Applied Economic Issues

Climate and the Economy: Assessing the Impacts

Ewen Gallic

Master 2 DADEE – 2025

amU Aix Marseille Université

amse école d'économie d'aix-marseille aix-marseille school of economics

Empirical Analysis

- IAMs are not the only tools used in applied economics to investigate or model the impacts of climate change.
- A lot of studies use **empirical data**, using the methods mentioned in the previous session (natural experiments, econometrics, panel data, quasi-experimental variation).
- The central idea is that climate impacts can be studied directly through observed variation in weather and climate shocks.
- Carleton and Hsiang (2016, Science) provides a nice overview of the social and economic impacts of climate and cites many empirical economic papers.

Roadmap of the lecture

1. **Agriculture**
2. **Health**
3. **Growth**
4. **Sea-Level Rise**
5. **Migration**
6. **Social Interactions**

Key references (1/3)

- **Agriculture** :
  - Deschênes, O. and Greenstone, M. (2007). The economic impacts of climate change: Evidence from agricultural output and random fluctuations in weather. *American Economic Review*. 97: 354–385, doi:10.1257/aer.97.1.354.
- **Health**
  - Barwick, P. J., Li, S., Rao, D. and Zahur, N. B. (2024). The healthcare cost of air pollution: Evidence from the world's largest payment network. *Review of Economics and Statistics*. 1–52, doi: 10.1162/rest_a_01430.
  - Carleton, T., Jina, A., Delgado, M., Greenstone, M., Houser, T., Hsiang, S., Hultgren, A., Kopp, R. E., McCusker, K. E., Nath, I., Rising, J., Rode, A., Seo, H. K., Viaene, A., Yuan, J. and Zhang, A. T. (2022). Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits. *The Quarterly Journal of Economics*. 137: 2037–2105, doi:10.1093/qje/qjac020.
  - Deschênes, O. and Greenstone, M. (2011). Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US. *American Economic Journal: Applied Economics*. 3:152–185, doi:10.1257/app.3.4.152.

Key references (2/3)

- **Labor, Macroeconomics**:
  - Somanathan, E., Somanathan, R., Sudarshan, A. and Tewari, M. (2021). The impact of temperature on productivity and labor supply: Evidence from Indian manufacturing. *Journal of Political Economy*. 129:1797–1827, doi:10.1086/713733.
  - Konradt, M. and Mauro, B. Weder di (2023). Carbon taxation and greenflation: Evidence from Europe and Canada. *Journal of the European Economic Association*. 21:2518–2546, doi:10.1093/jeea/jvad020.
  - Dell, M., Jones, B. F. and Olken, B. A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics*. 4:66–95, doi: 10.1257/mac.4.3.66.
- **Sea Level Rise**
  - Agarwal, S., Qin, Y., Sing, T. F. and Zhan, C. (2025). Sea level rise risks, adaptation strategies, and real estate prices in Singapore. *Journal of Public Economics*. 241:105290, doi:10.1016/j.jpubeco.2024.105290.

Key references (3/3)

- **Migration** :
  - Sedova, B. and Kalkuhl, M. (2020). Who are the climate migrants and where do they go? Evidence from rural India. *World Development*. 129:104848, doi:10.1016/j.worlddev.2019.104848.
- **Social Interactions** :
  - Evans, M. F., Gazze, L. and Schaller, J. (2025). Temperature and maltreatment of young children. *The Review of Economics and Statistics*. 1–37doi: 10.1162/rest_a_01564.

2. Agriculture

Agriculture

- As previously mentioned, agriculture is highly sensitive to temperature and precipitation, especially **rainfed crops**.
- Some studies focus on the impacts on **agricultural yields** (which threatens food security), e.g.:
  - Schlenker and Roberts (2009, PNAS): crop yields fall sharply above heat thresholds,
  - Deschênes and Greenstone (2007, AER): weather shocks reduce U.S. ag. output.
- Some explore **adaptation techniques**, e.g.:
  - crop selection and switching to more resilient varieties (Di Falco and Veronesi 2013, Land Econ.),
  - changing crop mix (Aragón et al. 2021, AEJ: Econ. Pol.),
  - planting dates (Zhao et al., 2025).

3. Health

Exercise

If temperature increases by 2°C in Aix-en-Provence, what health effects would you expect in the short and long run?

Exercise

If temperature increases by 2°C in Aix-en-Provence, what health effects would you expect in the short and long run?

Reasoning from the viewpoint of:

- **Public health researchers**: which outcomes can we *observe and measure*?
- **Economists**: how can we *value* these outcomes economically?
- **Policy makers**: which effects justify *immediate policy intervention*?

Health (1)

- Temperatures outside a range are harmful to human health and lead to **premature mortality** (see Basu, 2002 for a review).
  - E.g., using U.S. historical data, Deschênes and Greenstone (2011, AEJAE) show nonlinear effects between mortality and daily temperatures: extremely cold and hot days are associated with elevated mortality rates,
  - Similar results are found in Mexico (Cohen and Dechezleprêtre 2022, AEJEP).
  - The effects are **unequally distributed** across countries, as shown in Carleton et al. (2022, QJE)
    - using subnational historical data from 40 countries, they show that an additional hot day ($>32°C$) increases mortality and that the magnitude of the effect is larger in poorer countries.
    - they estimate that the release of an additional ton of CO_2 today will cause mortality-related damages of $36.6 under a high-emissions scenario (by applying the value of a statistical life to projected deaths).

Value of a Statistical Life (1/2)

A few words on the **Value of a Statistical Life** (VSL):

- From Thaler and Rosen (1976, NBER): "*the value of a life is the amount members of society are willing to pay to save one.*"
- it "*defines the monetary value of a (small and similar among the population) mortality risk reduction that would prevent one statistical death and, therefore, should not be interpreted as how much individuals are willing to pay to save an identified life.*" Andersson and Treich (2011)
- One of the ways to estimate it is based on individuals' **willingness to pay** (approached attributed to Drèze, 1962, but the paper cannot be accessed online).

Value of a Statistical Life (2/2)

- Andersson and Treich (2011) give a nice intuition to understand the VSL concept:

  "*Suppose that in a city composed of 100,000 identical individuals, there is an investment project that will make the city's roads safer. It is known that on average 5 individuals die every year on these roads, and the project is expected to reduce from 5 to 2 the number of expected fatalities per year. Suppose now that each member of the city is willing to pay $150 annually to benefit from this reduction in mortality risk induced by the project. Then the corresponding VSL would be $150×100,000/3 =$5 million. Indeed $15 million could be collected in this city to save 3 statistical lives, and so the value of a statistical life could be established at $5 million.*"

- In climate economics, VSL allows converting mortality impacts of heat or pollution into **monetary damages**.

- Viscusi (2015, AJHE) reports that the values used by U.S. government agencies vary between $6 to $10 millions of 2013 USD.

Health (2)

- Beyond mortality, **morbidity and healthcare spending** are also strongly affected.
- Barwick et al. (2024, REStat) use daily healthcare spending by city, in China, and find that:
  - a short-run increase of 10 $\mu g/m^3$ in $PM_{2.5}$ raises healthcare transactions by 0.65%, and a medium-run increase raises them by 2.65%,
  - stronger effects in spendings in children's hospitals $\rightarrow$ increased vulnerability for younger populations,
  - non-healthcare spending falls in the short term $\rightarrow$ economic spillovers,
  - an anticipation of poor air quality increases current-day spending $\rightarrow$ **avoidance behaviour** (reduced outdoor activities to mitigate exposure).
  - the elevated $PM_2.5$ level relative to the WHO's annual standards entails at least \$42 billion added healthcare expenditure in 2015.

4. Growth

Productivity and Growth

- Long observed correlation: "*hot countries tend to be poor*" Dell et al. (2009, AER)
- de Secondat de Monstesquieu (1758, Chap. II, Livre III): "*Nous avons déjà dit que la grande chaleur énervait la force et le courage des hommes; et qu'il yavait dans les climats froids une certaine force de corps et d'esprit qui rendait les hommes capables des actions longues, pénibles, grandes et hardies. Cela se remarque non seulement de nation à nation, mais encore dans le même pays, d'une partie à une autre. [...] Il ne faut donc pas être étonné que la lâcheté des peuples des climats chauds les ait presque toujours rendus esclaves, et que le courage des peuples des climats froids les ait maintenus libres.*"
- The debate today:
  - Are **climate factors** themselves key drivers of prosperity?
  - Or are they correlated with other determinants (institutions, trade, colonial history) as argued by Acemoglu et al. (2002, QJE)?

Temperature and Output

- Evidence shows **sectoral output losses** from heat, especially in agriculture (as we previously mentioned).
- But effects extend beyond agriculture:
  - worker productivity and absenteeism (Somanathan et al. 2021, JPE),
  - heat stress and labor efficiency (Hsiang 2010, PNAS),
  - mortality and health impacts (Burgess et al., 2017),
  - conflict risk (Hsiang et al. 2013, Science).
- The mechanisms put forward by Dell et al. (2012, AEJ Macro):
  1. lower level of output (productivity losses, absenteeism).
  2. reduced capacity of the economy to **grow** over time.

Temperature and Economic Growth

- More specifically, Dell et al. (2012, AEJ Macro) find that:
  - in poor countries, a 1°C hotter year reduces GDP growth by ≈1.3 p.p.,
  - in rich countries, little to no effect.
  - This suggests that temperature affects not just **levels of output**, but also the **growth rate** in developing countries.
- Burke et al. (2015, Nature) show, using yearly data on 166 countries over the period 1960–2010, that the relationship between temperatures and economic growth is nonlinear: the change in log per capita GDP peaks at a ≈13–15°C, declines sharply above.
  - this implies that climate change threatens to slow growth and development, particularly in tropical and poorer regions.

5. Sea-Level Rise

Coastal Areas and Climate Risks

- With climate change, there is an increasing risks of **flooding**:
  - the IPCC reports that the global mean sea level is expected to rise between 0.43 m and 0.84 m by 2100 relative to the level in 1986–2005 Calvin et al. (2023)
- This threatens:
  - **communities**: via displacement, migration,
  - **infrastructure**: ports, transport, housing,
  - **markets**: property values, insurance, lending.
- Who bears the costs? Property owners, insurers, mortgage lenders, governments.

Climate Risks and Housing Markets

- Housing markets are starting to reflect **climate risks**, through **prices**.
  - Bernstein et al. (2019, JFE) find that U.S. homes exposed to SLR sell for 6.6% less than comparable unexposed homes.
  - Yet, Hino and Burke (2021, PNAS) show that properties in 100-year flood zones in the U.S. are overvalued by 8.5%.
  - As recalled by Bakkensen and Barrage (2021, RFS), mispricing may create a **climate-related housing bubble**.
- There is a need to understand how to better inform people on risks:
  - Agarwal et al. (2025, J. Pub. Econ.): Singapore PM's 2019 speech triggered a 7.2% fall in SLR-prone housing prices (2016–2023, DiD).
  - Adaptation announcements mitigated depreciation to 0.6%.
- $\rightarrow$ markets partially adjust to new information on climate risks, but often under-react.

Mispricing and Inequality

- To try to better cope with the **potential bubble**, the **overvaluation of risky assets** (houses exposed to high climate-related risks) needs to be documented.
  - Gourevitch et al. (2023, Nature CC) exhibit that U.S. coastal housing are overvalued by $121–237B.
  - They show that the overvaluation is concentrated where flood disclosure laws are weak and climate concerns low.
- The literature has highlighted **distributional issues**:
  - Gourevitch et al. (2023, Nature CC) also showed that the overvaluation is widespread among low-income households, which can be explained as follows:
    - low-income households locate in hazardous areas (cheaper housing) (Bakkensen and Ma 2020, JEEM),
    - poorer areas face higher flood losses due to weaker public protection infrastructure (Seong et al., 2021).
- $\rightarrow$ potential loss of home equity and wealth for already vulnerable populations.

Insurance Markets and Affordability

- As climate risks intensify, **availability and affordability of homeowners insurance is uncertain**.
- Keys and Mulder (2024, NBER):
  - U.S. average nominal premiums increased by 33% between 2020 and 2023 (from \$1,902 to \$2,530, i.e., a 13% real increase),
  - A 1 s.d. increase in disaster risk leads to an increase in average annual premium of \$335,
  - Lower-income and racialized areas pay disproportionately higher premiums.
- As a consequence:
  - Insurance may become inaccessible in high-risk zones.
  - Risk of widening inequality in housing and financial markets.

Exercise

Suppose sea level rise will damage $1B of coastal property. Who ultimately pays? homeowners, insurers, taxpayers, or future generations? How?

6. Migration

Environmental Migrants

The International Organization for Migration defines environmental migrants as follows:
"*Environmental migrants are persons or groups of persons who, for compelling reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad.*"
(Laczko and Aghazarm, 2010)

Why Migration?

- **Climate-related hazards**
  - Sea-level rise (Jacobson, 1988)
  - Extreme events (droughts, floods, storms)
  - Agricultural impacts (Barrios et al. 2006, J. Urb. Econ.; Munshi 2003, QJE)
- **Transmission channels** In their review, Berlemann and Steinhardt (2017) recall that if weather shocks occur and they affect food production, they may lead to:
  - **income losses** from reduced agricultural productivity,
  - **food insecurity**: declining supply *rightarrow* higher prices → famine,
  - **health risks** linked to malnutrition and disease spread.

Coping Strategies

- Migration is viewed a common **adaptation strategy** in response to environmental stress (Sedova and Kalkuhl 2020, World Dev.).
- There is a trade-off between staying and adapt in place vs. displacement as a "survival strategy" (as coined in Barrios et al. 2006, J. Urb. Econ.).
- But, as reported in Sedova and Kalkuhl (2020, World Dev.), the causal link between weather events and migration is not universal:
  - some shocks push people into cities,
  - others reduce international migration due to financial constraints.

Displacement Pathways

- **Internal migration**
  - drought in Syria (2010s): 1.5m rural farmers → urban peripheries (Kelley et al. 2015, PNAS),
  - rural–urban migration in sub-Saharan Africa (Barrios et al. 2006, J. Urb. Econ.).
- **Cross-border migration**
  - Mexico: rainfall shocks → increased US migration via labour networks (Munshi 2003, QJE),
  - Sub-Saharan Africa: weather anomalies lead to a decrease in rural wages, which entails rural–urban flows, puttins pressure on urban wages, leading to international migration (Marchiori et al. 2012, JEEM).

Evidence from Recent Studies

- Cai et al. (2016, JEEM): positive link between temperature and international outmigration, but only significant in the most agriculture-dependent countries.
- Sedova and Kalkuhl (2020, World Dev.): mixed evidence, especially for rainfall. They recall that the effects interact with age, gender, wealth.
- Missirian and Schlenker (2017, Science): nonlinear positive effect of deviations of temperatures from a moderate optimum (20°C) on EU asylum applications
  - Moderate climate scenario (RCP 4.5): +28% asylum applications by 2100.
- Marchiori et al. (2012, JEEM): 5m displaced in SSA due to temperature and precipitation anomalies during the period 1960–2000.

Impacts of Migration

- **Sending areas**
  - Berlemann and Steinhardt (2017) recalls that the loss of skilled workers leads to brain drain,
  - which increases the vulnerability of left-behind populations.
- **Receiving areas**
  - Challenges: urban overcrowding, social/ethnic tensions, demand for housing and jobs.
  - Opportunities: labour force, positive effect on productivity of local workers,
- **International**
  - Pressure on asylum systems and international relations.

Climate & Migration: To Go Further

Some nice reviews to go further on this topic:

- Berlemann and Steinhardt (2017)
- Hoffmann et al. (2021)

7. Social Interactions

Preliminary Exercise

Can climate influence the frequency or intensity of violent behaviour?

You can think about:

- physiological or psychological,
- economic channels,
- social or institutional channels.

Social Interactions: Crime and Weather Shocks

- In what follows, we will focus on interaction between the weather and crime, and more specifically, domestic violence.
- The links between **weather** an **crimes** has been extensively studied in the (economic, but not only) literature.
- 👉 Let us begin with general crime models for theoretical grounding.

The Economics of Crime: Becker (1968, JPE)

- Becker (1968, JPE) viewed crime as an **economic decision** made under uncertainty.
- Individuals weigh the **expected benefits** of committing an offence against the **expected costs** if caught and punished.
- The decision rule writes

$$\mathbb{E}(U_{\text{crime}}) = \underbrace{p\,U(Y-f)}_{\text{if caught}} + \underbrace{(1-p)\,U(Y+g)}_{\text{if not caught}}$$

where:

- p: probability of being caught,
- f: monetary/fine equivalent of punishment,
- g: illegal gain,
- Y: initial income.

- Individuals commit the crime if

$$E(U_{\text{crime}}) > U(Y).$$

- Hence, crime can be reduced by increasing either the **probability of detection (p)** or the **severity of punishment (f)**.

Economic Intuition Behind Becker's Model

- For Becker, crime is not only a moral or psychological act, it can be modelled as a **rational choice under risk**.
- The expected utility depends on:
  - **incentives** (potential gain g),
  - **deterrence** (probability and severity of punishment),
  - **opportunity cost** (alternative legal earnings).
- In Becker's model:
  - $\uparrow p$ or $\uparrow f \Rightarrow$ lower crime (deterrence effect),
  - $\uparrow g$ or $\downarrow$ legal income $\Rightarrow$ higher crime (opportunity effect).

From Becker to Weather Shocks

- Becker's model predicts that when legitimate income opportunities fall, the **expected utility of crime increases**.
- If we apply the model to weather shocks (e.g., droughts, floods, heatwaves), these shocks can:
  - reduce agricultural and informal income,
  - weaken local enforcement or deterrence,
  - increase stress and social tension.
- This creates both:
  - a **behavioural channel** (stress, aggression),
  - and an **economic channel** (crime as income substitution).

The Household Context

- In what comes next, we will have a brief overview of the **behavioural channel** and the **economic channel**.
- We will mostly focus on the **household context**:
  - in such a context, the individual choice framework generalizes: partners bargain over joint resources, and violence may enter the strategy set as a coercive tool to shift payoffs.

7.1. Opening Example: Witch Killings in Tanzania (Miguel, 2005, I

Context

- In Miguel (2005, REStud): examination of the link between **extreme rainfall shocks** and **murders of elderly women** accused of witchcraft.
- **Some context** :
  - In rural Tanzania, **witch killings** (targeting elderly women) have long been tolerated in some regions.
  - These acts surge **following years of extreme rainfall shortfalls**, i.e., droughts that destroy crops and incomes.

Research question

Research Question in Miguel (2005, REStud)

Can weather-induced income shocks trigger social violence?

The paper investigates **two competing theories**:

1. **Scapegoat theory**: people under stress direct aggression at symbolic targets ('witches') to vent frustration,
2. **Income shock theory**: negative shocks that worsen economic stress lead to violence against vulnerable members.

Main findings

- The empiric study relies on village-level data on weather and killings of elderly women (1990–2001).
- It compares variation across years and districts, and it exploits rainfall shocks as **exogenous income fluctuations**.
- **Main findings** :
  - Witch killings rise sharply after extreme droughts but not after floods.
  - This result aligns with the **income shock hypothesis**:
    - Drought → crop failure → income loss → food scarcity → targeting of elderly women perceived as economic burdens.
  - On the other hand, the **scapegoat hypothesis** is not supported, because no similar increase in other crimes is observed.

Policy implication

- How do we interpret these results?
  - These killings reflect economic motives under distress, not superstition alone,
  - Violence becomes a perverse coping mechanism in contexts with **weak social safety nets**.
- What are the **policy implications**?
  - Strengthening formal insurance systems or providing social pensions for elderly women ($\approx$ turning them into an 'asset') could reduce such violence by easing consumption pressure on households.
  - This paper shows that income instability can translate into gendered violence, especially where women have limited economic value or protection.

7.2. Some Definitions and Facts

Gender-Based Violence

Gender-Based Violence

Gender-based violence takes many forms: physical, sexual, emotional, and psychological. Examples include female genital mutilation, killing in the name of so-called 'honor', murder, forced and early marriage, and sex trafficking. Two of the most prevalent types of violence that women experience are intimate partner violence (IPV) and non-partner sexual violence (NPSV). Almost one in three women across the world have experienced one or both of these forms of violence at least once in their lifetime.

Source: 🌐 Violence against women and girls – what the data tell us, World Bank, 2022

Intimate Partner Violence

Intimate Partner Violence

Intimate Partner Violence *(IPV) includes psychological, sexual, and physical violence committed by a current or former intimate partner or husband. All IPV statistics refer to 'ever-partnered' women. This means that the denominator for calculating these estimates only includes women who have ever been in an intimate relationship or in a marriage.*

Source: 🌐 Violence against women and girls – what the data tell us, World Bank, 2022

Gender-Based Violence: Some Facts

Some facts

More than 1 in 4 women (26%) aged 15 years and older have suffered violence at the hands of their partners at least once since the age of 15. Applying this percentage to the 2018 population data from World Population Prospects, the WHO estimates that 641 million women have been affected. And an estimated 245 million (or 10% of women ages 15 and above) have experienced IPV in the last 12 months alone.

Source: Violence against women and girls – what the data tell us, World Bank, 2022

Consequences and Societal Costs

Gender-based violence and intimate partner violence have consequences and societal costs (see, e.g., Rizzotto et al. 2025, Rev. Econ. Household):

- **On health**: physical injuries, trauma, depression, suicide risk.
- **On victim's children**: emotional distress, lower educational outcomes.
- **In the economy**: reduced productivity, absenteeism, long-term earnings loss.
- **In the social sphere**: perpetuation of gender inequality and intergenerational transmission.

Linking Domestic Violence to Climate Change (1/2)

- We observe emerging evidence showing that weather shocks can exacerbate IPV through multiple channels (see Thurston et al. 2021, BMJ Global Health for a review).
- Why does domestic violence respond to weather shocks?
  1. households may be **under stress** because of droughts and heatwaves that reduce income, food security, and emotional well-being.
  2. **women often bear disproportionate burdens** (Gevers et al., 2020):
     - care needs rise during/after weather shock, so that women's unpaid workload expands and leaves them with less time for paid work, education, leisure,
     - because of resource scarcity, women must travel longer distances to fetch resources (such as food or water),
     - men often need to temporarily migrate to find work, leaving women behind to manage the household and making them more exposed to violence.

Linking Domestic Violence to Climate Change (2/2)

- Why does domestic violence responds to weather shocks?
  - 3 weather shock can induce **behavioural response**:
    - financial strain can **increase tensions and conflicts** within the household (Sekhri and Storeygard 2014, JDE; Díaz and Saldarriaga 2023, JHE) (the inability to meet basic needs causes frustration, guilt, anger),
    - increase in **anxiety and stress** (psychological distress because of financial insecurity, loss of status or control) (Díaz and Saldarriaga 2023, JHE)
    - increase in **alcohol consumption** as a coping device, leading to worsen judgment and drop in self-control (Bloch and Rao 2002, AER).

Two main theoretical mechanisms

According to Rizzotto et al. (2025, Rev. Econ. Household), there seems to be, at the moment, **two main mechanisms**:

1. A **heat stress channel**:
   - the exposure to high temperatures affects human physiology and emotional regulation.
2. An **income channel**:
   - a negative weather shock can reduce agricultural output, wages, and local economic activity.

7.3. Heat Stress Channel

The Heat Stress Channel

"*The temperature-aggression hypothesis is the theoretical statement that uncomfortable temperatures cause increases in aggressive motivation and, under the right conditions, in aggressive behavior.*" (Anderson et al., 2000, p. 65)

"*Although the physiological mechanism linking temperature to aggression remains unknown, the causal association appears robust across a variety of contexts*" (Hsiang et al. 2013, Science)

Laboratory Evidence

- Baron and Bell (1976) conducted two laboratory experiments manipulating **ambient temperature** (73°F, 84°F, 93°F) ($\approx$ 23°C, 29°C, 34°C).
- Participants received either **positive or negative evaluations** from a confederate and could then **administer electric shocks** to that person.
- The paper finds that:
  - under positive evaluation (no provocation): aggression **increased** with temperature.
  - under negative evaluation (provoked): aggression **decreased** at high temperature, suggesting that subjects preferred to escape discomfort $\rightarrow$ **Negative Affect Escape Model**,
  - a **cooling drink** before administrating electric shocks reduced aggression, confirming mediation by **negative affect**.
- $\Rightarrow$ heat influences aggression through **affective arousal**, **not by physiology alone**. The relationship is **curvilinear**: aggression rises with moderate discomfort, then falls when heat becomes overwhelming.

Laboratory Evidence

Cohn and Rotton (1997, J. Pers. Soc. Psychol.)

As Bell (1992) observed, heat sometimes led to higher levels of aggression; at other times, it led to lower levels of aggression; and at still other times, heat had no effect on aggression. Baron and Bell (1976) advanced what is now called the Negative Affect Escape (NAE) model *to reconcile these inconsistent results. According to the NAE model, relationships between heat and aggression are mediated by negative affect. Initially, moderately high levels of heat tend to increase aggression, but as discomfort intensifies, people become more interested in escaping, which conflicts with aggressive tendencies.*

From the Lab to the Field (1/2)

- Cohn and Rotton (1997, J. Pers. Soc. Psychol.) test the NAE model using police reports of assaults in Minneapolis (1987–1988), matched with 3-hour temperature data.
- The paper shows that:
  - Assaults increased up to ≈75°F (24°C), then declined at higher temperatures.
  - Non-violent crime shows no consistent pattern.
  - This supports the curvilinear "inverted-U" pattern predicted by the NAE model: moderate heat increases aggression; extreme heat promotes escape.
  - When aggregated to daily data, the nonlinear pattern disappears.

From the Lab to the Field (2/2)

- Recent papers using high-resolution data find a mostly monotonic increase in violent and family crimes with heat.
  - Ranson (2014, JEEM) argues that the mixed results found in early field literature could be due to a lack of geographic and temporal resolution in their crime and weather data, and because of quality issues with US aggregate crime statistics in the 1970s and 1980s (because of different sources of datasets measuring somewhat different crimes, as reminded in Levitt 2004, JEP)
- Ranson (2014, JEEM): U.S. counties (1980–2009): violent crime rises roughly linearly with temperature.
- Cohen and Gonzalez (2024, AEJ: Econ Policy): $+1°C \rightarrow +1.78\%$ in daily charges (Mexico); strongest for violent and family violence crimes.

IPV and the Heat Stress Channel

- Michael and Zumpe (1986, Am. J. Psychiatry), using monthly data (1981–1984) from 23 U.S. shelters aiding battered women, reported evidence on seaonality of IPVn with a max. in **July-August**, coinciding with peak ambient temperature:
  - IPV occurrence may possibly be linked to temperature-related changes in aggressivity, but this is purely correlational, **not a causal identification**.

Testing the Heat–Stress Hypothesis: Rizzotto et al. (2025)

- Rizzotto et al. (2025, Rev. Econ. Household) examines:
  - immediate effects of weather shocks on domestic violence → assumed to be caused by **acute stress**,
  - effects of prolonged periods of drought or extreme heat → assumed to be caused by **chronic stress**.
- The paper uses daily municipal panel data in Brazil, between 2010–2019: hospital assault reports, hotline calls, and female homicides.
  - the hospital data provide information on the aggressor's relationship,
  - the hotline calls correspond to cases of violence against women.
- Two-way fixed-effects model:

$$Y_{it} = \alpha + \beta_1 \, \text{Weather}_{i,t-1} + \gamma_i + \lambda_t + \varepsilon_{it},$$

where γ_i = municipality×year FE, λ_t = calendar-date FE.

Testing the Heat–Stress Hypothesis: Rizzotto et al. (2025)

- Rizzotto et al. (2025, Rev. Econ. Household) finds that:
  - Higher daily max temperature $\rightarrow$ immediate and short-lived increase in reports ($+1.5\%$ in per capita daily assaults rate and $+0.9\%$ hotline calls, no significant impact of homicides).
  - Results with rainfall are inconsistent.
  - No evidence of persistent or cumulative effects over weeks or months.

7.4. Income Channel

Two main theoretical mechanisms (bis)

We previously mentioned that, according to Rizzotto et al. (2025, Rev. Econ. Household), there seems to be, at the moment, **two main mechanisms**:

1. A **heat stress channel**:
   - the exposure to high temperatures affects human physiology and emotional regulation.
2. An **income channel**:
   - a negative weather shock can reduce agricultural output, wages, and local economic activity.

- We have highlighted physiological and affective mechanisms in the previous slides.
- 👉 Let us now move to the income channel, which relies on incentives and bargaining.

The Income Channel

The assumed mechanism works as follows:

- A weather shock occurs (e.g., a drought, or rainfall deficits).
- It lowers agricultural output, leading to **income loss**.
- Consequently, household consumption falls.
- This generates stress, alcohol use, conflicts.
- Intimate partner violence may become a **coping or control mechanism** under financial strain
  - 👉 let us see how.

Bargaining Power within the Household

- Households can be viewed not as a single decision-maker but as a **group of individuals with possibly conflicting preferences**.
- Each partner's influence on decisions depends on their bargaining power, which is shaped by:
  - individual income and assets,
  - access to credit and networks,
  - outside options (e.g. ability to leave),
  - social and legal norms.
- As explained in Eswaran and Malhotra (2011, Can. J. Econ.), violence can be interpreted as a strategic tool in this bargaining process:
  - the incentive for male partners to use violent as a tool to regain control over household decision-making increases with reduced (relative) income.
  - violence can also be used to **extract financial resources from the family**.

Empirical Illustrations of Financial Extraction from the Family

- Corno et al. (2020, Econometrica) study how households use **marriage transfers** to cope with income shocks in Sub-Saharan Africa (bride price) and India (dowry).
  - gendered bargaining decisions: during droughts (negative income shocks), families **advance or delay child marriages** depending on the direction of transfers.
- Sekhri and Storeygard (2014, J. Dev. Econ.) investigates rainfall shocks and **dowry-related violence** in India.
  - A one s.d. dry shock $\rightarrow$ 7.8% increase in dowry deaths and 4.4% rise in domestic violence.
  - Mechanism: in times of financial distress, **violence becomes a means of extracting additional transfers** from the bride's family.
- Both studies show that when **income shocks alter household bargaining positions**, women's safety and autonomy are often at risk.

How weather shocks alter bargaining power

- Following an income shock, there may be changes in relative economic contribution:
  - When male income falls (in male-dominated agriculture sector), the relative contribution of men in the household income drops, which leads to a **decrease of their bargaining power**.
  - Two opposite effects may follow:
    1. **empowerment effect** : women gain relative control over resources and decisions, which is assumed to lower IPV (Díaz and Saldarriaga 2023, JHE).
    2. **backlash effect** : men feel threatened in their representation, they use violence to reassert control → increase in IPV (Anderberg et al. 2015, EJ, Aguilar-Gómez and Salazar-Díaz 2025).

Theoretical Interpretation

- Theoretically, household decision problems (how income is spent, who works, who eats first, who controls money) can be placed into a **bargaining framework** (Nash bargaining).
- **Collective household models** (Chiappori 1992, JPE) view the household as a group of individuals with distinct preferences.
- Decisions result from a bargaining process that depends on each member's **threat point** $\overline{U}_i$, i.e., the level of well-being each person can guarantee themselves if no collective agreement is reached.
- For any given income combination, the outcome of the decision process is supposed to maximize the product $(U_1 - \overline{U}_1)(U_2 - \overline{U}_2)$ under the budget constraint.
- ⚙ More details on the Nash bargaining framework.

Theoretical Interpretation: Model

- In a collective labour model, the collective labour supply will be the solution of the Nash bargaining program:

$$\begin{aligned} &\arg\max_{L,C} \left\{ (U_1(L_1, C_1) - \overline{U}_1)(U_2(L_2, C_2) - \overline{U}_2) \right\} \\ \text{s.t.} \quad &w_1 L_1 + w_2 L_2 + C_1 + C_2 \leq (w_1 + w_2) T + y, \end{aligned}$$

- where
  - L_i: leisure quantity,
  - C_i : quantity of private consumption good,
  - w_i: wage
  - y: non-labour income
  - T: total available time
  - $\overline{U}_i$: threat point

Theoretical Interpretation: Threat Point (1/3)

- **The threat points** $\overline{U}_i$ can be understood as individual utility levels when divorce is involved:
  - if agent's i's wage (or non-labour income) when divorced is w_i (or y_i), then $\overline{U}_i = V_i(w_i, y_i)$, where V_i is i's indirect utility function.
- each partner's threat point captures their **welfare outside the relationship**: their ability to leave or separate; their access to own income; the legal protection; social norms,
  - the higher an individual threat point, the greater their bargaining power,
  - if an individual's threat point is low, they are more dependent and their partner can push decisions in their favour.

Theoretical Interpretation: Threat Point (2/3)

The threat point can vary with income, employment of norms shift. For example :

- assume a woman **gains access to her own income** (work/government cash transfer)
  - her economic role strengthen,
  - her outside options rise, so her threat point rises as well,
  - her bargaining power increases.
- or, assume that **social norms** make divorce or separation acceptable:
  - leaving an abusive partner becomes less costly, the threat point rises
  - her bargaining power increases.
- on the other hand, if divorce is stigmatized:
  - the cost of exit is high, the threat point is low.
  - her bargaining power decreases.

Theoretical Interpretation: Wrap-Up

To wrap-up:

- If a partner's threat point **decreases**:
  - their bargaining power decreases,
  - they become more dependent and thus more exposed to violence,
  - but the **other partner** may also use violence instrumentally to extract transfers or reassert control (Eswaran and Malhotra 2011, Can. J. Econ.).
- If a partner's threat point **increases**:
  - their bargaining power increases,
  - they can better resist coercion and are less vulnerable to violence, yet, in contexts where female empowerment challenges traditional gender norms, a "**backlash effect**" may emerge:
    - men may respond violently to perceived loss of dominance (Anderberg et al. 2015, EJ)
    - violence becomes a means to restore status or discipline.

Empirical Illustrations: Income and Economic Stress

- Díaz and Saldarriaga (2023, JHE) provides one of the clearest tests of the **income channel**.
- Using survey data from rural Peru, the paper estimates the impact of **dry shocks during the cropping season** on physical IPV.
  - Exposure to a dry shock $\rightarrow$ +8.5 percentage points in probability of physical IPV.
  - Mechanisms:
    - income and consumption expenditures per capita decline (–20% and –15%, resp.),
    - increases in male alcohol intake and marital control,
    - decreases in women's employment and financial autonomy.
- The paper links drought-induced income shocks to IPV through both **economic hardship** and **bargaining-power loss**.

Empirical Illustrations: Policy Buffers and Adaptation

- Sarma (2022, World Dev.) evaluates India's **MNREGA employment guarantee scheme** as an insurance mechanism.
- MNREGE: this program guarantees 100 days of rural employment: aims at stabilizing household income. It mandates that 1/3 of beneficiaries should be women.
- The paper finds that:
  - during the initial phase of implementation, MNREGA **mitigated** the effect of adverse rainfall shocks on reported domestic-violence crimes by ∼8–22%.
  - the effects are concentrated in **dry shocks during agricultural months**.
- **For policy implications**:
  - **social insurance** and **employment programs** can **weaken the income-violence link**.

Wrap-Up: Domestic Violence and Weather Shocks

- **Climate shocks can exacerbate intimate partner and family violence** through multiple channels: economic, behavioural, and psychological.
- Two main mechanisms:
  1. **Heat–stress**: high temperatures → irritability, impulsivity, aggression (Cohen and Gonzalez 2024, AEJ: Applied; Rizzotto et al. 2025, Rev. Econ. Household).
  2. **Income shocks** Weather shock → stress, loss of bargaining power, male backlash (Miguel 2005, REStud; Díaz and Saldarriaga 2023, JHE).
- Some of the main findings from empirical evidence:
  - income shocks raise IPV through financial strain and bargaining dynamics,
  - high temperatures cause **acute, short-lived spikes** in violence,
  - social protection programs (e.g., MNREGA) **buffer** these effects by stabilizing income (Sarma 2022, World Dev.).

Wrap-Up: Domestic Violence and Weather Shocks

- **Policy insight:**
  - Climate adaptation must integrate **gender-sensitive safety nets** and **public-health preparedness** for heat waves.
- IPV represent some of the **hidden costs of climate change.**

8. Appendix

References I

Acemoglu, D., Johnson, S. and Robinson, J. A. (2002). Reversal of fortune: Geography and institutions in the making of the modern world income distribution. *The Quarterly Journal of Economics* 117: 1231–1294, doi: 10.1162/003355302320935025.

Agarwal, S., Qin, Y., Sing, T. F. and Zhan, C. (2025). Sea level rise risks, adaptation strategies, and real estate prices in Singapore. *Journal of Public Economics* 241: 105290, doi: 10.1016/j.jpubeco.2024.105290.

Aguilar-Gómez, S. and Salazar-Díaz, A. (2025). Droughts and domestic violence: Measuring the gender-climate nexus. doi: 10.18235/0013368, working paper.

Anderberg, D., Rainer, H., Wadsworth, J. and Wilson, T. (2015). Unemployment and domestic violence: Theory and evidence. *The Economic Journal* 126: 1947–1979, doi: 10.1111/ecoj.12246.

Anderson, C. A., Anderson, K. B., Dorr, N., DeNeve, K. M. and Flanagan, M. (2000). Temperature and aggression. Advances in Experimental Social Psychology Volume 32. Academic Press, 63–133, doi: 10.1016/s0065-2601(00)80004-0.

Andersson, H. and Treich, N. (2011). *The Value of a Statistical Life*. Edward Elgar Publishing. doi: 10.4337/9780857930873.00025.

Aragón, F. M., Oteiza, F. and Rud, J. P. (2021). Climate change and agriculture: Subsistence farmers' response to extreme heat. *American Economic Journal: Economic Policy* 13: 1–35, doi: 10.1257/pol.20190316.

Bakkensen, L. A. and Barrage, L. (2021). Going underwater? flood risk belief heterogeneity and coastal home price dynamics. *The Review of Financial Studies* 35: 3666–3709, doi: 10.1093/rfs/hhab122.

References II

Bakkensen, L. A. and Ma, L. (2020). Sorting over flood risk and implications for policy reform. *Journal of Environmental Economics and Management* 104: 102362, doi: 10.1016/j.jeem.2020.102362.

Baron, R. A. and Bell, P. A. (1976). Aggression and heat: The influence of ambient temperature, negative affect, and a cooling drink on physical aggression. *Journal of Personality and Social Psychology* 33: 245–255, doi: 10.1037//0022-3514.33.3.245.

Barrios, S., Bertinelli, L. and Strobl, E. (2006). Climatic change and rural–urban migration: The case of sub-saharan africa. *Journal of Urban Economics* 60: 357–371, doi: 10.1016/j.jue.2006.04.005.

Barwick, P. J., Li, S., Rao, D. and Zahur, N. B. (2024). The healthcare cost of air pollution: Evidence from the world's largest payment network. *Review of Economics and Statistics* : 1–52doi: 10.1162/rest_a_01430.

Basu, R. (2002). Relation between elevated ambient temperature and mortality: A review of the epidemiologic evidence. *Epidemiologic Reviews* 24: 190–202, doi: 10.1093/epirev/mxf007.

Becker, G. S. (1968). Crime and punishment: An economic approach. *Journal of Political Economy* 76: 169–217.

Bell, P. A. (1992). In defense of the negative affect escape model of heat and aggression. *Psychological Bulletin* 111: 342–346, doi: 10.1037/0033-2909.111.2.342.

Berlemann, M. and Steinhardt, M. F. (2017). Climate change, natural disasters, and migration—a survey of the empirical evidence. *CESifo Economic Studies* 63: 353–385, doi: 10.1093/cesifo/ifx019.

Bernstein, A., Gustafson, M. T. and Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of Financial Economics* 134: 253–272, doi: 10.1016/j.jfineco.2019.03.013.

References III

Bloch, F. and Rao, V. (2002). Terror as a bargaining instrument: A case study of dowry violence in rural India. *American Economic Review* 92: 1029–1043, doi: 10.1257/00028280260344588.

Burgess, R., Deschenes, O., Donaldson, D. and Greenstone, M. (2017). Weather, climate change and death in india.

Burke, M., Hsiang, S. M. and Miguel, E. (2015). Global non-linear effect of temperature on economic production. *Nature* 527: 235–239, doi: 10.1038/nature15725.

Cai, R., Feng, S., Oppenheimer, M. and Pytlikova, M. (2016). Climate variability and international migration: The importance of the agricultural linkage. *Journal of Environmental Economics and Management* 79: 135–151, doi: 10.1016/j.jeem.2016.06.005.

References IV

Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P. W., Trisos, C., Romero, J., Aldunce, P., Barret, K., Blanco, G., Cheung, W. W., Connors, S. L., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., Hayward, B., Jones, C., Jotzo, F., Krug, T., Lasco, R., Lee, Y.-Y., Masson-Delmotte, V., Meinshausen, M., Mintenbeck, K., Mokssit, A., Otto, F. E., Pathak, M., Pirani, A., Poloczanska, E., Pörtner, H.-O., Revi, A., Roberts, D. C., Roy, J., Ruane, A. C., Skea, J., Shukla, P. R., Slade, R., Slangen, A., Sokona, Y., Sörensson, A. A., Tignor, M., Vuuren, D. van, Wei, Y.-M., Winkler, H., Zhai, P., Zommers, Z., Hourcade, J.-C., Johnson, F. X., Pachauri, S., Simpson, N. P., Singh, C., Thomas, A., Totin, E., Alegría, A., Armour, K., Bednar-Friedl, B., Blok, K., Cissé, G., Dentener, F., Eriksen, S., Fischer, E., Garner, G., Guivarch, C., Haasnoot, M., Hansen, G., Hauser, M., Hawkins, E., Hermans, T., Kopp, R., Leprince-Ringuet, N., Lewis, J., Ley, D., Ludden, C., Niamir, L., Nicholls, Z., Some, S., Szopa, S., Trewin, B., Wijst, K.-I. van der, Winter, G., Witting, M., Birt, A. and Ha, M. (2023). *IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.*. doi: 10.59327/ipcc/ar6-9789291691647.001.

Carleton, T., Jina, A., Delgado, M., Greenstone, M., Houser, T., Hsiang, S., Hultgren, A., Kopp, R. E., McCusker, K. E., Nath, I., Rising, J., Rode, A., Seo, H. K., Viaene, A., Yuan, J. and Zhang, A. T. (2022). Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits. *The Quarterly Journal of Economics* 137: 2037–2105, doi: 10.1093/qje/qjac020.

Carleton, T. A. and Hsiang, S. M. (2016). Social and economic impacts of climate. *Science* 353, doi: 10.1126/science.aad9837.

References V

Chiappori, P.-A. (1992). Collective labor supply and welfare. *Journal of Political Economy* 100: 437–467, doi: 10.1086/261825.

Cohen, F. and Dechezleprêtre, A. (2022). Mortality, temperature, and public health provision: Evidence from Mexico. *American Economic Journal: Economic Policy* 14: 161–192, doi: 10.1257/pol.20180594.

Cohen, F. and Gonzalez, F. (2024). Understanding the link between temperature and crime. *American Economic Journal: Economic Policy* 16: 480–514, doi: 10.1257/pol.20220118.

Cohn, E. G. and Rotton, J. (1997). Assault as a function of time and temperature: A moderator-variable time-series analysis. *Journal of Personality and Social Psychology* 72: 1322–1334, doi: 10.1037/0022-3514.72.6.1322.

Corno, L., Hildebrandt, N. and Voena, A. (2020). Age of marriage, weather shocks, and the direction of marriage payments. *Econometrica* 88: 879–915, doi: 10.3982/ecta15505.

Dell, M., Jones, B. F. and Olken, B. A. (2009). Temperature and income: Reconciling new cross-sectional and panel estimates. *American Economic Review* 99: 198–204, doi: 10.1257/aer.99.2.198.

Dell, M., Jones, B. F. and Olken, B. A. (2012). Temperature shocks and economic growth: Evidence from the last half century. *American Economic Journal: Macroeconomics* 4: 66–95, doi: 10.1257/mac.4.3.66.

Deschênes, O. and Greenstone, M. (2007). The economic impacts of climate change: Evidence from agricultural output and random fluctuations in weather. *American Economic Review* 97: 354–385, doi: 10.1257/aer.97.1.354.

References VI

Deschênes, O. and Greenstone, M. (2011). Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US. *American Economic Journal: Applied Economics* 3: 152–185, doi: 10.1257/app.3.4.152.

Di Falco, S. and Veronesi, M. (2013). How can african agriculture adapt to climate change? a counterfactual analysis from Ethiopia. *Land Economics* 89: 743–766, doi: 10.3368/le.89.4.743.

Díaz, J.-J. and Saldarriaga, V. (2023). A drop of love? rainfall shocks and spousal abuse: Evidence from rural Peru. *Journal of Health Economics* 89: 102739, doi: 10.1016/j.jhealeco.2023.102739.

Drèze, J. (1962). L'utilité sociale d'une vie humaine. *Revue Française de Recherche Opérationnelle* 23: 93–118.

Eswaran, M. and Malhotra, N. (2011). Domestic violence and women's autonomy in developing countries: theory and evidence. *Canadian Journal of Economics/Revue canadienne d'économique* 44: 1222–1263, doi: 10.1111/j.1540-5982.2011.01673.x.

Gevers, A., Musuya, T. and Bukuluki, P. (2020). Why climate change fuels violence against women. United Nations Development Programme. https://www.undp.org/blog/why-climate-change-fuels-violence-against-women.

Gourevitch, J. D., Kousky, C., Liao, Y., Nolte, C., Pollack, A. B., Porter, J. R. and Weill, J. A. (2023). Unpriced climate risk and the potential consequences of overvaluation in us housing markets. *Nature Climate Change* 13: 250–257, doi: 10.1038/s41558-023-01594-8.

References VII

Hino, M. and Burke, M. (2021). The effect of information about climate risk on property values. *Proceedings of the National Academy of Sciences* 118, doi: 10.1073/pnas.2003374118.

Hoffmann, R., Šedová, B. and Vinke, K. (2021). Improving the evidence base: A methodological review of the quantitative climate migration literature. *Global Environmental Change* 71: 102367, doi: 10.1016/j.gloenvcha.2021.102367.

Hsiang, S. M. (2010). Temperatures and cyclones strongly associated with economic production in the caribbean and central america. *Proceedings of the National Academy of Sciences* 107: 15367–15372, doi: 10.1073/pnas.1009510107.

Hsiang, S. M., Burke, M. and Miguel, E. (2013). Quantifying the influence of climate on human conflict. *Science* 341, doi: 10.1126/science.1235367.

Jacobson, J. L. (1988). Environmental refugees: a yardstick of habitability. *Bulletin of Science, Technology & Society* 8: 257—-258, doi: 10.1177/027046768800800304.

Kelley, C. P., Mohtadi, S., Cane, M. A., Seager, R. and Kushnir, Y. (2015). Climate change in the fertile crescent and implications of the recent Syrian drought. *Proceedings of the National Academy of Sciences* 112: 3241–3246, doi: 10.1073/pnas.1421533112.

Keys, B. and Mulder, P. (2024). *Property Insurance and Disaster Risk: New Evidence from Mortgage Escrow Data*. doi: 10.3386/w32579.

References VIII

Laczko, F. and Aghazarm, C. (2010). *Migration, the environment and climate change: assessing the evidence.*. International Organization for Migration.

Levitt, S. D. (2004). Understanding why crime fell in the 1990s: Four factors that explain the decline and six that do not. *Journal of Economic Perspectives* 18: 163–190, doi: 10.1257/089533004773563485.

Marchiori, L., Maystadt, J.-F. and Schumacher, I. (2012). The impact of weather anomalies on migration in sub-Saharan Africa. *Journal of Environmental Economics and Management* 63: 355–374, doi: 10.1016/j.jeem.2012.02.001.

Michael, R. P. and Zumpe, D. (1986). An annual rhythm in the battering of women. *American Journal of Psychiatry* 143: 637–640, doi: 10.1176/ajp.143.5.637.

Miguel, E. (2005). Poverty and witch killing. *The Review of Economic Studies* 72: 1153–1172, doi: 10.1111/0034-6527.00365.

Missirian, A. and Schlenker, W. (2017). Asylum applications respond to temperature fluctuations. *Science* 358: 1610–1614, doi: 10.1126/science.aao0432.

Monstesquieu, C. de Secondat de (1758). *De l'esprit des lois*.

Munshi, K. (2003). Networks in the modern economy: Mexican migrants in the U. S. labor market. *The Quarterly Journal of Economics* 118: 549–599, doi: 10.1162/003355303321675455.

Nash, J. F. (1950). The bargaining problem. *Econometrica* 18: 155, doi: 10.2307/1907266.

References IX

Ranson, M. (2014). Crime, weather, and climate change. *Journal of Environmental Economics and Management* 67: 274–302, doi: 10.1016/j.jeem.2013.11.008.

Rizzotto, J. S., Sims, K. M. and Gibbs, H. K. (2025). Hot tempers: Differential effects of heat and drought on domestic violence. *Review of Economics of the Household* doi: 10.1007/s11150-025-09806-0.

Sarma, N. (2022). Domestic violence and workfare: An evaluation of India's MGNREGS. *World Development* 149: 105688, doi: 10.1016/j.worlddev.2021.105688.

Schlenker, W. and Roberts, M. J. (2009). Nonlinear temperature effects indicate severe damages to u.s. crop yields under climate change. *Proceedings of the National Academy of Sciences* 106: 15594–15598, doi: 10.1073/pnas.0906865106.

Sedova, B. and Kalkuhl, M. (2020). Who are the climate migrants and where do they go? Evidence from rural India. *World Development* 129: 104848, doi: 10.1016/j.worlddev.2019.104848.

Sekhri, S. and Storeygard, A. (2014). Dowry deaths: Response to weather variability in India. *Journal of Development Economics* 111: 212–223, doi: 10.1016/j.jdeveco.2014.09.001.

Seong, K., Losey, C. and Gu, D. (2021). Naturally resilient to natural hazards? urban–rural disparities in hazard mitigation grant program assistance. *Housing Policy Debate* 32: 190–210, doi: 10.1080/10511482.2021.1938172.

Somanathan, E., Somanathan, R., Sudarshan, A. and Tewari, M. (2021). The impact of temperature on productivity and labor supply: Evidence from Indian manufacturing. *Journal of Political Economy* 129: 1797–1827, doi: 10.1086/713733.

References X

Thaler, R. and Rosen, S. (1976). The value of saving a life: evidence from the labor market. In *Household production and consumption*. NBER, 265–302.

Thurston, A. M., Stöckl, H. and Ranganathan, M. (2021). Natural hazards, disasters and violence against women and girls: a global mixed-methods systematic review. *BMJ Global Health* 6: e004377, doi: 10.1136/bmjgh-2020-004377.

Viscusi, W. K. (2015). The role of publication selection bias in estimates of the value of a statistical life. *American Journal of Health Economics* 1: 27–52, doi: 10.1162/ajhe_a_00002.

Zhao, Q., Wu, L., Huo, F., Li, Z. and Li, Y. (2025). Assessing the impacts of shifting planting dates on crop yields and irrigation demand under warming scenarios in Alberta, Canada. *Agricultural Water Management* 309: 109304, doi: 10.1016/j.agwat.2025.109304.

What Is a Bargaining Problem?

- A **bargaining situation** arises whenever two (or more) agents can **cooperate** to obtain mutual gains, but must **agree on how to share** those gains.
- Fro example:
  - two firms negotiating a joint venture,
  - two countries dividing emission permits,
  - two partners deciding how to split household income.
- If they fail to agree, each agent obtains an **outside option** (the **threat point**), i.e., the payoff they can guarantee alone.
- A bargaining problem is defined by:

$$(\mathcal{U},\ \overline{U}_1, \overline{U}_2)$$

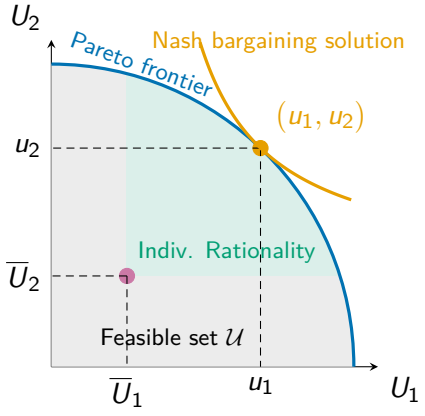
where $\mathcal{U}$ is the set of all feasible utility pairs, and $(\overline{U}_1, \overline{U}_2)$ are the threat points.

The Idea of Nash Bargaining

- Introduced by Nash (1950, Econometrica).
- The **Nash Bargaining Solution (NBS)** describes the outcome that rational, cooperative agents would agree on, given their threat points.
- Nash proposed that the solution should:
  - be **Pareto efficient**: no other feasible allocation can make one better off without hurting the other,
  - be **symmetric**: if players are identical, they should get the same outcome,
  - respect **invariance to affine transformations**,
  - satisfy **independence of irrelevant alternatives**.
- Under these axioms, the solution maximizes the product of each player's gain over their threat point:

$$\max_{(U_1,U_2)\in\mathcal{U}} (U_1 - \bar{U}_1)(U_2 - \bar{U}_2)$$

Geometric Intuition



Go back

- Each point (U_1, U_2) in the set $\mathcal{U}$: a possible agreement between agents 1 and 2.
- $(\overline{U}_1, \overline{U}_2)$ is the **threat point** (utilities if they fail to agree).
- The curved boundary is the **Pareto frontier**, i.e., the efficient allocations (one's gain requires the other's loss).
- The **Nash solution** maximizes the product of utility gains:

$$\max_{(U_1,U_2)\in\mathcal{U}} (U_1 - \overline{U}_1)(U_2 - \overline{U}_2)$$

- Intuitively: each partner's improvement over their outside option is balanced: neither can gain more without reducing the other's proportional gain.