Fair Intergenerational Utilitarianism:

Risk, Learning, and Discounting

P.G. Piacquadio[1]

[1]Department of Economics,
University of Oslo

FEEM seminar, 22-05-14

Research question

- How to evaluate climate change policies?
- Which welfare criterion should we use to assess the social desirability of a policy that distributes risky benefits and costs across generations?
- Since the publication of the Stern Review on the Economics of Climate Change (2007), a lively and ongoing debate discusses the proper way to evaluate climate change policies (Weitzman, 2007; Nordhaus, 2007; Dasgupta, 2008; Heal, 2009; etc...).

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Welfare analysis in the literature

Discounted expected utilitarianism

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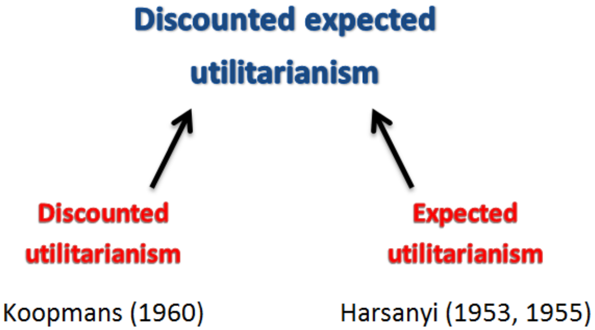
Koopmans (1960)

Welfare analysis in the literature



What discount rate?

- The main issue seems to be the discount rate:
  - "The discount rate measures how fast the value of goods diminishes with time [...]. Nordhaus discounts at roughly 6 percent a year; Stern discounts at 1.4 percent. The effect is that Stern gives a present value of $247 billion for having, say, a trillion dollars' worth of goods a century from now. Nordhaus values having those same goods in 2108 at just $ 2.5 billion today. Thus Stern attaches nearly 100 times as much value as Nordhaus to having any given level of costs and benefits 100 years from now" (Broome, 2008: 71)
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Drawbacks of *expected* utilitarianism

- DEU cannot disentangle aversion to intergenerational inequality from aversion to risk.
- DEU is over-sensitive to fat-tailed catastrophic risk. The "dismal theorem" by Weitzman (2009) shows that the planner might promote policies that transfer almost all resources to the generations facing such risks.
- The axiomatic foundation of EU is specific to a static model in which all uncertainty resolves in one-shot. Instead, risk resolves gradually, period after period, and later policies can be based on previously realized shocks.

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Methodology and results (1)

- I construct a model with risk and time.
- I introduce ethical considerations (axioms) that guide the planner in the evaluation of alternatives:
  - Pareto efficiency;
  - concern for intergenerational justice;
  - concern for risk;
  - and some technical conditions (continuity, separability, etc...).
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- I compare the FIU with DEU.
  - *advantages*:
    - it is based on compelling principles of justice;
    - it avoids the mentioned drawbacks of DEU.
  - *disadvantages*:
    - it is more complicated;
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2. The model.
3. DEU vs FIU: a comparison.
4. Axioms and characterization result.
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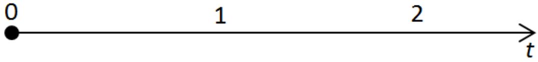

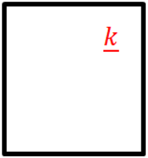

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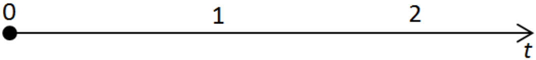

$$\boxed{y \leq F(\underline{k})}$$

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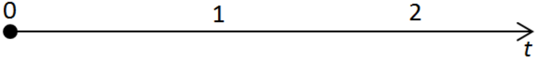

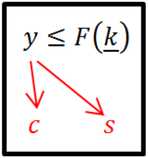

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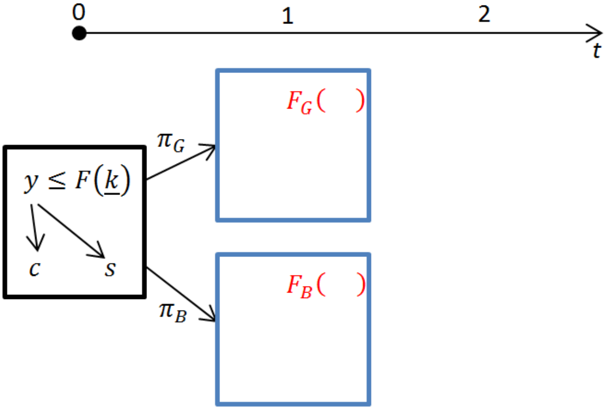

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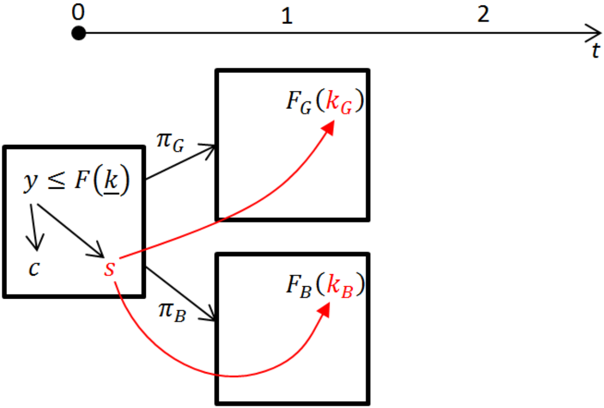

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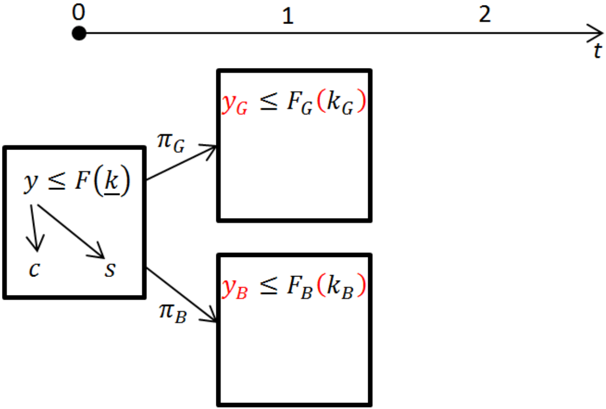

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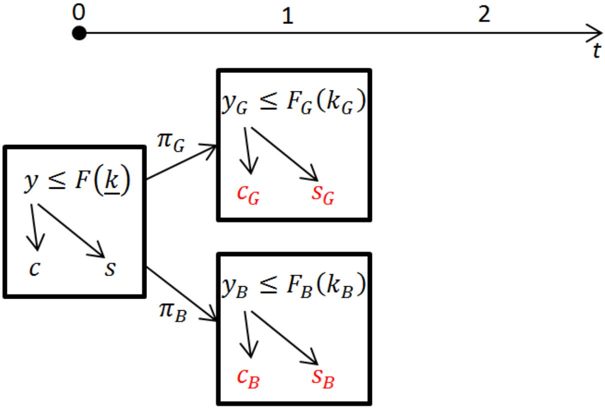
0
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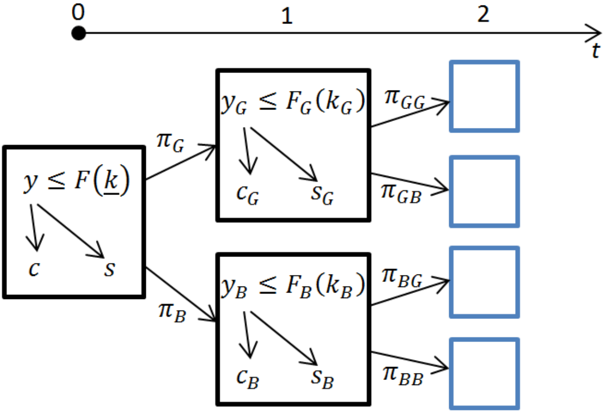
Period 2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A decision tree

$$D \equiv \left\langle \langle \pi_n, F_n \rangle_{n \in N}, \underline{k} \right\rangle$$

where:

- N is the event tree;
- $\underline{k}$ is the initial capital stock.

For each $t \in T$ and $n \in N_t$:

- $\pi_n \in (0, 1]$ is the probability that node n is reached at t;
- F_n is the production function that transforms input k_n into output $y_n \in \mathbb{R}_+$; F_n is continuous, strictly increasing, and satisfies no-free lunch;
- output y_n can be consumed, c_n, or saved s_n;
- s_n determines the capital stock of the immediate successor nodes: $k_{n'} = s_n$ for each $n' \in N_{+1}(n)$.

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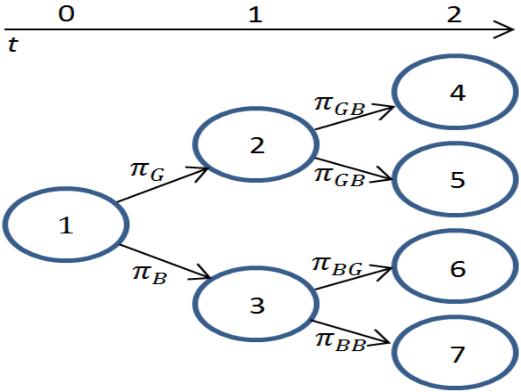
A risky intergenerational prospect



$$c \equiv (\{c_n\}_{n \in N}) \in C(D)$$

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Definitions

DEU **FIU**

$$V(c) = \sum_{t} \beta^{t} \; v_t(c_t)$$

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A methodological difference: the SOF approach

- For each $D \in \mathscr{D}$, a **social ordering** of D is a complete and transitive binary relation defined over the prospects $C(D)$.
- A **social ordering function** $\succsim$ assigns to each decision tree $D \in \mathscr{D}$ a social ordering of D denoted $\succsim_D$.
- Thus, $c \succsim_D c'$ means that the prospect c is at least as desirable as c' from a social viewpoint for decision tree D.
    - The symmetric and asymmetric counterparts of $\succsim_D$ are $\sim_D$ and $\succ_D$.
- $V(c; D)$ is a welfare representation of $\succsim_D$.

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Aversion to intergenerational inequality and risk

DEU

It depends on the concavity of u:
the larger the concavity, the larger are both the aversion to int. inequality and the aversion to risk.

FIU

Aversion to int. inequality depends on ρ;
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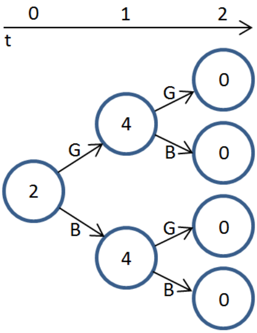
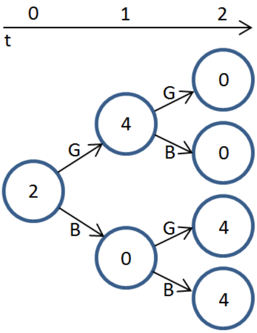
Allocation (a) or (b)?



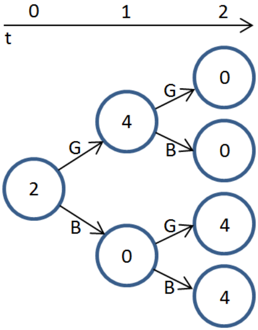
(a)



(b)

- Let $\beta = 1$. EU suggests (a) is as good as (b);
- in a famous critique, Diamond (1967) suggests (for one-shot lotteries) that (b) is better than (a): ex-ante egalitarianism.

Allocation (b) or (c)?



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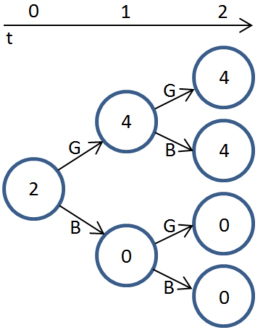
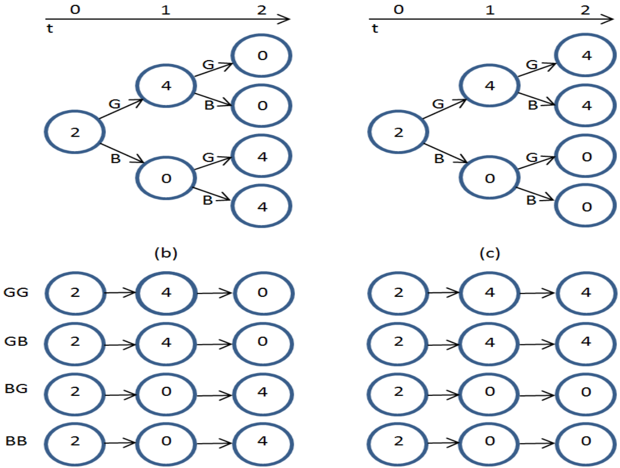


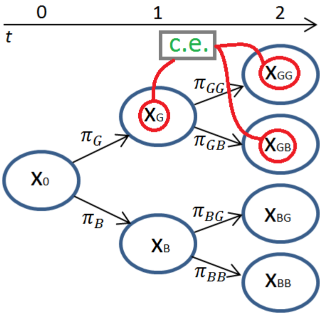
(c)

- EU and ex-ante egalitarianism suggest (b) is as good as (c);
- Broome (1991) suggests (for one-shot lotteries) (c) is more desirable than (b): ex-post egalitarianism.

Ex-post egalitarianism or "learning"?



Interim egalitarianism



Interim egalitarianism

Let $\mu : \mathbb{R}_+ \to \mathbb{R}_+$ be strictly increasing and concave. For each $D \in \mathscr{D}$, each $x \in \phi(E)$, and each $n \in N$:

$$x_n = \mu^{-1}\left(\frac{\sum_{n' \in N_{+1}(n)} \pi_{n'} \mu(x_{n'})}{\sum_{\bar{n} \in N_{+1}(n)} \pi_{\bar{n}}}\right)$$

The fair prospect

- The fair prospect $x \equiv \left(\{x_n\}_{n \in N}\right)$ is the unique prospect selected by the *fair rule* $\phi : \mathscr{D} \rightarrow 2^{C(\mathscr{D})}$.
- The fair rule ϕ satisfies:
  - *interim egalitarianism*; and
  - *Pareto optimality*.

The ethical role of the time disclosure of risk

- The DEU criterion is independent of the time disclosure of risk.
- The FIU criterion introduces a role for learning through the *fair prospect*.
- This leads to specific discounting formulas, which depend on
  - the time disclosure of risk,
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Discounting formulas

- Case 1. There is no technological risk. Then discounting is exponential: $\tilde{\beta}_t = \beta^t$. The FIU simplifies into:

$$V(c; D) = \sum_t \beta^t \frac{\left(\sum_{n \in N_t} \pi_n (c_n)^\gamma\right)^{\frac{1-\rho}{\gamma}}}{1-\rho}$$

- Case 2. The planner is indifferent to risk at x (μ is linear). Then discounting is exponential: $\tilde{\beta}_t = \beta^t \left(\frac{\sum_{\bar{n} \in N_t} \pi_n x_n}{x_0}\right) = \beta^t$.

- Case 3. Uncertainty resolves after one period. Then discounting is quasi-hyperbolic: $\tilde{\beta}_0 = \beta^0 \left(\frac{x_0}{x_0}\right) = 1$ for generation 0 and $\tilde{\beta}_t = \beta^t \theta$ for each $t \geq 1$.

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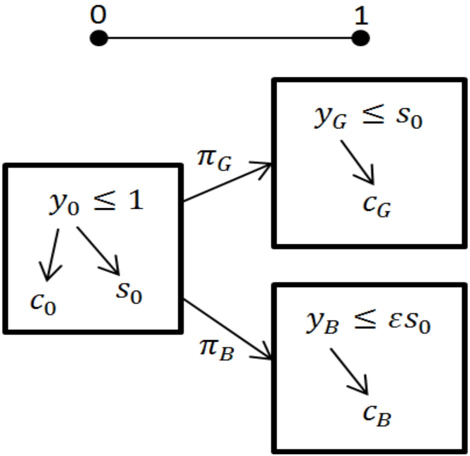
An example of catastrophic risk



Optimality conditions

DEU optimality

$$u'\left(c_0^*\right) = \beta\left[\pi_G u'\left(1-c_0^*\right) + \pi_B u'\left(\varepsilon\left(1-c_0^*\right)\right)\right]$$

DEU optimality with CRRA

$$\left(c_0^*\right)^{-\sigma} = \beta\left[\pi_G\left(1-c_0^*\right)^{-\sigma} + \pi_B\left(\varepsilon\left(1-c_0^*\right)\right)^{-\sigma}\right]$$

with $\sigma \geq 0$.

FIU opyimality

$$\left(\frac{c_0^*}{x_0}\right)^{-\rho} = \beta\left[\pi_G\left(\frac{1-c_0^*}{x_G}\right)^{\gamma-1} + \pi_B\left(\frac{\varepsilon(1-c_0^*)}{x_B}\right)^{\gamma-1}\right]\kappa$$

with $\rho \geq 0$ and $\gamma < 1$.

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Avoiding the dismal theorem

- When $\varepsilon \to 0$ and $\sigma > 0$, c_0^* tends to 0 and the expected utilitarian planner is willing to give away all consumption of generation 0.
- What about FIU? If the reference prospect x was independent of ε, the same result would arise (as $\varepsilon \to 0$, $\pi_B(\varepsilon(1-c_0^*))^{\gamma-1} \to \infty$).
- Whereas, the *fair prospect* x is such that $\mu(x_0) = \pi_G \mu(1-x_0) + \pi_B \mu(\varepsilon(1-x_0))$ and $x_B = \varepsilon x_G = \varepsilon(1-x_0)$.
- Therefore, $\lim_{\varepsilon \to 0} \pi_B \left(\frac{\varepsilon(1-c_0^*)}{\varepsilon(1-x_0^*)}\right)^{\gamma-1} = \pi_B \left(\frac{1-c_0^*}{1-x_0^*}\right)^{\gamma-1}$ is finite and $c_0^* > 0$.

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The intuition

- As ε decreases, the bad scenario becomes more and more catastrophic and it becomes more and more costly to improve the generation's outcome at that history.
- As a consequence, the legitimate claim to outcome is smaller.
- This smaller claim counterbalances the increased marginal benefit of small outcomes and avoids a dismal type of result.

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Outline of the talk

1. *Introduction, motivation, contribution.*
2. *The model.*
3. *DEU vs FIU: a comparison.*
4. Axioms and characterization result.
5. Discussion, literature, and conclusions.

AXIOM: Intergenerational equity

Intergenerational equity

For each $D \in \mathscr{D}$, for each pair $c, \bar{c} \in C(D)$, for each pair $t, t' \in T$ and each $\delta \in \mathbb{R}_+$ such that:

i) [donor] $c_n = \bar{c}_n - \frac{\delta}{\beta^t} \geq x_n$ for each $n \in N_t$;

ii) [recipient] $c_{n'} = \bar{c}_{n'} + \frac{\delta}{\beta^{t'}} \leq x_{n'}$ for each $n' \in N_{t'}$;

iii) [ceteris paribus] $c_{n''} = \bar{c}_{n''}$ for each $n'' \in N \setminus \{N_t \bigcup N_{t'}\}$,

then $c \succsim_D \bar{c}$.

AXIOM: Risk-reducing transfer

Risk-reducing transfer

For each $D \in \mathscr{D}$, for each pair $c, \bar{c} \in C(D)$, for each $t \in T$, each pair $n, n' \in N_t$, and each $\delta \in \mathbb{R}_+$ such that:

i) [donor] $c_n = \bar{c}_n - \frac{\delta}{\pi^n} \geq x_n$;

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Other axioms

Strong Pareto

For each $D \in \mathscr{D}$ and each pair $c, \bar{c} \in C(D)$, $c > \bar{c}$ implies $c \succ_D \bar{c}$.

Generalized utilitarianism

For each $D \in \mathscr{D}$, $\succsim_D$ can be represented by
$V(c; D) = \sum_{t \in T} v_t \left(\sum_{n \in N_t} u_n(c_n) \right)$, with v_t, u_n continuous functions.

Proportionality

For each $D, D' \in \mathscr{D}$, if x is proportional to x' then $\succsim_D = \succsim_{D'}$.

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The main result

Theorem

The following statements are equivalent:

1. *a SOF* $\succsim$ *satisfies:*
   - *intergenerational equity;*
   - *risk-reducing transfer;*
   - *strong Pareto;*
   - *generalized utilitarianism;*
   - *proportionality;*
2. *each* $\succsim_D$ *can be represented by the FIU criterion.*

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Intrinsic and Option risk (1)

- The FIU criterion introduce 2 different concerns for risk, based on the distinction between intrinsic and option risk.

- *Intrinsic* risk is unavoidable and depends on D: it is determined by
  - the magnitude of the technological shocks; and
  - the timing of their resolution.
  - The ethical concern for intrinsic risk is specified by the *fair prospect* (interim egalitarianism).

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Intrinsic and Option risk (2)

- *Option* risk is the risk that the planner incurs when deviating from the fair prospect:
  - in the attempt to obtain a higher social welfare, the planner may choose to deviate from the fair prospect;
  - (redistributing across generations introduces intergenerational inequality)
  - redistributing across histories introduces *option* risk.
  - The ethical concern for option risk is specified by the CES parameter γ.

Related literature (1)

- *Welfare of risk*.
    - static settings: Harsanyi (1953, 1955); Diamond (1967); Epstein and Segal (1992); Grant et al. (2010); Fleurbaey (2010);...
    - dynamic settings: Traeger (2012); Asheim and Zuber (2013); Fleurbaey and Zuber (2013, 2014);
    - fat tail events: Weitzman (2009, 2011); Nordhaus (2011); Millner (2013); ...
    - event-tree structure: Hammond (1988, 2013).
- *Reference-based choice with risk*. Kahneman and Tversky (1979); Sugden (2003); Kòszegi and Rabin (2006).

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Related literature (2)

- *Discounting*.
    - social discounting: Dasgupta (2008); Nordhaus (2007); Stern (2007, 2008); Weitzmann (1998, 2007); ,...
    - quasi-hyperbolic discounting: Laibson (1997); Dasgupta and Masking (2005); Gerlach&Liski (2013);...
    - discounting with risk: Dasgupta and Heal (1974, 1979); Bommier and Zuber (2008); Llavador et al. (2010); Fleurbaey and Zuber (2012).
- *Preference for early resolution of risk*. Kreps and Porteus (1978); Epstein and Zin (1989).

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Summary

- I study intergenerational decision making in settings with risk and learning;
- I propose a set of axioms that separately introduce the ethical concern for:
  - intergenerational equity;
  - aversion to intrinsic risk (at the fair prospect);
  - aversion to option risk (deviations from the fair prospect);
- I characterize the family of FIU criteria and show that it overcomes some serious drawbacks of discounted expected utilitarianism.

Summary

Thank you!