Climate Change, Cricket, and Caution

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Motivation

1. Heat reduces labor productivity [ISO 1989; Parsons 1993]
2. Lab experiments - WBTs rise above 25 celsius, task efficiency falls by 1%-2% [Hsiang 2010]
3. Controlled experiments do not capture real world
4. Real World - Workers operate within physical limits and have room to increase effort in response to incentives.
5. Individual worker level is not easily available - surveys of firms [Somanathan et al, 2020] or aggregate firm level production data

Research Question

What is the effect of temperature shocks on labor productivity of individual workers?

- heterogeneity by time gap in temperature shock
- effect of accumulation of heat
- effect of excessive heat (>25°C)

Setting

1. Sports provide a setting to observe individual worker productivity & track location
2. Cricket - a two sided bat and ball game
3. 2 teams - 11 players each
4. Player types - Batsmen, Bowlers, All-rounders
5. Cricket T20 World Cup : October - November 2022
    - Location Australia
    - 16 countries
    - South Asia : India, Pakistan, Bangladesh, Sri Lanka, Afghanistan
    - Europe : England, Ireland, Scotland, Netherlands
    - Oceania : Australia, New Zealand
    - Africa : South Africa, Namibia, Zimbabwe
    - Middle East : United Arab Emirates
    - Caribbean : West Indies

Cricket

How to play cricket?

Table 1: Type of Cricket Games

Format	Number of Overs (Per Side)	Length
Test	Unlimited	Up to 5 days
One Day	50 Overs	1 day
T20	20 Overs	3 hours

Data

Cricket Data

- Novel dataset
- Scraped ESPN Cricinfo - Ball to Ball data
- Player level data
- Tracks each player performance for every game over 2021, 2021/2022, 2022, and 2022/2023 season
- Player hometown/base location

Temperature data

- Global Meteorogical Forcing Dataset for Land Surface Modeling
  - Monthly means - Air Temperature ($^{\circ}C$), Humidity ($kgkg^{-}1$) , Precipitation ($kgm^{-}2s^{-}1$)
  - 1.0 x 1.0
  - Historical Data - January 2000 - December 2008
- Virtual Crossing Global Weather Database
  - Daily data - Temperature ($^{\circ}C$), Relative Humidity (%) , Precipitation (mm)
  - April 4, 2021 - December 10, 2022

Data

Batsmen performance

- **Runs Scored**
- **Balls Faced**
- **Boundaries**
- **Strike Rate**

$$\text{strike rate} = (\frac{RunsScored}{Balls}) * 100$$

Bowler performance

- **Runs Given**
- **Balls Bowled**
- **Wickets**
- **Economy Rate**

$$\text{economy rate} = \frac{RunsGiven}{OversBowled}$$

- **Extras**

$$\text{extras} = NoBalls + WideBalls + LegByes$$

Data

Variables

1. Temperature Shock = $Tempmax_{mdv} - Tempmax_{mdv-1}$
   - (-Inf,-2], (-2,2], (2,Inf)
2. Gap Bin = Days between two consecutive games
   - [0,3], (3,14], (14,Inf)
3. Heat accumulation [Miller et.al 2021]
   $E_{ivd} = max\{0, E_{ivd-1} + 1(T_{ivd} \geq T_{i,home})h_+(T_{ivd}, T_{i,home}) - 1(T_{ivd} < T_{i,home})h_-(T_{ivd}, T_{i,home})\}$
   - [0,50], (50,110), (110,Inf)

Data Cut

1. Only complete games - abandoned matches dropped
2. All types of games - Test, ODI (One Day International), T20 (Twenty 20) & IPL (Indian Premier League)
3. Only players who played in the World Cup

Summary Stats

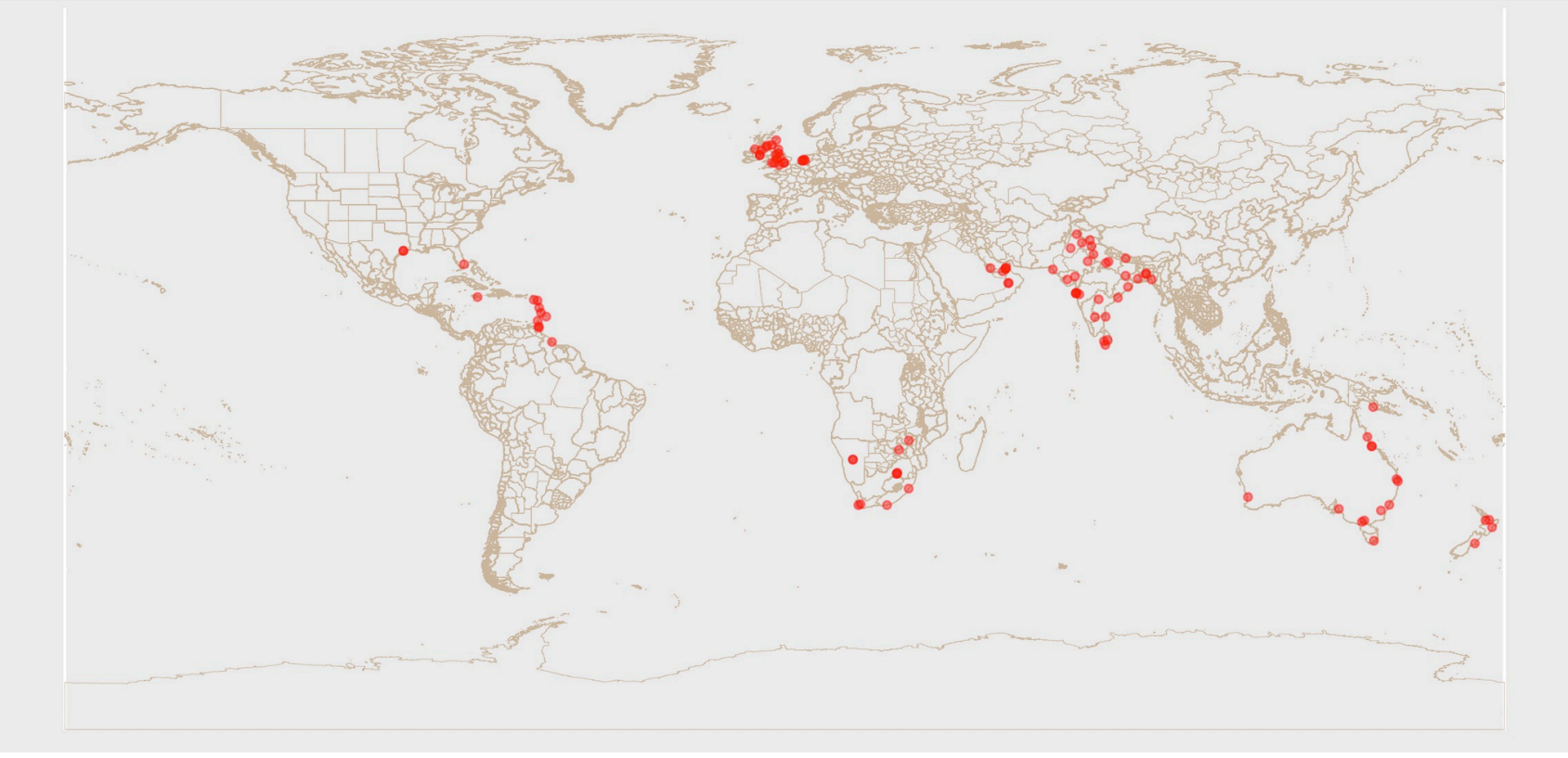
Table 2: Summary (Bastmen = 163; Matches = 346)

Measure	Mean	SD	Observations
Runs	18.62	22.08	2796
Balls	17.62	19.47	2796
Strike Rate	94.04	60.61	2796
Boundary	2.21	2.96	2796

Table 3: Summary (Bowlers = 111; Matches = 346)

Measure	Mean	SD	Observations
Runs Given	27.05	13.86	1868
Wicket	1.33	1.20	1868
Economy	6.39	2.60	1868
Extras	1.63	1.99	1868

Game Venue



Identification

Identification comes from variation in level of heat shock within and across teams

Panel regression with fixed effects

$$y_{itmdv} = \sum_j \beta_j TEMPSHOCK_{imdv} GAPBIN_i + \eta PRECIP_{mdv} + \nu HUMIDITY_n$$
$$+ \rho X_{mdv} + \theta_t + \theta_{order} + \theta_{type} + \theta_{innings} + \epsilon_{itmdv}$$

- y_{itmdv} measure of productivity for player i in team t playing in match m on day d at venue v
- β_j is the parameter of interest
- $TEMPSHOCK$ difference in temperature from previous game to current
- $GAPBIN$ gap in days between consecutive games
- X_{mdv} aggregate opposing team's temperature shock
- θ_t team fixed effect
- θ_{order} batting order (only used for batsmen)
- θ_{type} game type - test, odi, t20, ipl

Temperature Shock

Table 4: Effect of temperature shocks on Batsmen productivity

	runs	balls	strike rate	boundary
interact_var(-Inf,-2].[0,3]	2.1904	2.4082	-0.9380	0.2894
	(2.2576)	(2.0228)	(4.6905)	(0.3201)
interact_var(2, Inf].[0,3]	0.3295	0.0535	3.9446	-0.0439
	(2.0849)	(1.9167)	(6.1735)	(0.2427)
interact_var(-Inf,-2].(3,14]	0.6498	-0.5453	5.2349	0.1396
	(1.5728)	(1.1517)	(4.6124)	(0.2240)
interact_var(-2,2].(3,14]	4.3501**	4.2370***	2.8813	0.5524**
	(1.3587)	(1.1911)	(3.5863)	(0.1895)
interact_var(2, Inf].(3,14]	0.0535	0.0755	-5.5751	0.1114
	(1.6863)	(1.3342)	(4.0395)	(0.2304)
interact_var(-Inf,-2].(14,Inf]	1.8042	1.9927+	0.6509	0.2565
	(1.2252)	(1.0856)	(3.4026)	(0.1674)
interact_var(-2,2].(14,Inf]	4.2559*	5.4508**	-1.9252	0.4466+
	(2.1053)	(2.0714)	(5.6913)	(0.2642)
interact_var(2, Inf].(14,Inf]	2.4381+	2.2622*	2.4666	0.3354+
	(1.4056)	(1.1340)	(4.7113)	(0.1931)
precip	-0.1771*	-0.0667	-0.6988**	-0.0341**
	(0.0841)	(0.0788)	(0.2640)	(0.0119)
humidity	0.0644+	0.0363	0.0840	0.0095*
	(0.0354)	(0.0367)	(0.0901)	(0.0044)
opp_team_temp	0.0782	0.0947	-0.1370	0.0063
	(0.0754)	(0.0673)	(0.2314)	(0.0100)
Num.Obs.	2595	2595	2587	2595
R2	0.107	0.106	0.017	0.107
R2 Adj.	0.099	0.098	0.008	0.099
FE: batting_order	X	X	X	X
FE: innings	X	X	X	X

Note: ^^ + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Comparison : [-2,2].[0,3]

Temperature Shock

Table 5: Effect of temperature shocks on Bowler's productivity

	economy	runs given	wicket	extras
interact_var(-Inf,-2].[0,3]	-0.6979**	2.9195+	0.1382	0.5684*
	(0.2579)	(1.5020)	(0.1571)	(0.2649)
interact_var(2, Inf].[0,3]	0.2833	2.7649+	0.2796	0.3353
	(0.4602)	(1.6610)	(0.2021)	(0.2762)
interact_var(-Inf,-2].(3,14]	0.2700	-0.2136	-0.2569*	0.1798
	(0.3019)	(1.2531)	(0.1202)	(0.1772)
interact_var(-2,2].(3,14]	-0.2454	3.5985***	-0.0484	0.1600
	(0.2169)	(0.9288)	(0.0808)	(0.1567)
interact_var(2, Inf].(3,14]	-0.0126	0.9541	0.0258	-0.0064
	(0.2275)	(0.9492)	(0.1169)	(0.1560)
interact_var(-Inf,-2].(14,Inf]	0.0050	3.1747**	-0.0325	0.2261
	(0.1768)	(0.9660)	(0.0786)	(0.1586)
interact_var(-2,2].(14,Inf]	-0.0724	6.6789***	-0.1830	0.5746*
	(0.2481)	(1.7958)	(0.1206)	(0.2257)
interact_var(2, Inf].(14,Inf]	0.0089	3.0158**	0.0903	0.3558*
	(0.2131)	(1.1303)	(0.1111)	(0.1605)
precip	-0.0185	-0.1918**	-0.0001	-0.0263***
	(0.0212)	(0.0719)	(0.0052)	(0.0076)
humidity	0.0008	0.0617**	-0.0013	0.0071+
	(0.0055)	(0.0210)	(0.0020)	(0.0041)
opp_team_temp	-0.0183	0.0666	-0.0017	0.0065
	(0.0126)	(0.0614)	(0.0059)	(0.0103)
Num.Obs.	1734	1734	1734	1734
R2	0.079	0.057	0.026	0.038
R2 Adj.	0.058	0.036	0.005	0.016
FE: bowling_team	X	X	X	X
FE: innings	X	X	X	X

Note: ^^ + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Comparison : [-2,2].[0,3]

Heat Accumulation

Table 6: Effect of heat accumulation on Batsmen productivity

	runs	balls	strike rate	boundary
interact_home[0,100].[0,3]	-2.5550	-1.8530	-0.4230	-0.3733
	(2.0909)	(1.7497)	(4.7965)	(0.2766)
interact_home(100,Inf].[0,3]	-2.9127+	-2.8080*	-0.4361	-0.3711
	(1.5564)	(1.0998)	(3.9255)	(0.2300)
interact_home[0,100].(3,14]	-2.1182	-0.8958	-5.5853	-0.2766
	(1.8272)	(1.5643)	(3.9690)	(0.2431)
interact_home[0,100].(14,Inf]	-0.9679	0.0939	-2.4776	-0.1644
	(2.0234)	(1.7029)	(4.8759)	(0.2618)
interact_home(100,Inf].(14,Inf]	-1.3547	-1.0155	1.2014	-0.1577
	(1.9953)	(1.5580)	(5.4900)	(0.2769)
precip	-0.2010*	-0.0862	-0.7732**	-0.0367**
	(0.0889)	(0.0795)	(0.2903)	(0.0125)
humidity	0.0731*	0.0568+	0.0562	0.0092+
	(0.0357)	(0.0321)	(0.1022)	(0.0047)
opp_team_temp	0.0702	0.1133+	-0.2850	0.0043
	(0.0711)	(0.0614)	(0.2051)	(0.0094)
Num.Obs.	2595	2595	2587	2595
R2	0.111	0.122	0.054	0.116
R2 Adj.	0.095	0.107	0.037	0.101
FE: batting_team	X	X	X	X
FE: batting_order	X	X	X	X
FE: innings	X	X	X	X

Note: ^^ + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

;Comparison : [0,50].[0,3]

Heat Accumulation

Table 7: Effect of heat accumulation on Bowler's productivity

	economy	runs given	wicket	extras
interact_home[0,100].[0,3]	-0.2554	-0.7013	0.2114+	0.1364
	(0.2409)	(1.3661)	(0.1183)	(0.1781)
interact_home(100,Inf].[0,3]	-0.2633	-2.1149*	0.1752+	-0.1354
	(0.2012)	(1.0088)	(0.0973)	(0.1594)
interact_home[0,100].(3,14]	-0.4879*	-0.7530	0.1280	-0.0261
	(0.2418)	(1.3050)	(0.1210)	(0.1771)
interact_home[0,100].(14,Inf]	-0.2197	1.0770	0.1039	0.1952
	(0.2026)	(1.4172)	(0.1175)	(0.1667)
interact_home(100,Inf].(14,Inf]	-0.1792	2.1235+	0.1858+	0.2148
	(0.2433)	(1.2172)	(0.1105)	(0.1796)
precip	-0.0178	-0.1905*	-0.0005	-0.0285***
	(0.0217)	(0.0738)	(0.0052)	(0.0075)
humidity	0.0007	0.0647**	-0.0015	0.0073+
	(0.0055)	(0.0221)	(0.0020)	(0.0041)
opp_team_temp	-0.0163	0.0829	0.0034	0.0059
	(0.0098)	(0.0501)	(0.0052)	(0.0102)
Num.Obs.	1734	1734	1734	1734
R2	0.076	0.048	0.022	0.034
R2 Adj.	0.057	0.028	0.002	0.014
FE: bowling_team	X	X	X	X
FE: innings	X	X	X	X

Note: ^^ + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

;Comparison : [0,50].[0,3]

Excessive Heat - Batsmen

Table 8: Effect of excessive heat on Batsmen productivity

	runs	balls	strike rate	boundary
interact_shock0.[0,3]	-1.2526	-0.4638	-0.9734	-0.1902
	(1.4970)	(1.2321)	(4.0287)	(0.1947)
interact_shock1.[0,3]	2.7785	2.9229+	6.6888	0.2454
	(1.8986)	(1.6061)	(5.5123)	(0.2463)
interact_shock0.(3,14]	-1.3290	-0.7044	0.3060	-0.1727
	(1.6662)	(1.4076)	(4.8812)	(0.2114)
interact_shock1.(3,14]	4.4439*	5.1743***	0.9382	0.4876*
	(1.8555)	(1.5274)	(5.5627)	(0.2414)
interact_shock1.(14,Inf]	4.0523*	5.3086**	3.8688	0.4074+
	(1.8683)	(1.5839)	(5.8581)	(0.2374)
precip	-0.2563**	-0.1357+	-0.8466**	-0.0429***
	(0.0856)	(0.0746)	(0.2907)	(0.0124)
humidity	0.1059**	0.0921**	0.0909	0.0127**
	(0.0368)	(0.0327)	(0.1111)	(0.0048)
opp_team_temp	-0.0552	-0.0172	-0.4023+	-0.0094
	(0.0796)	(0.0718)	(0.2272)	(0.0101)
Num.Obs.	2595	2595	2587	2595
R2	0.115	0.130	0.054	0.119
R2 Adj.	0.100	0.115	0.037	0.104
FE: batting_team	X	X	X	X
FE: batting_order	X	X	X	X
FE: innings	X	X	X	X

Note: ^^ + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Excessive Heat - Bowler

Table 9: Effect of excessive heat on Bowler's productivity

	economy	runs given	wicket	extras
interact_shock0.[0,3]	-0.0976	-4.4859***	0.0037	-0.1890
	(0.2143)	(1.1125)	(0.0983)	(0.1962)
interact_shock1.[0,3]	-0.2564	-0.6354	-0.1287	-0.1483
	(0.2579)	(1.5145)	(0.1275)	(0.2242)
interact_shock0.(3,14]	-0.1522	-4.4082***	-0.1281	-0.0160
	(0.2777)	(1.1770)	(0.1159)	(0.2358)
interact_shock1.(3,14]	-0.1638	0.4652	-0.2382*	-0.2421
	(0.2430)	(1.5948)	(0.1142)	(0.2163)
interact_shock1.(14,Inf]	-0.1805	0.9016	-0.1809	0.0723
	(0.2161)	(1.5591)	(0.1147)	(0.2383)
precip	-0.0170	-0.2356**	0.0012	-0.0279***
	(0.0213)	(0.0725)	(0.0053)	(0.0078)
humidity	-0.0005	0.0854***	-0.0027	0.0072+
	(0.0054)	(0.0235)	(0.0021)	(0.0042)
opp_team_temp	-0.0135	0.0047	0.0080	0.0060
	(0.0105)	(0.0577)	(0.0058)	(0.0121)
Num.Obs.	1734	1734	1734	1734
R2	0.074	0.057	0.023	0.033
R2 Adj.	0.055	0.038	0.003	0.013
FE: bowling_team	X	X	X	X
FE: innings	X	X	X	X

Note: ^^ + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Next Steps

1. More on incentives

- International games vs League games
- Presence of Supertars [Brown 2011]

2. Why are batsmen & bowlers behaving differently?
3. Heat accumulation measure by month and not aggregate

End

Thank you!