

**Productivity impact of temperature change:
evidence from Indonesia household-based enterprises survey**

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Online Appendix

Table A1. Labor seasonality

	N of workers
February	-0.073 (0.310)
March	-0.038 (0.323)
April	-0.090 (0.353)
May	0.050 (0.456)
June	0.205 (0.753)
July	-0.098 (0.907)
August	0.055 (0.898)
September	-0.004 (0.898)
October	-0.051 (0.909)
November	3.438 (0.962)
December	3.154 (1.134)
N	8899

Note: The displayed coefficients are the coefficients of each survey-month dummy (base category: January) from regressing the number of workers in household businesses on survey-month dummies, controlling for log capital, year, sector, and subdistrict fixed effects.

Table A2. Averages and medians of temperature, temperature long-term mean (LTM), and temperature deviation from long-term mean

Month	Average temperature	Median temperature	Average temperature LTM	Median Temperature LTM	Average temperature deviation from LTM	Median temperature deviation from LTM
	(1)	(2)	(3)	(4)	(5)	(6)
Jan	26.54	26.50	26.29	26.29	0.34	0.35
Feb	26.51	26.44	26.25	26.25	0.22	0.17
Mar	26.89	26.91	26.56	26.56	0.25	0.25
Apr	27.13	27.20	26.83	26.83	0.28	0.19
May	27.16	27.16	26.77	26.77	0.29	0.29
Jun	26.56	26.54	26.35	26.35	0.25	0.16
Jul	26.19	26.11	25.81	25.81	0.21	0.19
Aug	26.19	26.13	25.90	25.90	0.18	0.15
Sep	26.76	26.73	26.49	26.49	0.23	0.22
Oct	27.35	27.35	26.85	26.85	0.28	0.28
Nov	27.32	27.24	26.99	26.99	0.31	0.17
Dec	26.81	26.75	26.52	26.52	0.34	0.29

Table A3. The effect of temperature shock on business owners' migration probability

	Out-migration		In-migration	
	(1)	(2)	(3)	(4)
Avg. temperature deviation (°C)	0.002	0.003	0.004	0.004
	(0.007)	(0.007)	(0.006)	(0.006)
N	12496	12456	12059	12023
Controls	No	Yes	No	Yes

Notes: Standard errors, clustered at temperature grid level, are in parentheses. Migration is defined as moving to different subdistricts. All the temperature variables are an average of 6 months preceding the migration (for mover) or preceding the survey (for stayer). All models control for precipitation and include subdistricts FE and year-month FE. Other controls include age, marital status, sex, and education.

Table A4. The effects of temperature shocks on attrition probability

	(1)	(2)
	Stayer dummy	Stayer dummy
Avg. temperature deviation (°C)	0.016	0.019
	(0.017)	(0.020)
N	11596	8358
Other controls		Yes

Notes: Standard errors, clustered at the temperature grid level, are in parentheses. All the temperature variables are an average of 12 months preceding the survey. All models with temperature also control for precipitation. All models include subdistricts FE and year-month FE. Other controls include business age, business age squared, location (home-based vs partially home-based vs outside home) dummies, and sector dummies

In the above regression, we define staying household as those who still operate businesses in the subsequent round. Therefore, the non-stayers are either those who are still surveyed but no longer have businesses, or those who fail to be recontacted. The baselines are the third and fourth round of IFLS. We then pool the two rounds into a single sample.

Table A5. The effect of temperature shocks and worker productivity: by rural and urban subsamples

Panel A: Rural

	(1) Log revenue	(2) Log revenue	(3) Log (revenue / worker)	(4) Log (revenue / worker)
Avg. temperature deviation (°C)	-0.035 (0.122)	-0.073 (0.114)	-0.135 (0.129)	-0.168 (0.117)
N	5025	4763	5020	4758
Other controls		Yes		Yes

Panel B: Urban

Avg. temperature deviation (°C)	-0.149 (0.109)	-0.129 (0.108)	-0.192 (0.110)	-0.179 (0.111)
N	5902	5642	5890	5631
Other controls		Yes		Yes

Notes: Standard errors, clustered at temperature grid level, are in parentheses. All the temperature variables are an average of 12 months preceding the survey. All models control for precipitation and include subdistricts FE, year-month FE, and business order FE. Other controls include business age, business age squared, location (home-based vs partially home-based vs outside home) dummies, and sector dummies

Table A6. Mean revenue of household businesses in IFLS data

	IFLS 1 (2000)	IFLS 2 (2007)	IFLS 3 (2014)
Revenue (2024 IDR)	39,086,023	28,140,408	44,145,246
Revenue / worker (2024 IDR)	20,363,826	15,738,130	22,571,294
Revenue (2024 USD)	2,465	1,775	2,784
Revenue / worker (2024 USD)	1,284	993	1,424

Table A7. Main regression results with and without labor and capital controls

	(1)	(2)	(3)	(4)
	Log revenue	Log revenue	Log revenue	Log revenue
Avg. temperature deviation (°C)	-0.128	-0.137	-0.152	-0.145
	(0.082)	(0.076)	(0.074)	(0.067)
N	10929	10407	10391	10391
Input controls			Yes	Yes
Prod. function spec.			Cobb-Douglas	Translog
Other controls		Yes	Yes	Yes

Notes: Standard errors, clustered at temperature grid level, are in parentheses. All the temperature variables are an average of 12 months preceding the survey. All models control for precipitation and include subdistricts FE, year-month FE, and business order FE. Cobb-Douglas production function controls are comprised of log capital and log employment. Translog production function controls include those of Cobb-Douglas as well as their squared and interaction terms. Other controls include business age, business age squared, location (home-based vs partially home-based vs outside home) dummies, and sector dummies.

Table A8. Non-linear effect of temperature shock by sector

	(1)	(2)	(3)	(4)	(5)	(6)
	Primary sector		Secondary sector		Tertiary sector	
	Log revenue	Log (Revenue/ worker)	Log revenue	Log (Revenue/ worker)	Log revenue	Log (Revenue/ worker)
Avg. temperature deviation (°C)	0.763	0.634	-0.198	-0.198	-0.108	-0.169
	(1.625)	(1.515)	(0.139)	(0.128)	(0.092)	(0.094)
Avg. temperature deviation squared	0.544	0.387	-0.067	-0.086	-0.045	-0.049
	(0.517)	(0.520)	(0.058)	(0.052)	(0.036)	(0.036)
Joint p-value	0.3035	0.4814	0.0863	0.0160	0.0197	0.0038
N	268	267	1801	1798	8248	8237
Other controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The outcome variables for the models are log revenue and log revenue per worker. Standard errors, clustered at temperature grid level, are in parentheses. All the temperature variables are an average of 12 months preceding the survey. All models control for precipitation and include subdistricts FE, year-month FE, and business order FE.

Table A9. Main regression results with and without manager and household fixed effects

Panel A: Original main model

	(1)	(2)	(3)	(4)
	Log revenue	Log revenue	Log (revenue / worker)	Log (revenue / worker)
Avg. temperature deviation (°C)	-0.128	-0.137	-0.196	-0.206
	(0.082)	(0.076)	(0.090)	(0.083)
N	10929	10407	10912	10391
Other controls		Yes		Yes

Panel B: Main model with manager FE

Avg. temperature deviation (°C)	-0.195	-0.179	-0.251	-0.232
	(0.096)	(0.102)	(0.098)	(0.106)
N	7342	6917	7328	6902
Other controls		Yes		Yes

Panel C: Main model with household FE

Avg. temperature deviation (°C)	-0.238	-0.214	-0.284	-0.267
	(0.108)	(0.113)	(0.122)	(0.120)
N	8617	8046	8599	8030
Other controls		Yes		Yes

Notes: Standard errors, clustered at temperature grid level, are in parentheses. All the temperature variables are the average of 12 months preceding the survey. All models control for precipitation and include subdistricts FE, year-month FE. Models in panel A, B, and C alternately include business order FE, manager FE, and household FE. Other controls include business age, business age squared, location (home-based vs partially home-based vs outside home) dummies, and sector dummies.

Table A10. Varying the temporal fixed effects**Panel A: Separate year & month FE**

	Log revenue	Log revenue	Log (revenue / worker)	Log (revenue / worker)
Avg. temperature deviation (°C)	-0.130 (0.082)	-0.136 (0.077)	-0.196 (0.090)	-0.204 (0.082)
N	10930	10408	10913	10392
Other controls		Yes		Yes

Panel B: Year-month-province FE

Avg. temperature deviation (°C)	-0.254 (0.207)	-0.316 (0.209)	-0.248 (0.206)	-0.314 (0.210)
N	10908	10384	10889	10366
Other controls		Yes		Yes

Notes: Standard errors, clustered at temperature grid level, are in parentheses. All the temperature variables are an average of 12 months preceding the survey. All models control for precipitation and include subdistricts FE, and business order FE. Other controls include business age, business age squared, location (home-based vs partially home-based vs outside home) dummies, and sector dummies. Models in panel A includes year and month FE separately while models in panel B includes province-year-month FE.

Table A11. Main specifications, replacing temperature deviation with temperature bins**Panel A. 3C Bins**

	(1) Log revenue	(2) Log (revenue / worker)
T (25–28 °C)	0.007 (0.006)	0.005 (0.007)
T (28–31 °C)	0.004 (0.005)	0.003 (0.005)
T (31–34 °C)	0.003 (0.005)	0.002 (0.005)
T (34–50 °C)	0.002 (0.005)	0.003 (0.006)
N	9483	9469
Other controls	Yes	Yes

Panel B. 2C Bins

T (26–28 °C)	0.010 (0.004)	0.009 (0.005)
T (28–30 °C)	0.002 (0.003)	0.002 (0.003)
T (30–32 °C)	0.003 (0.003)	0.003 (0.003)
T (32–34 °C)	0.001 (0.003)	0.001 (0.003)
T (34–50 °C)	0.003 (0.004)	0.004 (0.004)
N	9483	9469
Other controls	Yes	Yes

Notes: To be above regression is the result of the following model: $y_{ijt} = \sum_{k=2}^K T_{jt}^k \alpha_k temp_{jt} + \beta precip_{jt} + \gamma' x_{ijt} + \phi_j + \tau_t + \varepsilon_{ijt}$ where T^k is a count of the number of days during the last 365 days preceding the survey with daily maximum temperature that fall within the temperature bin k . The rest of the variables are identical to those in Equation (1) in the main text. Standard errors, clustered at temperature grid level, are in parentheses. T is an indicator for a day in the year falling in a corresponding temperature bin (the coolest temperature bin is the omitted category). All models control for precipitation and include subdistricts FE, year-month FE, and business order FE. Other controls include business age, business age squared, location (home-based vs partially home-based vs outside home) dummies, and sector dummies.

Table A12. Main results using a balanced household panel

	(1) Log revenue	(2) Log revenue	(3) Log (Revenue / worker)	(4) Log (Revenue / worker)
Avg. temperature deviation (°C)	-0.299 (0.090)	-0.296 (0.086)	-0.303 (0.090)	-0.320 (0.085)
N	3539	3366	3533	3360
Other controls		Yes		Yes

Notes: All models use balanced panel dataset, sub-sample of household that own business in all three rounds (IFLS 3, 4, and 5). The outcome variables for the models are log revenue and log revenue per worker. Standard errors, clustered at temperature grid level, are in parentheses. All the temperature variables are an average of 12 months preceding the survey. All models control for precipitation and include subdistricts FE, year-month FE, and business order FE. Other controls include business age, business age squared, location (home-based vs partially home-based vs outside home) dummies, and sector dummies.

Table A13. Varying the measure of employment (all workers vs paid workers)

	(1) Log revenue / all workers	(2) Log revenue / all workers	(3) Log revenue / paid workers	(4) Log revenue / paid workers
Avg. temperature deviation from LTM (°C)	-0.196 (0.090)	-0.206 (0.083)	-0.148 (0.079)	-0.163 (0.073)
N	10912	10391	10915	10394
Other controls		Yes		Yes

Notes: Standard errors, clustered at temperature grid level, are in parentheses. All the temperature variables are an average of 12 months preceding the survey. All models control for precipitation and include subdistricts FE, year-month FE, and business order FE. Other controls include business age, business age squared, location (home-based vs partially home-based vs outside home) dummies, and sector dummies.

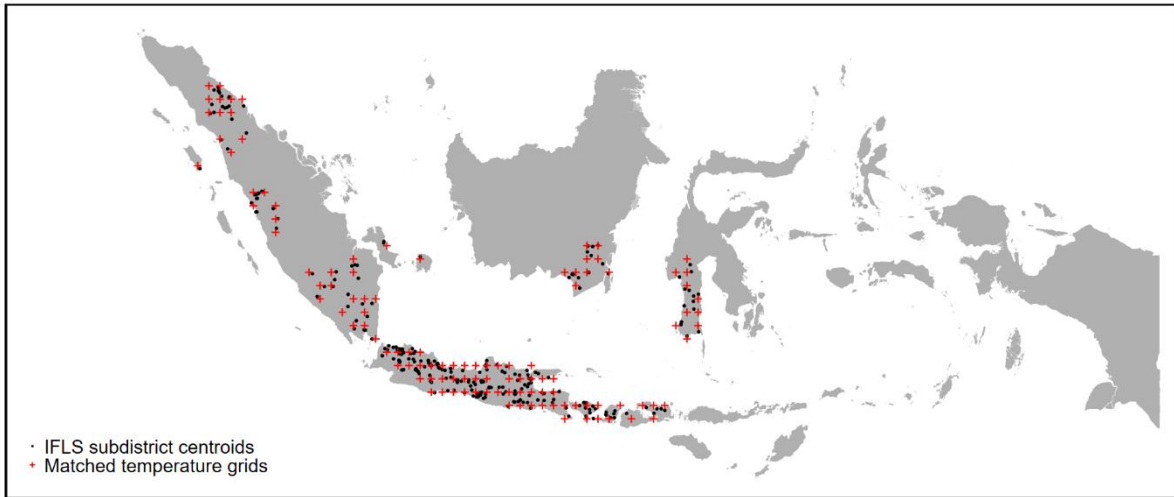


Figure A1. Sampled IFLS subdistricts and temperature grids.

Notes: The above map shows the centroids of IFLS subdistricts included in the sample (in black dots) along with the nearest temperature data grids from GHCN CAMS (in red crosses).

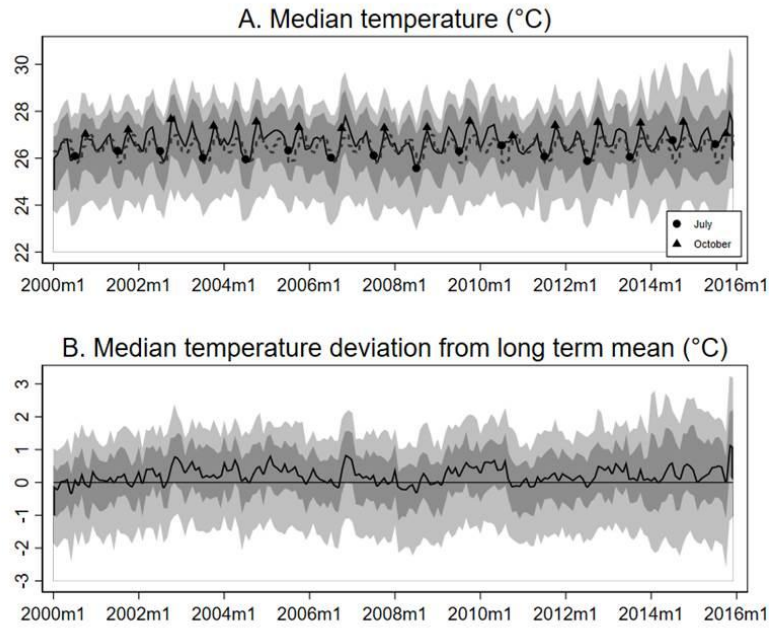


Figure A2. Temperature evolution for selected grids.

Notes: The above figures plot the summary of monthly temperature data from GHCN CAMS for grids that are matched with the IFLS sample. The black line shows the median value. The dark gray and light gray areas show 25th-75th percentiles and 10th-90th percentiles, respectively. Dashed line in panel A shows monthly long term mean.

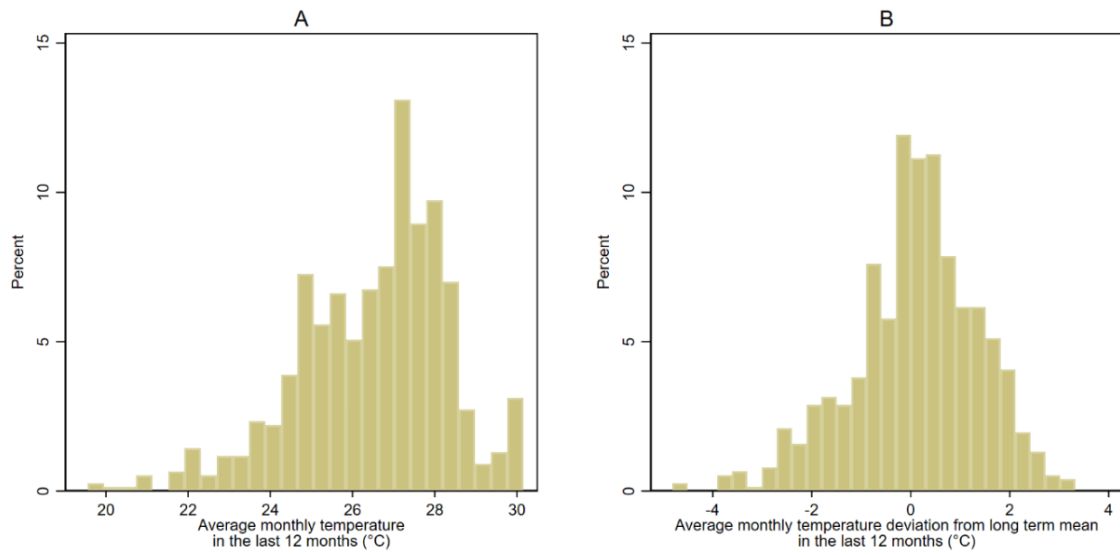


Figure A3. Temperature distribution for matched grids and periods.

Notes: The above figures plot the distribution of 12-month average temperature and temperature deviation preceding the household business surveys. The data is derived from GHCN CAMS for grids and periods that are matched with the IFLS sample.

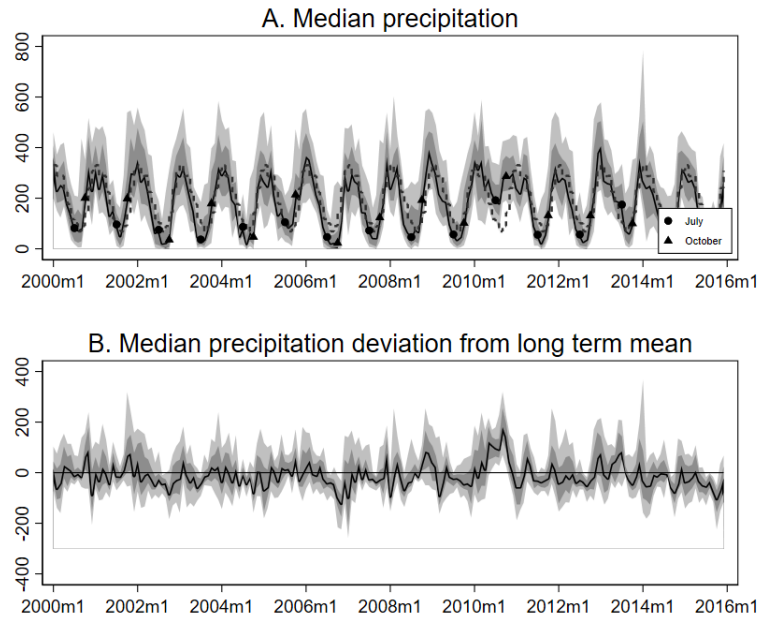


Figure A4. Precipitation evolution for selected grids.

Notes: The above figures plot the summary of monthly precipitation data from GPCC for grids that are matched with the IFLS sample. The black line shows the median value. The dark gray and light gray areas show 25th-75th percentiles and 10th-90th percentiles, respectively. Dashed line in panel A shows monthly long term mean. July and October are the trough and peak of temperature, respectively.

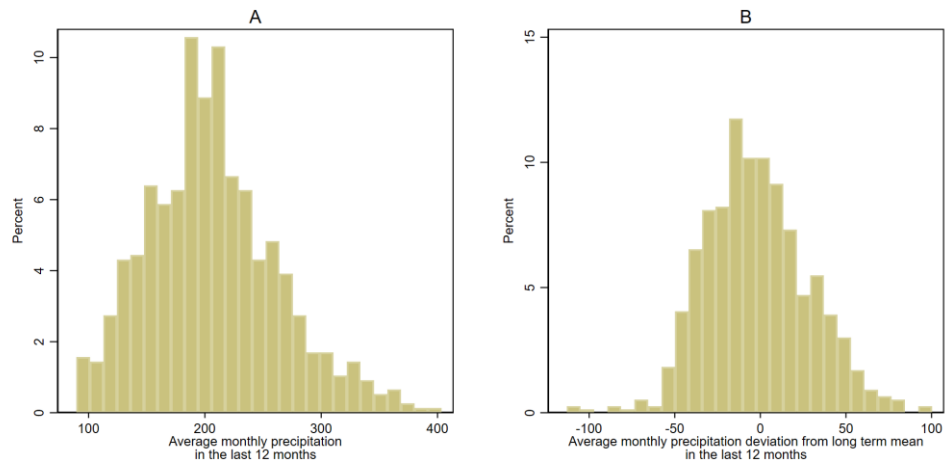


Figure A5. Precipitation distribution for matched grids and periods.

Notes: The above figures plot the distribution of 12-month average precipitation and precipitation deviation preceding the household business surveys. The data is derived from GPCC for grids and periods that are matched with the IFLS sample.