

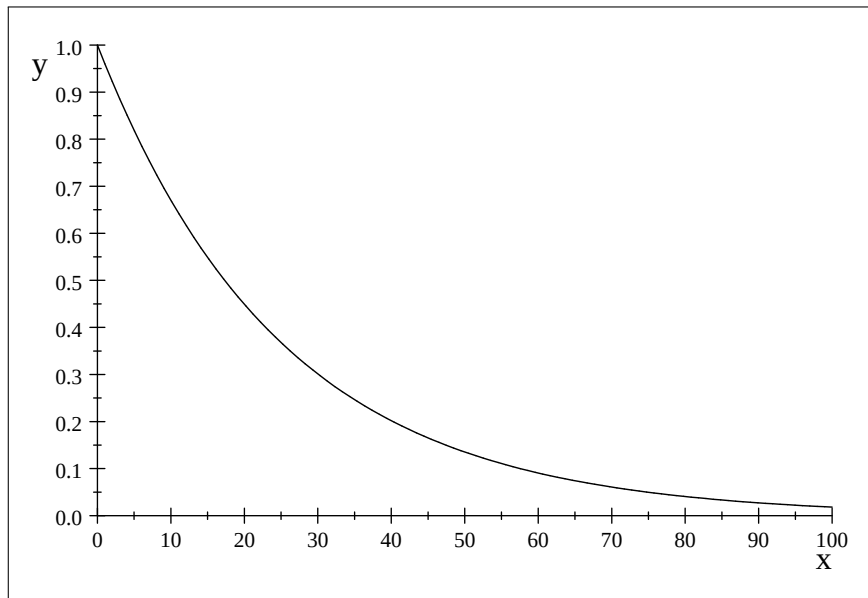
Dynamic Games in Environmental Economics: **Discounting and Politics**

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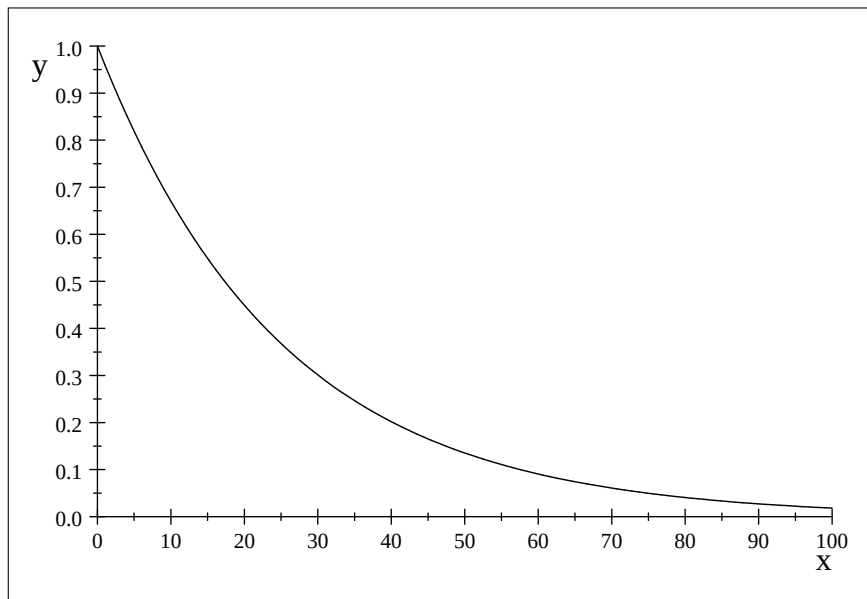
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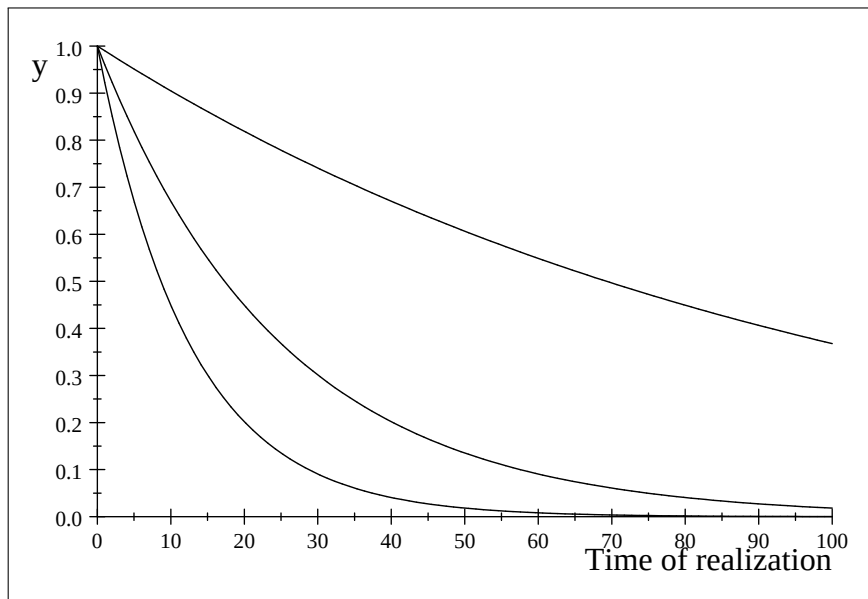
A Measure



Present-discounted value with 4 % discount rate



Present-discounted value with 1, 4, 8 % discount rate

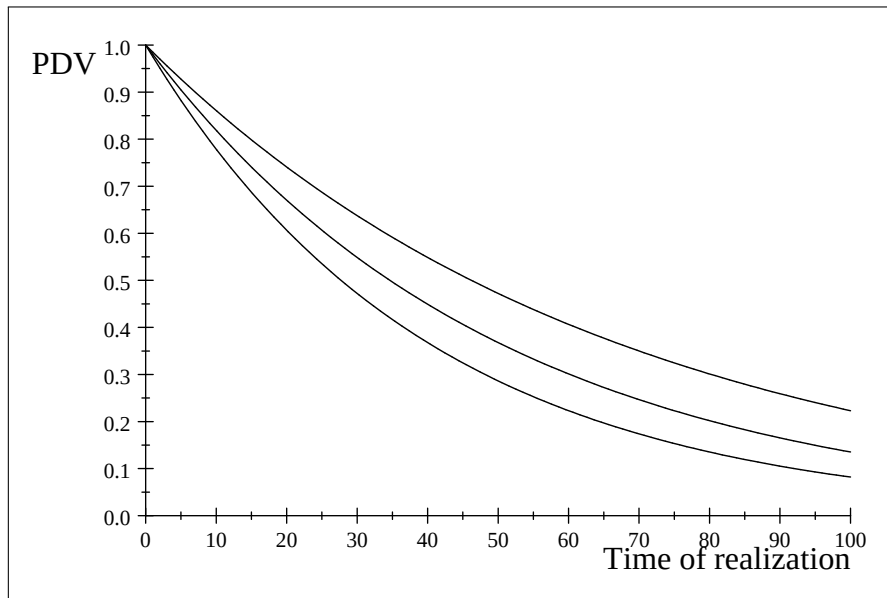


The Value of a future dollar (in cents today)

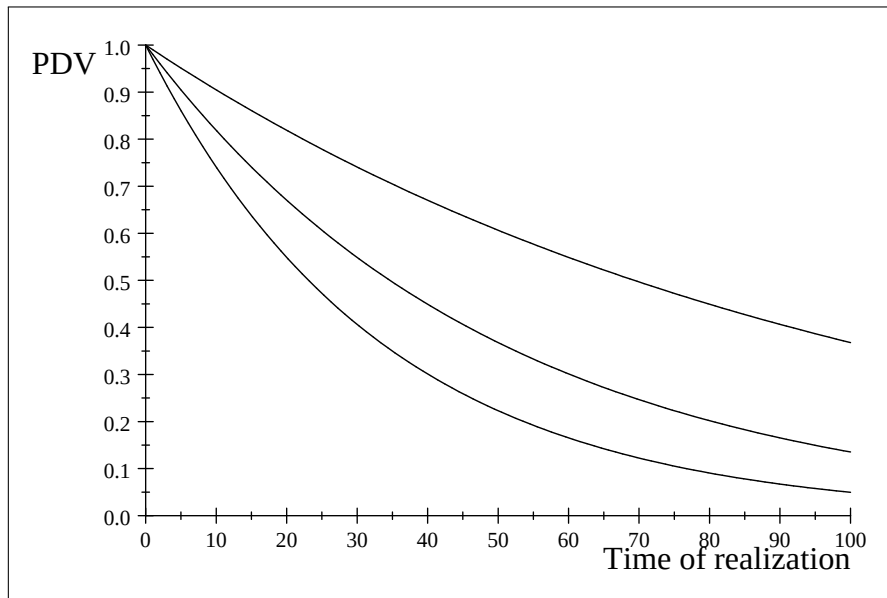
interest rate \ years:	50	100	200
$r = 1\%$	60	37	13
$r = 4\%$	13	1,8	0,03
$r = 8\%$	1,8	0,03	0,00001

Stern-review vs Nordhaus: debate on interest rate.

Present-discounted value with 1.5, 2, 2.5 % discount rate



Present-discounted value with 1, 2, 3 % discount rate



A Brief History on Discounting

- Rae, Jevons, Senior, Bohm-Bawerk: **Multiple** psychological factors
- Ramsey (1928):

$$\max v_0 = \sum_{t=0}^{\infty} D(t) u_t.$$

- Samuelson (1937):

$$D(t) = \delta^t = \left(\frac{1}{1+\rho} \right)^t \approx e^{-\rho t}.$$

- Koopman (1960): **axiomatic foundation**
- "the simplicity and elegance of this formulation was irresistible" and the criterion became "dominant... largely due to its simplicity... not as a result of empirical research demonstrating its validity" (Frederick et al, '02: 355-6;352-3)

- ① Continuity
 - ② Sensitivity
 - ③ Non-Complementarity
 - ④ Stationarity
 - ⑤ Boundedness
- Koopmans (1960): With 1-5, $v_0 = \sum_{t=0}^{\infty} \delta^t u_t$.

Normative or Political Justifications?

- Samuelson careful: "It is completely arbitrary to assume that the individual behaves so as to maximize an integral of [this] form". And: "any connection between utility as discussed here and any welfare concept is disavowed" (Samuelson '37: 159;161)
- Ramsey (1928): "how much of its income should a nation save? ...it is assumed that we do not discount later enjoyments in comparison with earlier ones, a practice which is **ethically indefensible and arises merely from the weakness of the imagination**".
- But individuals *do* discount
 - Politicians are individuals - they *do* discount
 - Politicians are accountable/elected by individuals: they *must* and *will* discount
- But how?

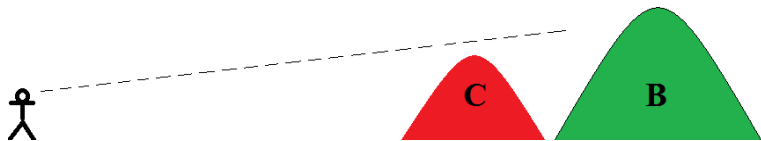
Critique of Exponential Discounting

- **Empirically:** Eisenhauer and Ventura (2006), Frederick et al (2002), Angeletos et al (2001), Fang and Silverman (2004), Shui and Ausubel (2004), Attanasio and Weber (1995), Attanasio et al (1999), DellaVigna (2009)
 - Paserman (2004): **short**-run discount rate that range from 11% to 91% and a **long**-run discount rate of only 0.1%.
 - Laibson et al (2007): "short-term discount rate is 15% and the long-term discount rate is 3.8%."
 - O'Donoghue and Rabin (1999): "hyperbolic individuals will show exactly the low **IRA participation** we observe."
- **Experimentally:** Viscusi and Huber (2006), Kirby and Marakovic (1995), Benhabib, Bisin and Scholter (2010), Ainslie (1992), Kirby and Herrnstein (1995), Thaler (1981)).
- **Intergenerationally:** "Thoughtful parents" lead to discounting (Arrow/Barro). But if care about grandchildren's welfare, nonstationarity (Harstad '99, Saez-Marti and Weibull '05)
- **Intuitively:** The difference between t and $t + 1$ vanishes as t grows

Pay C to later get B?



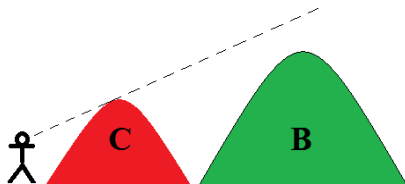
Pay C to later get B?



Pay C to later get B?



Pay C to later get B?



Realistic Time Preferences

- When time is relative, **hyberbolic discounting**:

$$\delta_t = 1 - \frac{\alpha}{1 + \alpha t}, \alpha > 0.$$

- "the collective evidence outlined above seems overwhelmingly to support hyperbolic discounting" (Frederick et al, '02:361)
- Intuitively, δ_t increases (strictly) in t
- **Quasi-hyperbolic discounting**:

$$\delta_1 = \beta\delta < \delta = \delta_t \quad \forall t > 1.$$

- Phelps and Pollak (1968): "Imperfect altruism" between generations. David Laibson adopts this function to within-lifetime choices.
- Alternative names: (β, δ) -discounting, quasi-geometric discounting, quasi-exponential discounting, hyperbolic discounting, present bias.

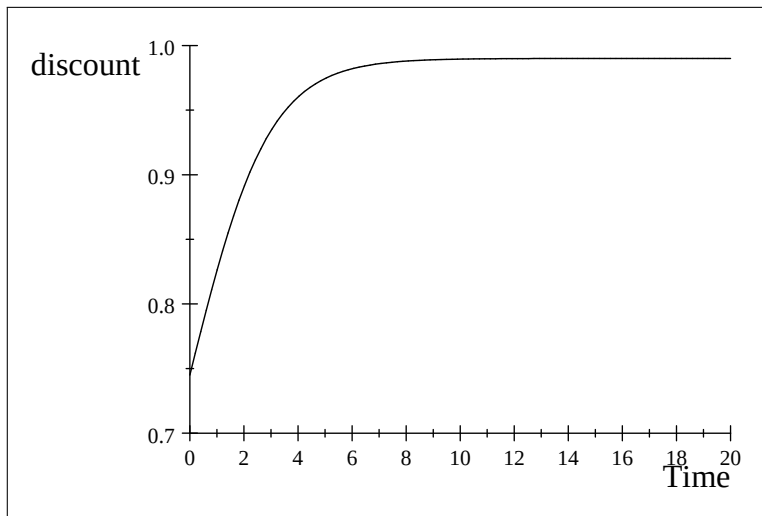
Uncertainty/Disagreement about the discount factor

- Suppose $\delta = \underline{\delta}$ or $\delta = \bar{\delta}$ with equal chance. We may disagree, or be uncertain.
- Then, the weight at time $t + 1$, relative to t , is:

$$\frac{\frac{1}{2}\underline{\delta}^{t+1} + \frac{1}{2}\bar{\delta}^{t+1}}{\frac{1}{2}\underline{\delta}^t + \frac{1}{2}\bar{\delta}^t} = \frac{\underline{\delta}}{1 + (\bar{\delta}/\underline{\delta})^t} + \frac{\bar{\delta}}{(\underline{\delta}/\bar{\delta})^t + 1}$$

- When $t \rightarrow \infty$, this approaches $\bar{\delta}$.

Uncertainty/Disagreement about the discount factor



Optimal applied discount factor if $\underline{\delta} = 0.5$ and $\bar{\delta} = 0.99$.

Discounting in Politics

- Even if everyone were endowed with time-consistent preferences, policy makers are still likely to be time inconsistent for political reasons.
- Suppose the party or policymaker in office today expects to remain in office with probability q in the next period.
- In a simple symmetric setting with two parties, the party outside office gains power with probability $1 - q$.
- If p_t measures the probability that the party is in power in period t , then p_t follows the Markov process

$$p_t = qp_{t-1} + (1 - q)(1 - p_{t-1}),$$

- which is a difference equation with the following solution:

$$p_t = (2q - 1)^t (p_0 - 1/2) + 1/2, \quad (1)$$

where $p_0 = 1$ for the incumbent at time 0.

Discounting in Politics

- One of the benefits of being in power is that one can allocate the budget to some pet projects, giving the policymaker a marginal benefit normalized to 1.
- Suppose the policymaker at time $t - 1$ can forgo some of this benefit by doing something good that pays off in period t .
- The fraction $z \in [0, 1/2]$ measures the benefit to the party not in office, while the remaining fraction $1 - z$ benefits the party then in office.
- The policymaker's expected PDV of the return is $\delta^t [(1 - z) p_t + z (1 - p_t)]$.
- The expected PDV of perks at $t - 1$ is $\delta^{t-1} p_{t-1}$.
- Thus, the policymaker at $t = 0$ benefits from the investment at time $t - 1$ if and only if the investment cost (per unit of return) is smaller than

$$\delta_t \equiv \delta \frac{(1 - z) p_t + z (1 - p_t)}{p_{t-1}}. \quad (2)$$

Discounting in Politics

- In other words, for any pair $(t - 1, t)$, δ_t measures how the policymaker at $t = 0$ discounts returns realized at t relative to the cost at $t - 1$. If we combine (1) and (2), we learn how the discount factor δ_t depends on t .
- FINDING 1. If $q \in (1/2, 1)$, the PM's discount factor δ_t is a strictly increasing concave function of t .

$$\delta_t = \delta \left[1 - \frac{1 - q + z(2q - 1)}{\left[1 + (2q - 1)^{1-t} \right] / 2} \right] \Rightarrow \frac{\partial \delta_t}{\partial t} > 0 > \frac{\partial \delta_t}{\partial z} \text{ and } \frac{\partial^2 \delta_t}{\partial z \partial t} > 0. \quad (3)$$

- COROLLARIES TO FINDING 1.
- (1) If $q \uparrow 1$, then the discount factor is constant and equal to $\delta_t = \delta(1 - z) \forall t$.
- (2) The change in δ_t is especially large if the externality z is large.
- (3) If $q \downarrow 1/2$, then $\delta_1 = \delta/2$ but $\delta_t = \delta$ for $t > 1$, so discounting is quasi-hyperbolic.

Discounting in Politics

Discount factor	$q = 3/5$		$q = 4/5$	
	$z = 0$	$z = 1/2$	$z = 0$	$z = 1/2$
δ_1	0,57	0,48	0,76	0,48
δ_2	0,82	0,79	0,81	0,59
δ_3	0,92	0,91	0,85	0,70
δ_4	0,94	0,94	0,88	0,78
δ_5	0,95	0,95	0,91	0,84

Problem: Time Inconsistency

Costly today? Better to postpone until tomorrow!

- People save too little (subsidize saving: Krusell et al 2010)
- Retire too early (Diamond and Koszegi 2003)
- Eat too much $\Rightarrow$ obesity (Scharff 2009)
- Smoke too much (Gruber and Koszegi 2001, 2004)
- Governments pollute too much; conserves too little

Solution: Commitment

With time inconsistency, **pre-commitment** is beneficial:

- Saving plans (costly to exit). Thaler and Benartzi's (2004) "Save More Tomorrow" program (SMarT)
- Invest in housing (Laibson 1997)
- Annual gym-membership (DellaVigna and Malmendier 2006) or appointments with friends
- Debt ceilings for governments; spending rule in Norway

Questions for Us

- What if governments cannot commit to rules?
- How can today's government encourage later governments to abate?
- To which extent can strategic investments in **technologies** help?

A Single Country

- Three periods, two decisions, no technology, and $G_{t+1} = q_G G_t + g_{i,t}$.
- In the second period:

$$B'(g_2) = \beta \delta C'(G_3)$$

- By differentiating,

$$\begin{aligned} B'' dg_2 &= \beta \delta C''(G_{t+1}) (q_G dg_1 + dg_2) \Leftrightarrow \\ \frac{dg_2}{dg_1} &= -\frac{\beta \delta q_G C''}{\beta \delta C'' - B''} < 0. \end{aligned}$$

- In the first period, the government sets g_1 to maximize:

$$B(g_1) - \beta \delta C(G_2) + \beta \delta B(g_2) - \beta \delta^2 C(G_3) \Rightarrow$$

- Government 1 emits a low to encourage its next government to emit less:

$$B'(g_1) = \beta \delta C'(G_2) - \beta \delta^2 (1 - \beta) C'(G_3) \left(-\frac{dg_2}{dg_1} \right).$$

A Single Country

- Many periods, linear climate change harm, and technology:

$$\frac{\partial B(g_{i,t}, R_{i,t})}{\partial g_{i,t}} = \beta \delta \frac{c}{1 - q_G \delta}.$$

- By differentiation:

$$\frac{dg_i}{dR_i} = -\frac{B_{gR}}{B_{gg}}.$$

- So, optimal investments become:

$$\begin{aligned} k'(r_{i,t}) &= \beta \delta \frac{\partial B(g_{i,t+1}, R_{i,t+1})}{\partial r_{i,t}} + \beta \delta \left[\frac{\partial B(g_{i,t+1}, R_{i,t+1})}{\partial g_{i,t+1}} - \frac{\delta}{1 - q_G \delta} c \right] \\ &= \beta \delta \frac{\partial B}{\partial r_i} + \beta \delta (1 - \beta) \frac{\delta}{1 - q_G \delta} c \frac{B_{gR}}{B_{gg}}. \end{aligned}$$

- Invest more in green, and less in brown technology, if $\beta < 1$.
- If we subsidize future revenues for private investors,

$$k'(r_i) = (1 + s) \beta \delta \frac{\partial B}{\partial r_i}.$$

Multiple Countries

- Suppose:

$$R_{i,t+1} = r_{i,t} + e \sum_{j \in N \setminus i} r_{j,t} \text{ and } G_{i,t+1} = q_G G_{i,t} + g_{i,t} + \epsilon \sum_{j \in N \setminus i} g_{j,t}.$$

- Now, a government may also invest to induce neighbors to abate.
The foc for $r_{i,t}$ becomes

$$k'(r_i) = \beta \delta \frac{\partial B}{\partial r_i} + \beta \delta [1 + (n-1) e \epsilon - \beta] \frac{\delta}{1 - \delta} c.$$

- Private investors:

$$k'(r_i) = (1 + s) \beta \delta \frac{\partial B}{\partial r_i}.$$

- The two are equal if

$$s = \frac{1 + (n-1) e \epsilon}{\beta} - 1.$$

- Note: $\beta < 0$ justifies subsidies similarly as do cross-country technological spillovers.

Multiple Countries

100s		(1)	(3)	(4)
		$e = \epsilon = 0$	$e = \epsilon = 0.5$	$e = 1, \epsilon = 1$
(A)	$\beta = 0.6$	67	108	400
(B)	$\beta = 0.8$	25	56	275
(C)	$\beta = 1$	0	25	200

The table reports on the subsidies in percentages (100s) when $n = 2$.

Participate or free ride?

- Suppose the government can decide now whether the future government will participate in the treaty.
- Since the current government thinks that the next government emits too much, it might be tempting to sign.
- Suppose, first, that there is no technology. With the same logic as in Lecture 3, one is now willing to participate even if m is as large as:

$$m = 2 + \sqrt{1 + \frac{1 - \beta^2}{\epsilon^2}}.$$

- So, if $\beta = 1$, $m = 3$, as before.
- if $\beta < 1$, $m > 3$, especially if ϵ is small.
- Intuition?

Extensions

- Green/brown/adaptation technology
- Chain of technologies (R&D vs. installation/capacity)
- Heterogeneity
- Parameters that change over time (stochastically)
- Incomplete information and learning.
- International trade
- Trade in permits
- Trade in fossil fuel
- The supply side

Summary - This Lecture

- Individuals, and especially policymakers, do have time-inconsistent preferences
- Technology can facilitate self-commitment
- Even in the absence of traditional market failures: Subsidize investments in **green** (complementing) technologies.
- This effect can be of similar importance to cross-country externalities, and the two strengthen each other.
- Time inconsistency can motivate more countries to participate (so this effect can rationalize larger coalitions).

Summary

- The dynamic common-pool problem is especially inefficient.
- Nevertheless, some (short-term) agreements can be even worse.
- We have studied the interaction between emission, quotas, tech investments, participation, compliance, time (in)consistency, and terms of the agreement.

Summary - Predictions

- A country that has invested more in green tech may end up with smaller emission allowances (e.g.: Denmark).
- Countries may not invest enough (especially without a large/long-lasting agreement)
- The countries will benefit from, and thus attempt to negotiate, a more long-lasting agreement.
- The duration will be longer if the coalition is large.
- This effect can motivate more countries to participate.
 - Countries may also participate more in a less ambitious treaty (like Paris).
 - This benefit is especially important when developing countries have become emerging economies. 'Thus, while Kyoto might have been best in the 1990s, Paris might be better now.
- Countries may also participate to "tie the hands" of future governments.
- A focus on transparency is important.
- But challenges remain with compliance, credibility, and time

Summary - Normative

- Agreements can be important also to solve domestic time-inconsistency problems
- Emission caps should be smaller if the agreement is short-lasting and technological spillovers are large (e.g., if IPR protection is weak).
- The duration should be longer if the spillovers are large and uncertainty less.
- Thus, treaties on IPR and climate are "strategic substitutes": One is more important in the absence of the other.
- Countries may need to invest more in "green" technology to make compliance, and future abatements, credible and time consistent.
 - Equivalently, they may need to invest less in "brown" technology.
 - Adaptation (/geoengineering) might be important for individual countries, but it is not a "public good" and it can even reduce the incentive to abate, participate, and comply.

Why not implemented already? Politics?

- Rotation in power: Each government hopes that the next will pay for the transition?
- Multiple PMs: The proposer ends up bearing the largest cost? (Alesina and Drazen, 1991).
- Strategic election: Strategic delegation? (Thomas Schelling)
- Endogenous election: While a binding treaty ties the hands of the next government, it also makes the two parties similar from the voters' point of view. A "weak" treaty, which the opponent may walk away from, can make the incumbent more attractive to voters.
- Legislative bargaining: When there are multiple "veto players", there is a status quo bias.
- Anticipating the future status quo bias, the "right wing" may be careful before accepting regulation today: Gridlock.
- Lobbying: Existing industries ("vested interests") have stronger incentives to lobby than do "potential" investors in new/green.
- Activism and psychology....

What's Next? Future Research

- There is a tension between our desire to make normative recommendations, and the need to make the predictions positive.
- If political economics can rationalize why the best policy is not (yet) implemented, the next question is: What (political) institutions can align the political equilibrium with a desirable outcome?
- But why, then, are not these "good" institutions already in place?
- The tension normative-positive never ends
- ...but it is fruitful and it can motivate a lot of new great research!