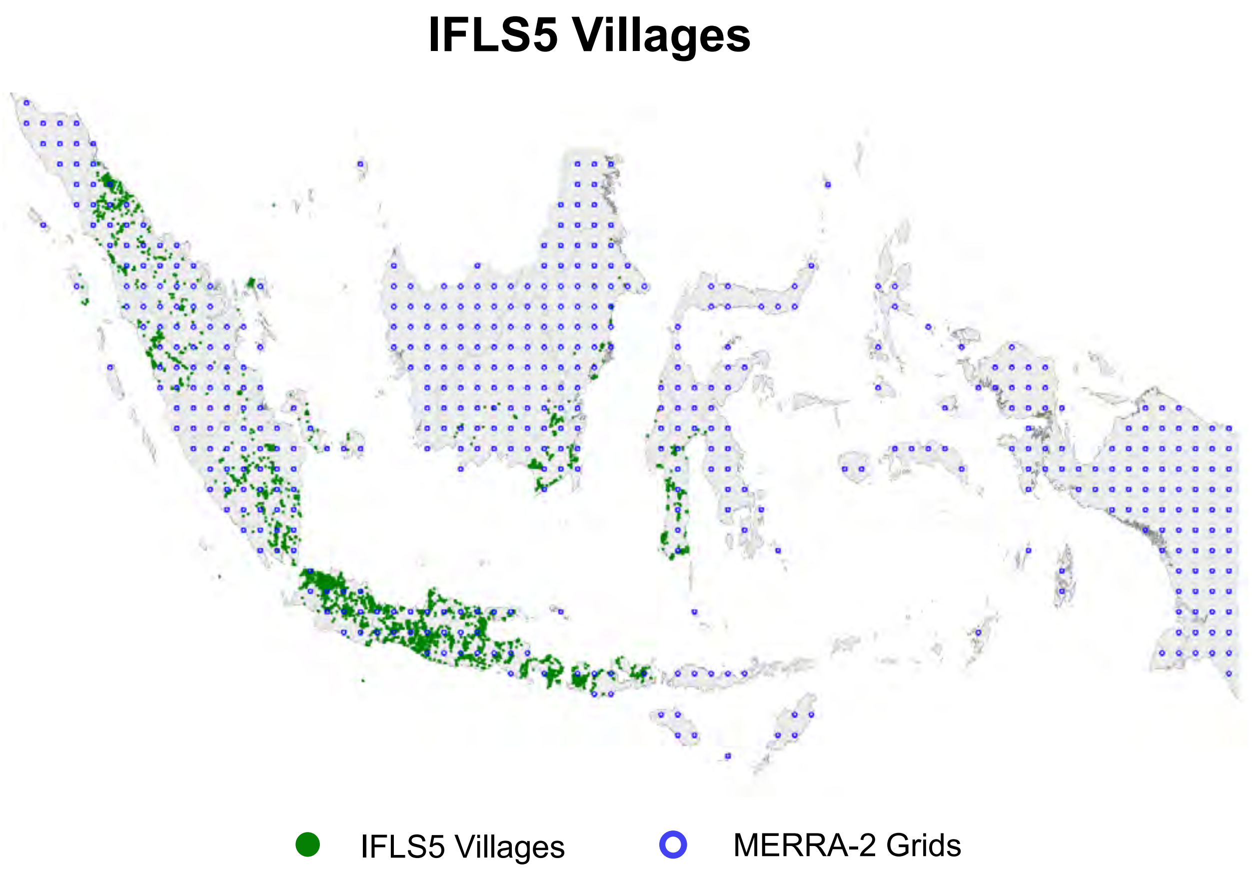
	Accumulation decisions		Risky Choices			
	Savings	Higher Education	Self Employed	Plan to Start Business	Use Tobacco	Number Cigarettes
	(1)	(2)	(3)	(4)	(5)	(6)
Most Impatient	-0.031***	-0.044***				
	(0.004)	(0.004)				
Most Risk Averse			-0.013***	-0.010***	0.001	-0.262*
			(0.005)	(0.003)	(0.004)	(0.148)
Gamble Averse			-0.005	-0.011***	0.003	-0.296**
			(0.004)	(0.003)	(0.004)	(0.141)
Outcome Mean	21.16%	48.09%	26.56%	6.62%	33.50%	11.65
R-squared	0.124	0.253	0.144	0.043	0.531	0.131
Observations	38463	52385	51778	49190	49574	16227

Note. – * p<0.1; ** p<0.05; *** p<0.01

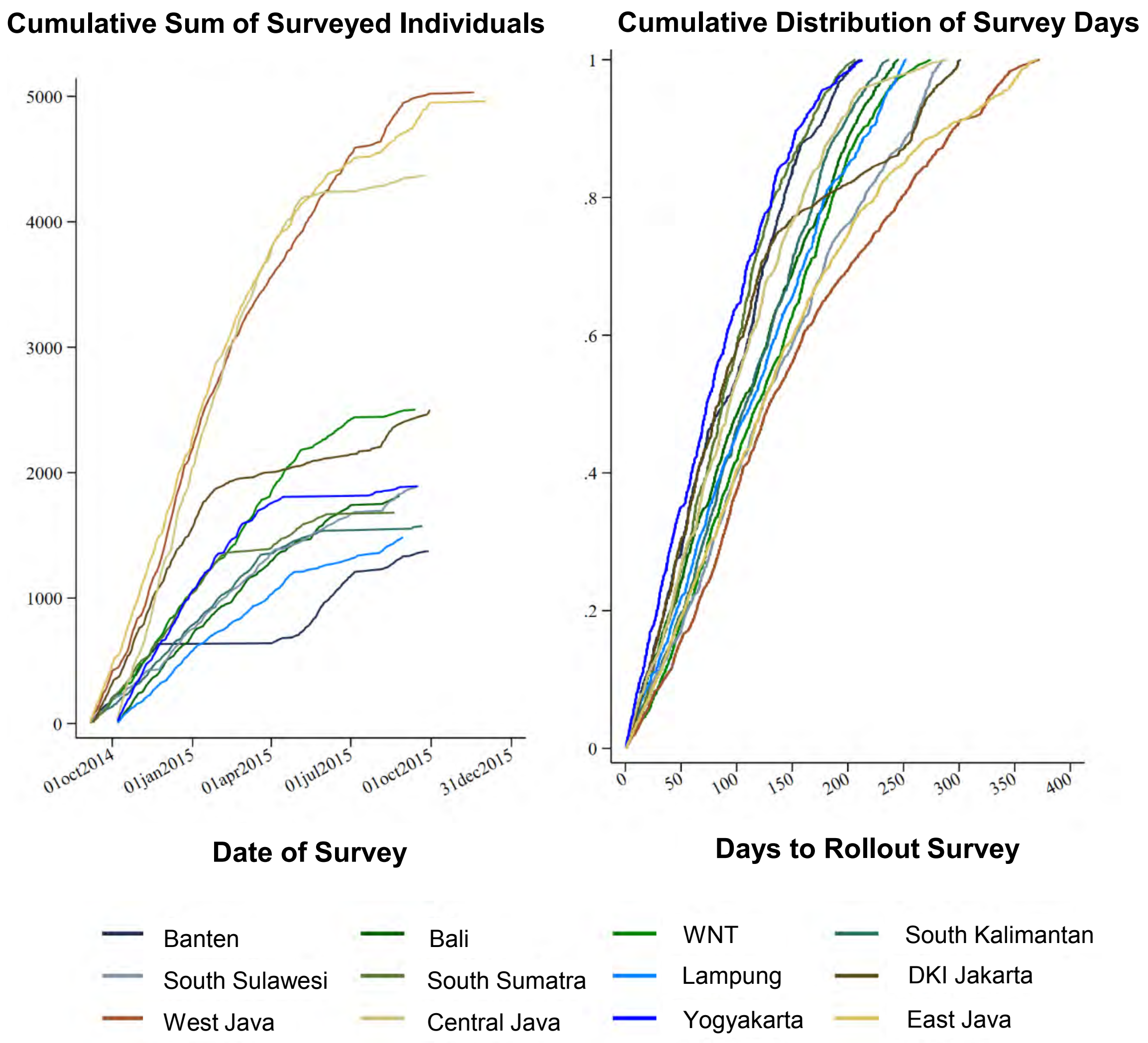
- Impatience is associated with lower savings and educational attainment
- Risk aversion and gamble aversion are significantly correlated with risky choices
- The correlation coefficient between gamble aversion and impatience is only 0.28

DATA - NASA MERRA2

- This reanalysis dataset integrates both station and satellite data. It provides global environmental estimates for 0.5º x 0.625º (50x60 kms) cells at hourly and daily time scales from 1981 to 2021.



EMPIRICAL STRATEGY



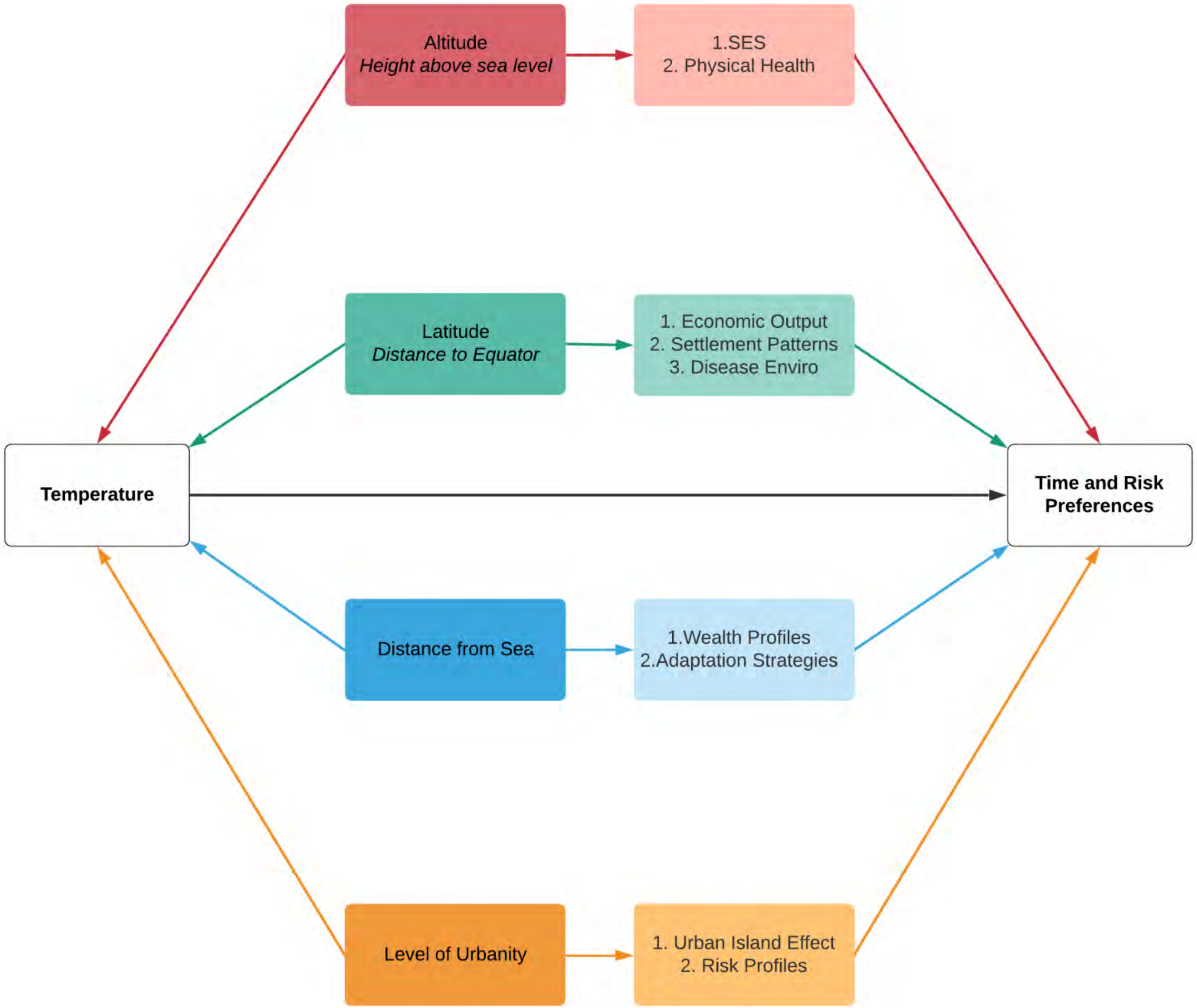
To identifying the effects of temperature on time and risk preferences:

1. Individual and household characteristics do not explain outdoor maximum (p = 0.0944) and midnight (p = 0.6877) temperatures

2. We then exploit quasi-random variations in temperature within **provinces** produced by time to roll-out surveys

3. Province-level analyses allow for enough variation in temperature

4. However, potential endogeneity issues by simple comparison of all individuals within province



EMPIRICAL STRATEGY

Microclimates

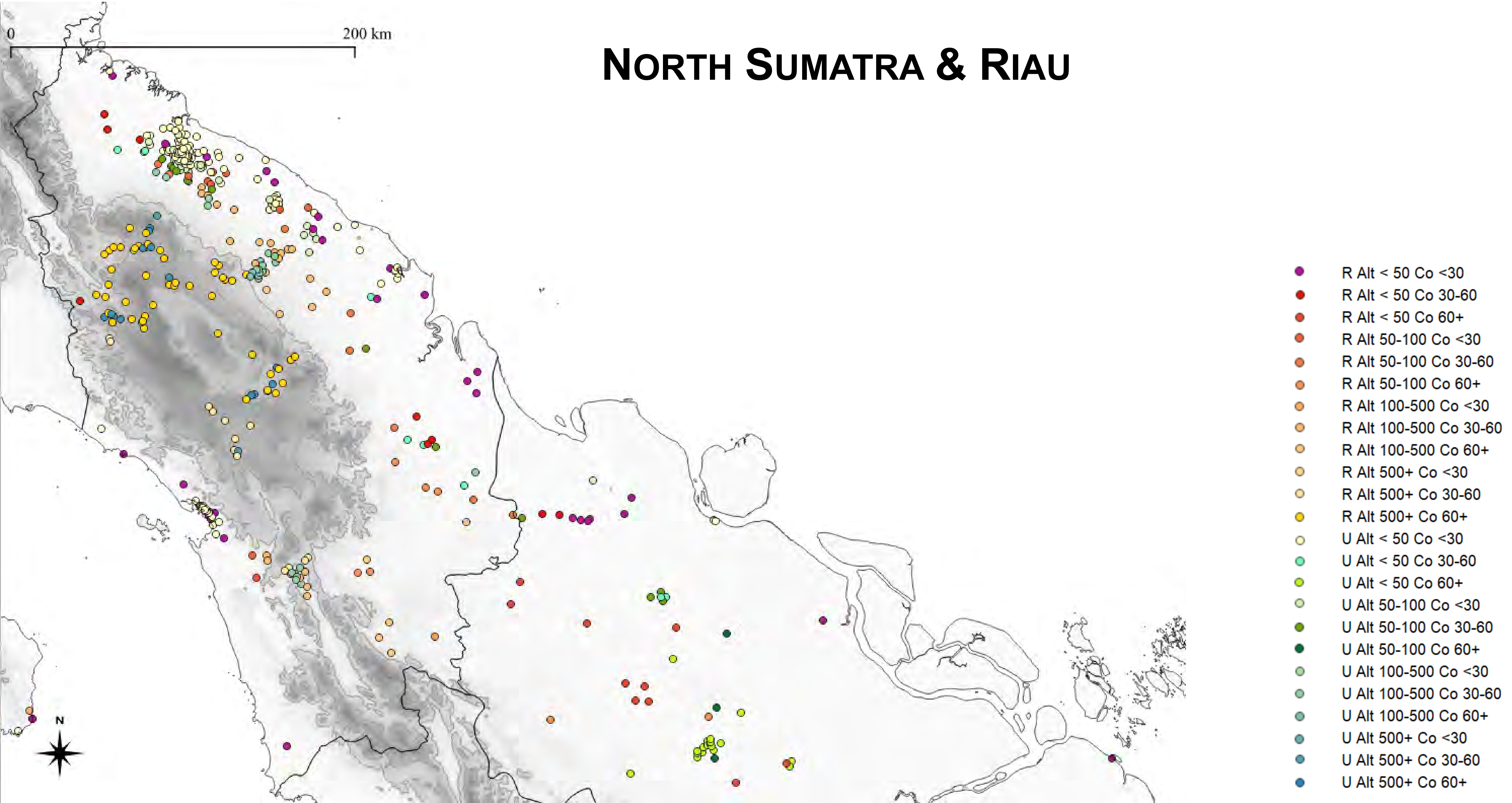
285 Bins:

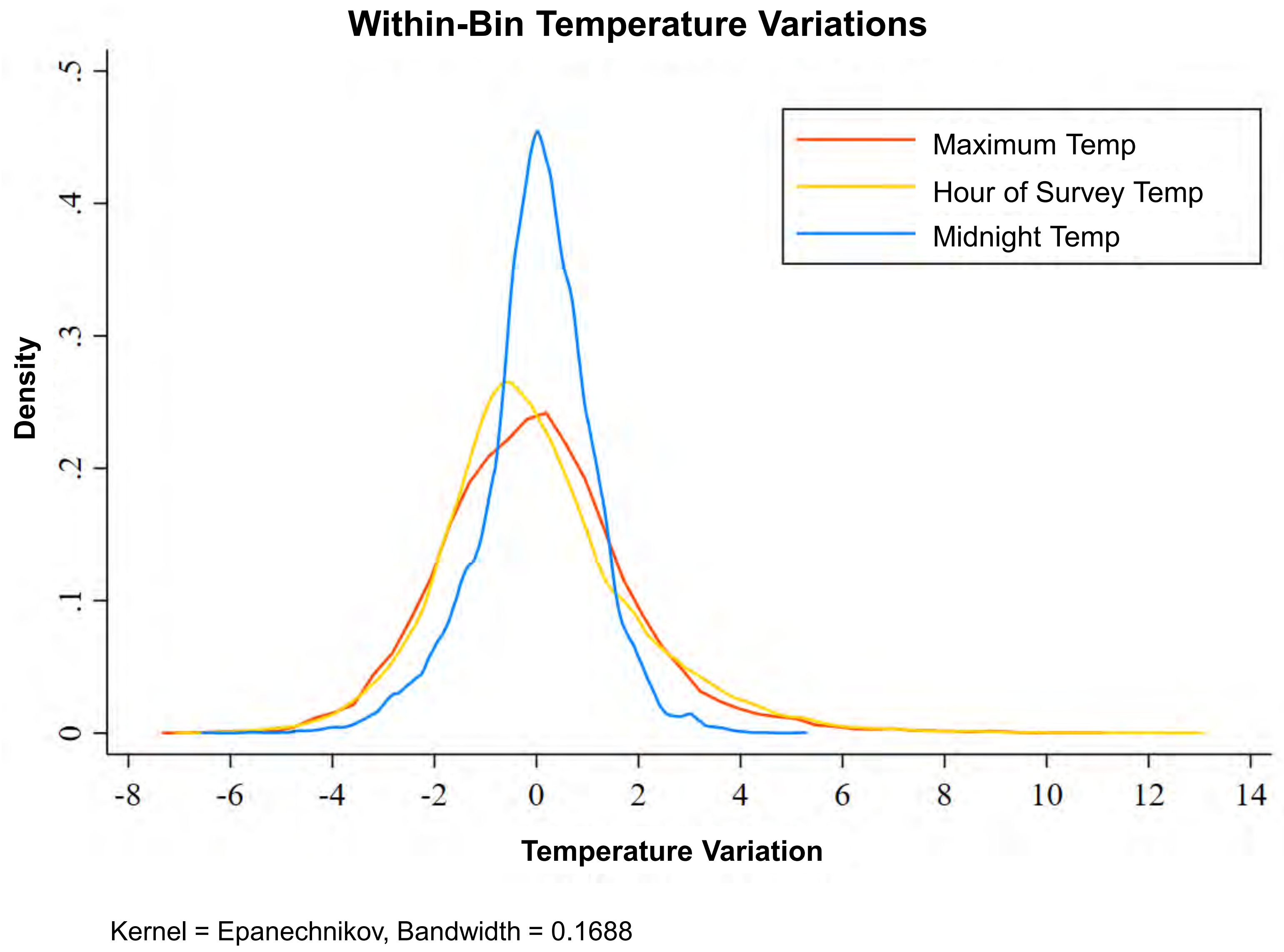
24 Provinces *
Dummy urban village*
4 Altitude groups *
3 Distance-to-the-coast groups

Altitude groups (<50 m, 50-100 m, 100-500 m, 500+ m)

Distance from the-coast groups (<30 km, 30-60 km, 60+ km)

NORTH SUMATRA & RIAU





- **Environmental Data**
- Hourly and Daily records:
  - Temperature
  - Relative Humidity
  - Wind Speed
  - Precipitation
  - PM 2.5
  - Sulfur dioxide

Maximum Temperatures
- Range: **21 – 40 º C**
- Average: **28.67º C**

Midnight Temperatures
- Range: **14 – 29 º C**
- Average: **23.64º C**

Survey Temperatures
- Range: **14.5 – 38º C**
- Average: **24.55º C**

EMPIRICAL STRATEGY

Year FE control for broad climate changes

Month FE control for seasonality

Location FEs control for spatial heterogeneity

$$Y_{ipbt} = \alpha + \beta temperature_{ipvt} + \lambda'_{ipvt} + X'_{ipbt} + \rho_m + \tau_y + \phi_b + \varepsilon_{ipbt} \quad (1),$$

Risk Aversion, Gamble Aversion, Impatience, Cognition, Sleep, Mood

Max Temperature, Temperature at Hour of Survey, Midnight Temperature

Controls for precipitation, wind speed, and particulate matter 2.5

Controls for age, gender, religion, activity, education, consumption, # children, # hhd members, demographics of head, day of week, hour when survey began

Bins: province * village's urban or rural status * 4 altitude groups * 3 distance-to-the-coast groups

Altitude groups (<50 meters, 50-100 meters, 100-500 meters, 500+ meters)
Distance from the-coast groups (<30 km, 30-60 km, 60+ km)

Cluster standard errors on village level (Abadie et al., 2017)

RESULTS – LINEAR EFFECTS OF TEMPERATURE ON PREFERENCES

Table 3. Linear Effects of Temperature on Time and Risk Preferences

	Most Risk Averse (1)	Gamble Averse (2)	Most Impatient (3)
Panel A			
Max Temperature on Day of Survey	0.001	0.004***	0.005***
	(0.002)	(0.001)	(0.001)
Panel B			
Temperature during hour of survey	0.002	0.008***	0.005***
	(0.002)	(0.001)	(0.002)
Panel C			
Midnight Temperature Yesterday	0.002	0.011***	0.012***
	(0.003)	(0.002)	(0.002)
Panel D			
Max Temperature on Day of Survey	0.000	0.001	0.003
	(0.002)	(0.002)	(0.002)
Midnight Temperature Yesterday	0.002	0.010***	0.010***
	(0.003)	(0.002)	(0.002)
p-value	0.6872	0.0389	0.0504
Outcome Mean	0.37	0.31	0.62
Observations	32119	48953	47566

Note. – * p<0.1; ** p<0.05; *** p<0.01

- Each additional Celsius degree:

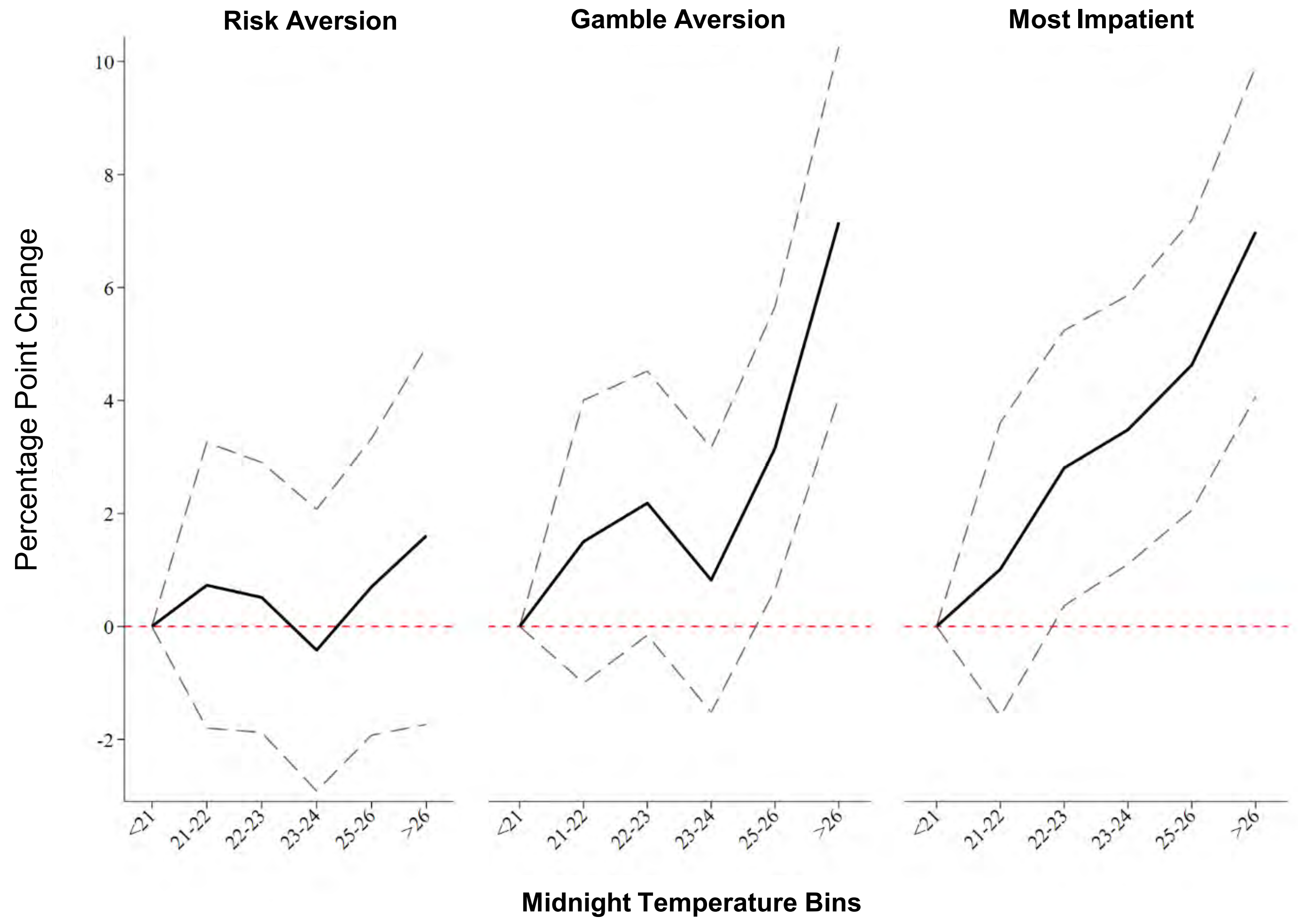
- No effects on risk aversion
- Increases gamble aversion by 2.6% – 3.6%
- Increases impatience by 0.8% – 1.9%

- Midnight temperatures:

- Consistently larger effects
- Completely dominate maximum temperature

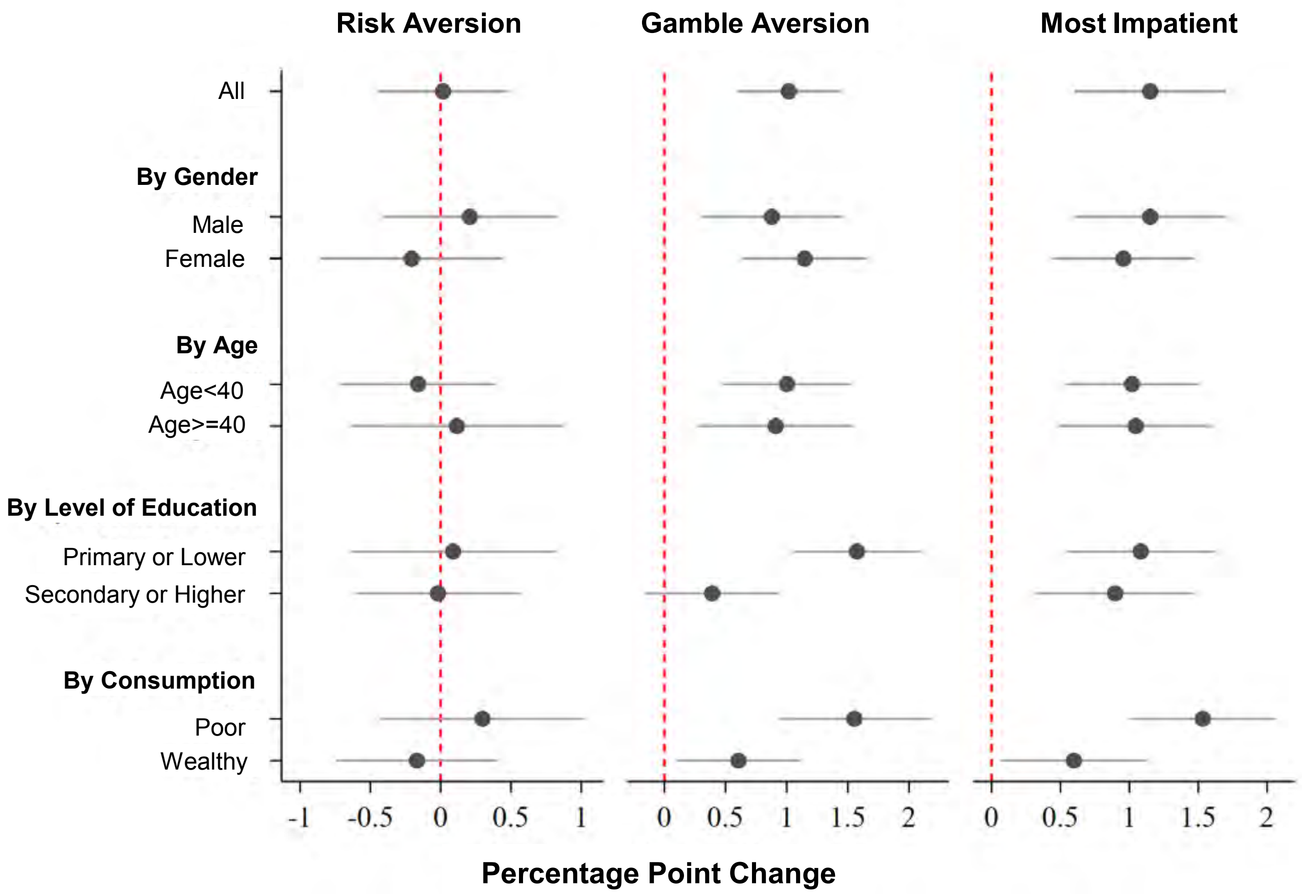
- What is happening at night?

RESULTS – NON PARAMETRIC ESTIMATES



- Reference level: 14-21^{o}C
- Quasi-linear effects of midnight temperature. Linear approximation in Table 3 can be generalized
- All forms of risk aversion and gamble aversion show linear increase after 25^{o}C of midnight temperature
- Monotonic increase in impatience after 22^{o}C of midnight temperature

HETEROGENEITY
TEMPERATURE EFFECTS VARY BY SUB-SAMPLES



- No significant differences by age or gender
- Adults with primary education or less experience higher midnight temperature effects on gamble aversion ($p = 0.001$)
- Night time heat makes poorer individuals more gamble averse ($p = 0.099$) and impatient ($p = 0.074$)

MECHANISMS – COGNITION, SLEEP AND MOOD

Table 4. Potential mechanisms behind temperature effects

Outcomes	Temperature at Midnight Yesterday/ Before Yesterday (1)	Outcome Mean (2)
Panel A - Cognition		
Cognition global z-score	-0.014** (0.006)	0
Fluid Intelligence z-score	-0.016*** (0.006)	0
TICS z-score	-0.003 (0.006)	0
Raven's Matrix z-score	-0.020*** (0.005)	0
Math z-score	-0.012** (0.006)	0
Panel B - Sleep		
Sleep Onset	-0.003 (0.011)	22.32
Sleep Offset	0.001 (0.010)	5.12
Time in Bed	0.004 (0.011)	6.8
Panel C - Mood		
Angry	-0.001 (0.003)	0.31
Stressed	-0.004 (0.002)	0.21
Enthusiastic	-0.002 (0.003)	0.58
Happy	0.000 (0.003)	0.64

Note. – * p<0.1; ** p<0.05; *** p<0.01

- **Cognition**

Each additional degree of midnight temperature reduces global cognitive scores by 1.4% of a standard deviation

- **Sleep**

Find not evidence that high midnight temperatures affect our measures of sleep

Caveat: these measures are unlikely to capture sleep efficiency

- **Mood**

Midnight temperatures do not have a significant effect anger, stress, happiness, or enthusiasm

EVIDENCE OF CUMULATIVE EFFECTS

Table 5. Test for Cumulative Effects of Midnight Temperature

	Most Risk Averse (1)	Gamble Averse (2)	Most Impatient (3)
Panel A			
Midnight Temp Yesterday 25C+	-0.012	0.026***	0.019**
	(0.011)	(0.009)	(0.008)
Panel B			
Midnight Temp Yesterday 25C+	0.001	0.023*	0.018
	(0.018)	(0.012)	(0.013)
# Midnights Temp 25+ Last Week	-0.003	0.008**	0.006**
	(0.003)	(0.003)	(0.003)
Midnight Temp Yesterday 25C+ *	-0.001	-0.007	-0.006
# Midnights Temp 25+ Last Week	(0.005)	(0.005)	(0.004)
F-test	0.77	3.22	2.07
p-value	0.4637	0.0402	0.1267

Note. – * p<0.1; ** p<0.05; *** p<0.01

- 24% of individuals had midnight temperatures above 25°C, and average of 1.65 nights above 25°C in past week
- Both midnight temperature, and the cumulative number of hot nights during past 7d increase gamble aversion
- A cool night prior to survey could **partially offset** the effect of a full week of intense heat on gamble aversion
- Col. 3 suggests effects of temperature on impatience are mainly result of cumulative heat exposure

ROBUSTNESS CHECKS

- **Sample Exclusions**
  - Excluding adults who were visited more than once to complete the time and risk modules (19% of sample)
- **Coefficient Stability after introduction of additional controls**
  - Concern: Confounding Ramadan and temperature
  - Concern: Confounding temperature and humidity
  - Concern: Temperature could have effects on the surveyor
- **Placebo Tests**
  - In addition to main temperature treatment variable, add a 14 day temperature lead
  - Confirm future temperatures have no effect on current time and risk preferences

CONCLUSIONS

1. Midnight temperatures significantly increase gamble aversion and impatience, risk aversion (IFLS4 only)

2. Quasi-linear increase in gamble aversion and impatience after 25º Celsius

3. Midnight temperatures significantly deplete cognitive functions, math skills in particular. Individuals have to rely on lower-level processing and intuition, defaulting to safer option

4. Monotonic decrease in different cognitive functions after 25º Celsius as well

5. Adults with lower education experience larger increases in gamble aversion with temperature. Poorer individuals become more gamble averse and impatient as temperatures rise

6. Individuals in low-income countries more likely to be affected by rising temperatures due to limited ability to adapt

POLICY IMPLICATIONS

1. Short-term Implications of High Temperatures

- Our days are full of small and big decisions
- Some of these include critical health investments and behaviors shaped by our willingness to take risk and the way we value the future
- Temperature effects might be short-lived... but some short-term decisions have long-term implications

2. Long-term implications of High Temperatures

- Global warming means some areas in the planet will reach temperatures close or beyond human adaptability thresholds
- Can these temperature effects become permanent?
- Many more questions yet to be answered

Remy Levin

Visiting Assistant Professor, University of Connecticut

@remylevin

Risk Preference Adaptation to Climate Change

Risk Preference Adaptation to Climate Change

Remy Levin [1]   Wesley Howden [2]

[1]Department of Economics, University of Connecticut

[2]Department of Economics, University of Arizona

- Climate change involves significant uncertainty about the future
- Risk preferences affect optimal response to climate change
  - Dietz, Gollier, Kessler (2018); Cai, Lontzek (2019); Lemoine (2020)

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- Risk preferences affect optimal response to climate change
  - Dietz, Gollier, Kessler (2018); Cai, Lontzek (2019); Lemoine (2020)
- Standard assumption: preferences are fixed, unaffected by environment
- **This paper**: Lifetime climate change experiences $\Rightarrow$ Δ individual risk aversion

Model: Risk Preference Adaptation

- EU maximizer, two income lotteries: endogenous + exogenous
- **Foreground risk** & **Background Risk** are substitutes
- Background risk stationary Gaussian, unknown mean and variance
- Bayesian agent learns from observed realizations about both moments

Predictions: Foreground risk aversion...

Model: Risk Preference Adaptation

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- **Foreground risk** & **Background Risk** are substitutes
- Background risk stationary Gaussian, unknown mean and variance
- Bayesian agent learns from observed realizations about both moments

Predictions: Foreground risk aversion...

1. $\downarrow$ in mean of background risk
2. $\uparrow$ in variance of background risk

Empirics

- Panel surveys, **Indonesia** & **Mexico** (total n=24,393)
  - Two elicited measures of risk aversion, same subjects, years apart
- + State-level, lifetime temperature & precipitation statistics

Results:

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Results:

1. $\uparrow$ temp & precip mean $\Rightarrow$ $\downarrow$ risk aversion in both settings
2. $\uparrow$ temp variance $\Rightarrow$ $\uparrow$ risk aversion in **Indonesia**
3. $\uparrow$ precip variance $\Rightarrow$ $\uparrow$ risk aversion in **Mexico**

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2. $\uparrow$ temp variance $\Rightarrow$ $\uparrow$ risk aversion in **Indonesia**
3. $\uparrow$ precip variance $\Rightarrow$ $\uparrow$ risk aversion in **Mexico**
4. Variance effects first order: 0.7 – 1.6 x mean effects

Welfare and Adaptation

- New method to estimate whether Δ preference $\Rightarrow\ \uparrow$ welfare $\Rightarrow$ adaptation
- Two estimates: overall risk pref adaptation + climate-induced pref adaptation

Results:

Welfare and Adaptation

- New method to estimate whether Δ preference $\Rightarrow$ $\uparrow$ welfare $\Rightarrow$ adaptation
- Two estimates: overall risk pref adaptation + climate-induced pref adaptation

Results:

1. **Indonesia**: overall Δ preference $\Rightarrow$ 6.1% $\uparrow$ welfare (adaptation)
2. **Mexico**: overall Δ preference $\Rightarrow$ 8.2% $\downarrow$ welfare (maladaptation)
3. **Both**: climate-induced Δ preference $\Rightarrow$ 0.8% - 1% $\uparrow$ welfare (adaptation)

EMPIRICS

IFLS

- Born after 1976
- In IFLS4 ('07-'08) & IFLS5 ('14)

MXFLS

- Born after 1940
- In MXFLS2 ('05-'06) & MXFLS3 ('09-'12)

Climate Data

- GHCN CAMS (Temp) + GPCC (Precip) Grid (.5° × monthly)
- Livneh et al (2015) CONUS Grid (6km × daily)

Risk Aversion Measures

- Hypothetical, high-stakes choices between sure income, 50-50 gamble
- Staircase design
- Construct ordinal measure of relative risk aversion R_{it}

Identification advantages:

Risk Aversion Measures

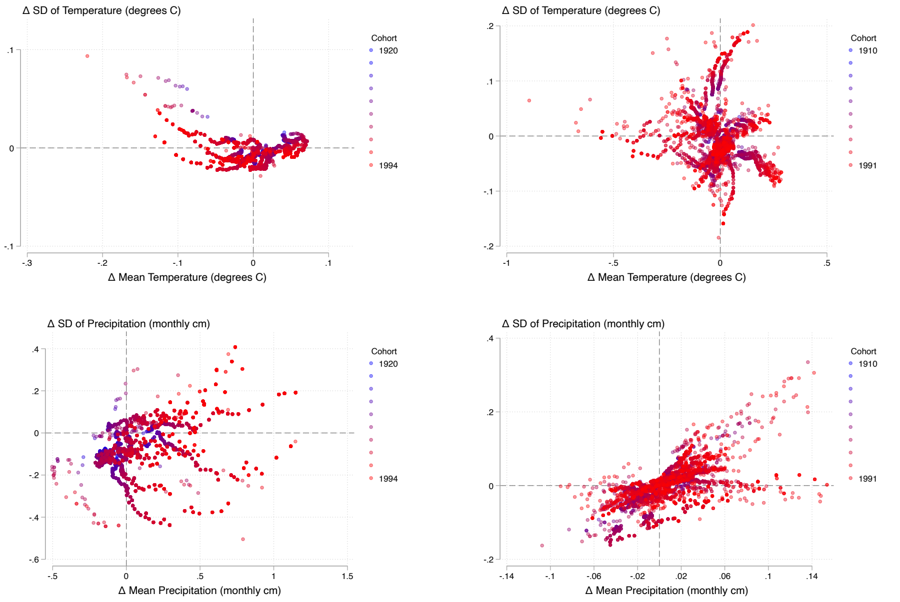
- Hypothetical, high-stakes choices between sure income, 50-50 gamble
- Staircase design
- Construct ordinal measure of relative risk aversion R_{it}

Identification advantages:

1. Odds & payoffs known $\Rightarrow$ foreground beliefs fixed
2. Lotteries exogenous to own history

Climate experience variables

1. Construct monthly temperature/precipitation series by state
   - match gridded data to state/province boundaries
   - collapse to state-by-month panel
2. Assign subjects to climate time series from <u>birth to measurement</u>
   - Ex: born in 1992 in West Java
   - IFLS4: WJ time series 1992–2007
   - IFLS5: WJ time series 1992–2014
3. Calculate Δ experienced Mean, Std Dev of temperature/precipitation



Indonesia **Mexico**

EMPIRICAL SPECIFICATION

$$\Delta R_{it} = \alpha + \beta_1 \Delta A_{it} + \beta_2 \Delta V_{it} + \gamma \mathit{Inflation}_s + \epsilon_{it}$$

Where

- R_{it}: Measured risk aversion for subject i, year t
- A_{it} & V_{it}: Temp/precip mean & standard deviation
- $\mathit{Inflation}_s$: Province/region s inflation between waves
- ϵ_{it}: Clustered at state-of-birth by birth-year level

Main Results

Dep. Var: Δ Risk Aversion	(1)	(2)	(3)	(4)	(5)	(6)
	Indonesia			Mexico		
Δ Mean Temp	-3.75††		-4.23††	-1.16†		-1.19††
	(.49)		(.57)	(.22)		(.22)
Δ Std. Dev. Temp		1.54	6.82**		-0.10	-0.35
		(2.32)	(2.37)		(.48)	(.49)
Δ Mean Precip	-0.25**		-0.21*	-1.14		-3.99**
	(.09)		(.10)	(.93)		(1.15)
Δ Std. Dev. Precip		-0.44	-0.27		1.17*	2.58***
		(.25)	(.28)		(.55)	(.69)
Observations	16267	16267	16267	8126	8126	8126

Measured Risk Aversion: 1-5, 5 highest. Province (Indonesia) or regional (Mexico) inflation in all regressions. * $p < .05$, ** $p < .005$, *** $p < .0005$, † $p < 5 \times 10^{-7}$, †† $p < 5 \times 10^{-13}$.

Additional Results

1. Highly robust to controls
   - Δ Demographics, income, assets, savings, violence, natural disasters, macro conditions
2. Mixed evidence on effects on risky behavior
   - Migration, smoking, self-employment, cash crops

Welfare & Adaptation

Are observed changes in preferences adaptive?

- Often think that adaptation = change. Strictly, adaptation = change + $\uparrow$ welfare
- Therefore, Δ welfare are instructive about adaptation
- But, Δ welfare with changing preferences is non-trivial

Are observed changes in preferences adaptive?

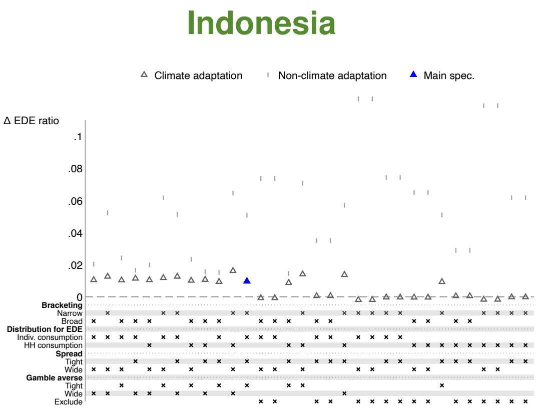
- Often think that adaptation = change. Strictly, adaptation = change + $\uparrow$ welfare
- Therefore, Δ welfare are instructive about adaptation
- But, Δ welfare with changing preferences is non-trivial
- Our approach: take empirical measure of risk preferences at face value

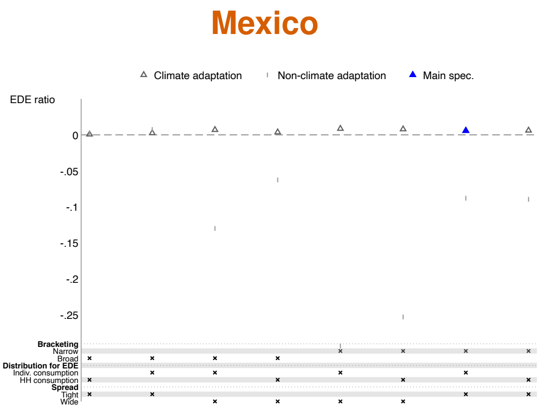
Detecting Adaptation: Method

1. Eden (2020): under EU, Equally Distributed Equivalent (*EDE*) can always be constructed given consumption $\mathcal{C}_t$ & risk pref ($\mathcal{R}_t$) distributions.
2. Structurally estimate $\mathcal{R}_1$ and $\mathcal{R}_2$ in our data (assuming CRRA)
3. Using our main regression results, estimate $\mathcal{R}_2^c$, counterfactual set of prefs had climate change not occurred
4. $\mathcal{W}^o = \frac{EDE(\mathcal{C}_2,\mathcal{R}_2)-EDE(\mathcal{C}_2,\mathcal{R}_1)}{\mu(\mathcal{C}_2)}$: overall Δ welfare from realized Δ prefs
5. $\mathcal{W}^c = \frac{EDE(\mathcal{C}_2,\mathcal{R}_2^c)-EDE(\mathcal{C}_2,\mathcal{R}_1)}{\mu(\mathcal{C}_2)}$: climate-induced Δ welfare from Δ prefs

Note: results sensitive to structural estimation assumptions $\Rightarrow$ explore sensitivity

Adaptation Results





CONCLUSIONS

CONTRIBUTIONS

1. First direct evidence lifetime Δ climate risk $\Rightarrow$ Δ individual risk preferences
2. Focus on long-run experiences, not one-off events, allows:
   - Separation, scaling, aggregation of tail and "body" effects
   - Better prediction of effects given world-wide heterogeneity in climate change
3. New method for detecting adaptation using empirical preference measures

Coming up Tomorrow!

Break-out 5 | 8:30-10am PT

SESSION 5.1

The Cumulative Costs of Climate Change

SESSION 5.2

Heat Vulnerability Affecting Workers, Healthcare, and Neighborhoods

SESSION 5.3

Innovative Toolkits for Urban Heat Adaptation

SESSION 5.4

Housing and Hazards: How Should We Protect Vulnerable Homes?

Break-out 6 | 10:15-11:45am PT

SESSION 5.1

Emerging Research on Financial Adaptations to Climate Impacts

SESSION 5.2

Wading into the Economic Impacts of Climate Change on Water

SESSION 5.3

Equitable Adaptation to Climate-Related Flood Risks: Part 2

CLIMATE ADAPTATION
RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

Thanks for tuning in!

UCLA Luskin Center for Innovation