Collective Risk Management: Prevention and Risk Sharing

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Introduction

Big issue in climate policy: presence of deep uncertainty.

- **Uncertainty in aggregate loss**:
  - if increase in temperature lower than $3^{\circ}\mathrm{C}$, aggregate loss between 0% and 4%
  - if higher increase in temperature, more uncertainty
- **Heterogeneity in regional impacts**:
  - high damages in Sub-Saharian region or Asian mega-deltas
  - if slight increase in temperature, benefits in former Soviet Union or Canada.

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- Mitigation policy as prevention investment. Comparison between two economies: perfect risk sharing vs no risk sharing

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- If inefficient risk sharing, optimal policy requires low mitigation targets unless the climate event is catastrophic
  - trade-off between income pooling and increase in prevention costs
  - inefficient risk sharing as state-specific background risk; impact in terms of either increase in risk aversion or prudence
- Risk sharing as adaptation measure $\rightarrow$ complementarity between adaptation and mitigation

Related Literature

- Literature on self-insurance and self-protection (Ehrlich and Becker 1972). Risk aversion and prevention: Dionne and Eeckhoudt (1984), Brits and Schlesinger, 1990; Jullien, Salanié and Salanié (1999). Prudence and prevention: Eeckhoudt and Gollier (2005)
- Literature on background risk: Gollier and Pratt (1996)
- Literature on mitigation and adaptation: Kane and Shogren, 2000; Auerswald et al. 2011

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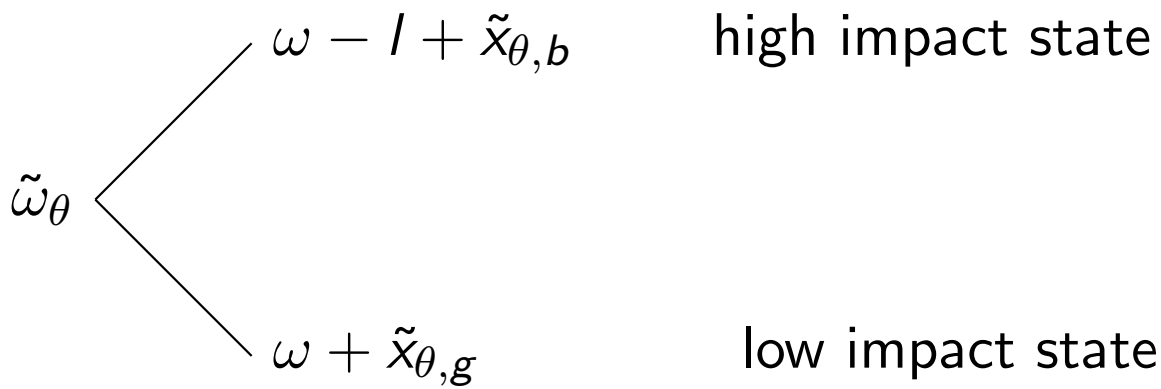
inequality shock

$$E_\theta x_{\theta,s} = 0$$

Two aggregate state economy



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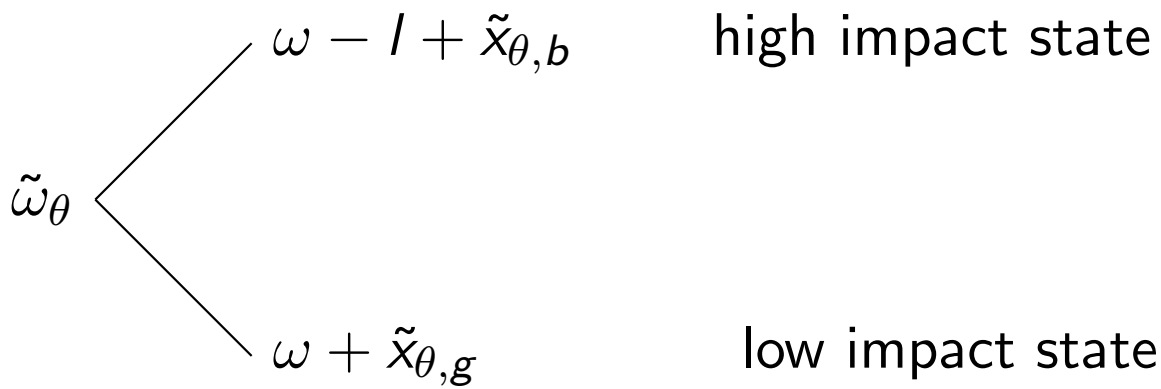

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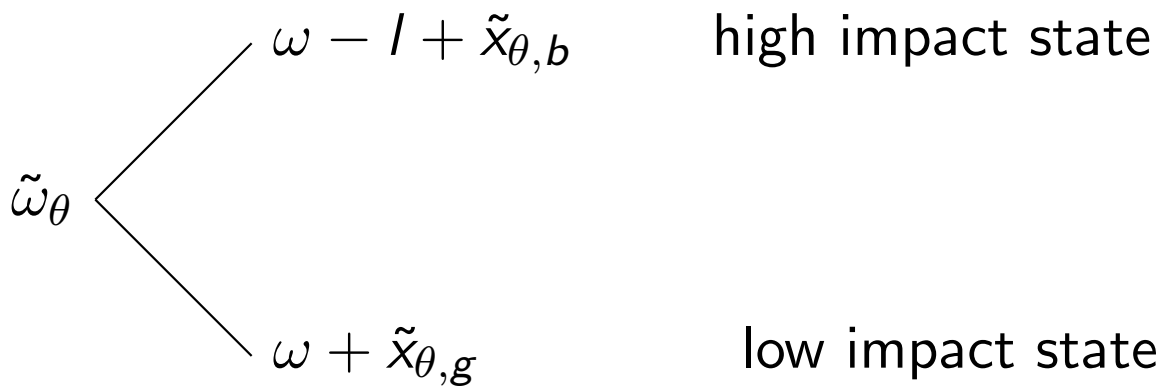

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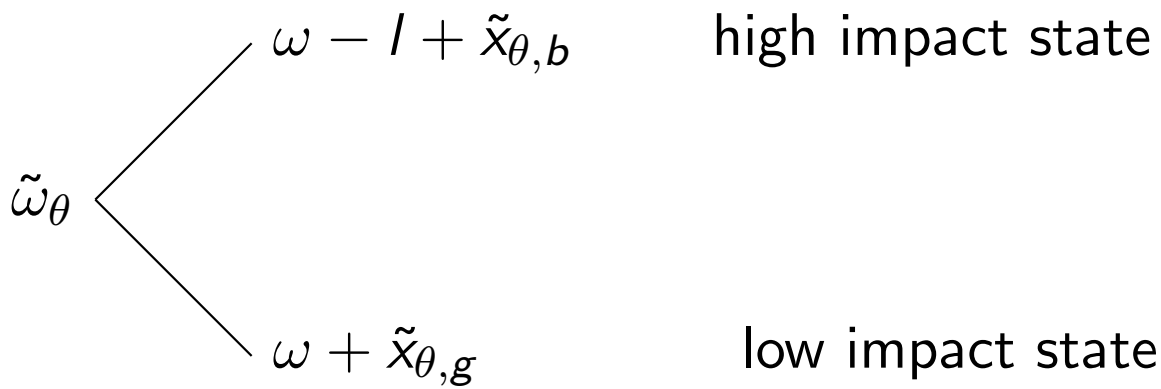

- probability of high impact state: $p(e)$, with $p' < 0$
- public investment e, whose costs are equally divided
- $E\tilde{x}_{\theta,b} = E\tilde{x}_{\theta,g} = 0$, $\forall\theta$

Inefficient risk sharing (1)

Optimal prevention investment $\hat{e}$ solves:

$$\max_e \quad E_\theta \Big\{ p(e) Eu(\omega - l + \tilde{x}_{\theta,b} - e) + (1 - p(e)) Eu(\omega + \tilde{x}_{\theta,g} - e) \Big\}$$

Because of symmetric distribution of income shocks $\tilde{x}_{\theta,b}$ and $\tilde{x}_{\theta,g}$, first order condition becomes:

$$-p'(\hat{e}) = \frac{p(\hat{e}) Eu'_b + (1 - p(\hat{e})) Eu'_g}{Eu_g - Eu_b}$$

Efficient risk sharing

Optimal sharing rule $z_{\theta,s}$, $\forall s \in S$:

$$\left.\begin{array}{rl} \max_{z_{\theta,s}} & E_\theta u(z_{\theta,s} - e) \\ \text{s.t} & E_\theta z_{\theta,s} = \omega_s \end{array}\right\} \quad \Rightarrow \quad z_{\theta,s} = \omega_s \quad \forall \theta$$

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Optimal prevention level e^*:

$$\max_e \quad p(e)u(\omega - l - e) + (1 - p(e))u(\omega - e)$$

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Optimal prevention level e^*:

$$\max_e \quad p(e)u(\omega - l - e) + (1 - p(e))u(\omega - e)$$

First order condition:

$$-p'(e^*) = \frac{p(e^*)u'_b + (1 - p(e^*))u'_g}{u_g - u_b}$$

Comparison

Prevention investment increases under inefficient risk sharing if and only if:

$$\frac{p(e^*)v_b' + (1-p(e^*))w_g'}{w_g - v_b} \leq \frac{p(e^*)u_b' + (1-p(e^*))u_g'}{u_g - u_b}$$

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Two effects under efficient risk sharing:

- income pooling $\Rightarrow$ incentive to reduce prevention
- lower marginal costs if prudence ($u''' > 0$) $\Rightarrow$ incentive to increase prevention

Increase in risk aversion

- Inefficient risk sharing is equivalent to a state specific uninsurable risk: $\tilde{x}_{\theta,b}$ and $\tilde{x}_{\theta,g}$
- Risk vulnerability: uninsurable risk is equivalent to an increase in the degree of risk aversion: $A_v > A_u$ and $A_w > A_u$
- Increase in risk aversion does not necessarily imply higher prevention
- Here: state-dependent increase in risk aversion

Persistent inequality risk

Suppose that $\tilde{x}_b =_d \tilde{x}_g$. Under risk vulnerability, inefficient risk sharing increases prevention if and only if $p(e^*) < \bar{p}$.

- higher investment in prevention implies lower wealth if the accident occurs $\rightarrow$ incentive to reduce investment
- threshold probability is decreasing in I

Divergent economies

Suppose that the high impact state is characterized by a larger heterogeneity in the distribution of impacts, i.e. $\tilde{x}_b =_d \tilde{x}_g + \tilde{\epsilon}$, $E\tilde{\epsilon} = 0$. Under risk vulnerability, inefficient risk sharing increases prevention if and only if one of the following conditions holds:

- $A_v - A_u < Q(I)$
- $A_v - A_u \geq Q(I)$ and $p(e^*) < \bar{p}$

where $Q(I)$ is a decreasing function of I. ▸ proof

Convergent economies

Suppose that the low impact state is characterized by a larger heterogeneity in the distribution of impacts, i.e. $\tilde{x}_g =_d \tilde{x}_b + \tilde{\eta}$, $E\tilde{\eta} = 0$. Under risk vulnerability, inefficient risk sharing increases prevention if and only if: $A_w - A_u \geq \hat{Q}(I)$ and $p(e^*) < \bar{p}$

Role of prudence

Suppose that the inequality risks $\tilde{x}_b$ and $\tilde{x}_g$ are small in both states, and $P_g < \frac{u'_g}{u_g - u_b}\left(\frac{u''_b \sigma_b}{u''_g \sigma_g} - 1\right)$. Inefficient risk sharing increases prevention if and only if one of the following conditions holds:

- $P_b < \frac{u'_b}{u_g - u_b}\left(1 - \frac{u''_g \sigma_g}{u''_b \sigma_b}\right)$
- $P_b \geq \frac{u'_b}{u_g - u_b}\left(1 - \frac{u''_g \sigma_g}{u''_b \sigma_b}\right)$ and $p(e^*) < \bar{p}$

▸ proof

Comparative statics

- presence of multiple state dependent risks decreases mitigation: larger prudence effect if high σ_b
- if $\sigma_b \geq \sigma_g$ and CRRA preferences, inefficient risk sharing increases mitigation irrespectively of the probability distribution only if the aggregate loss is sufficiently small.

Concluding remarks

- Analysis of the relationship between the collective prevention of climate change and efficiency of the risk sharing mechanism
- Sufficient condition for increasing mitigation is the presence of a catastrophic event
- Complementarity between mitigation and adaptation
- What if asymmetric distributions of income shock?