TAXES, TARGETS, AND THE SOCIAL COST OF CARBON

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  - And then countries (smaller aggregations) bargain over their own emission reductions.
  - Like textbook examples of Coase Theorem, country negotiations can involve monetary payoffs from rich countries to poor (and to those most vulnerable to climate change).
- But is bargaining over country-by-country emission reductions the best we can do? Would agreeing a carbon tax be better?

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- No consensus answers, so climate negotiations (including Paris in December 2015) have had limited success.
- Approach to pollution externalities generally preferred by economists: Estimate social (external) cost of pollutant and impose a corresponding tax. In this case, estimate the SCC.

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  - Can be flexible. Need not prevent monetary transfers or other forms of side payments.

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- To understand shift to a temperature target, must ask why we cannot agree on SCC.

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  - "The fundamental point about radical uncertainty is that if we don't know what the future might hold, we don't know, and there is no point pretending otherwise." M. King, 2016.
- Yet we have a proliferation of IAMs, which have become the standard tool for estimating the SCC. But as I have argued elsewhere, IAMs unsuitable for policy analysis.

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- But if we don't use IAMs to estimate SCC, what to do instead?
- Proposal: Estimate an *average* SCC using expert elicitation.

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  - Lends itself to expert elicitation.

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- Note focus on extreme outcomes.

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- Might claim I use a model, but model has very few moving parts, and is much more transparent than IAM-based analysis.

Opinion of Hypothetical Expert: BAU Outcomes

HORIZON $T = 50$

% GDP Reduction, z	0	0.020	0.050	0.100	0.200	0.500
$\phi = -\ln(1-z)$	0	0.020	0.051	0.105	0.223	0.693
Prob	.25	.50	.10	.06	.05	.04
$1 - F(\phi)$	1	.75	.25	.15	.09	.04

HORIZON $T = 150$

% GDP Reduction, z	0	0.020	0.050	0.100	0.200	0.500
$\phi = -\ln(1-z)$	0	0.020	0.051	0.105	0.223	0.693
Prob	0	.22	.40	.20	.10	.08
$1 - F(\phi)$	1	1	.78	.38	.18	.08

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- Expect the impact to begin before and continue and after T:

$$\phi_t = \phi_m[1 - e^{-\beta t}] \tag{1}$$

So ϕ_t starts at 0 and approaches maximum ϕ_m at rate given by β. Want to calibrate ϕ_m and β.

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- To get β, use average ϕ_t at T_1 and $T_2 > T_1$: $\bar{\phi}_1$ and $\bar{\phi}_2$. Using $\bar{\phi}_1$ and $\bar{\phi}_2$ from table:

$$[1 - e^{-\beta T_2}]/[1 - e^{-\beta T_1}] = \bar{\phi}_2/\bar{\phi}_1 = 2.06 \tag{2}$$

Solution to eqn. (2) is roughly $\beta = .01$.

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- Given β, distribution for ϕ_m follows from distribution for ϕ_1, which comes from range of expert opinions (for $T_1 = 50$):

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- SCC $= B_0/\Delta E$ (in dollars/ton).
- So need to estimate B_0 and ΔE.

Benefit of Abatement, B_0

- Instantaneous percentage benefit from truncating distribution is $\mathbb{E}_0(\tilde{z}_1) - \mathbb{E}_1(\tilde{z}_1)$, where $\mathbb{E}_0$ is expectation under full distribution, and $\mathbb{E}_1$ is expectation under truncated distribution:

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\begin{aligned}
B_0 &= [\mathbb{E}_0(\tilde{z}_m) - \mathbb{E}_1(\tilde{z}_m)]\, Y_0 \int_0^\infty [1 - e^{-\beta t}] e^{(g-R)t} dt \\
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- Here $\beta Y_0[\mathbb{E}_0(z_1) - \mathbb{E}_1(z_1)]/(1 - e^{-\beta T_1})$ is the instantaneous flow of benefits from truncating the distribution, and dividing by $(R-g)(R+\beta-g)$ yields present value of this flow.

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- Assume real cost per ton abated is constant, so discount future emission reductions at same rate R. (Need $R > m_0$.) So

$$\Delta E = E_0 \int_0^{\infty} \left[e^{(m_0 - R)t} - e^{(m_1 - R)t} \right] dt = \frac{(m_0 - m_1)E_0}{(R - m_0)(R - m_1)} \tag{4}$$

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  - Then implied SCC $= B_0/\Delta E = \$81$ per metric ton.

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- Average SCC declines as R is increased, but much less sharply than marginal SCC.

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Web of Science Search Terms

Single Search Terms	Joint Search Terms	
(A)	(B)	(C)
"climate change policy"	"ocean temperature"	"climate change"
"social cost of carbon"	"precipitation	"climate-change"
"climate policy"	"sea level rise"	"greenhouse gas"
"climate-change policy"	"sea level change"	"greenhouse gases"
"climate forcing"	"ocean acidity"	GHG
"radiative forcing"	catastrophe	(CO_2 AND emissions)
"climate feedbacks"	catastrophic	("carbon dioxide" AND emissions)
" climate sensitivity"	economy	
"equilibrium climate response"	economics	
"global mean surface temperature"	damages	
"carbon price"	mortality	
"carbon-price"	productivity	
"price of carbon"	risk	
"carbon tax"	"discount rate"	
"tax on carbon"	"atmospheric concentration"	
("cap-and-trade" AND carbon)	GDP	
(carbon AND quota)	"gross domestic product"	
(carbon AND trade AND cap)		

Note: Quotation marks mean phrase must appear exactly as written. Search results must include at least one term in column A *or* at least one term from *each of* columns B and C.

Publications and Authors by WOS Research Area

Research Area	(A) No. Pubs, Top 10% of Cites	(B) Distinct Authors	(C) No. Authors per Pub.	(D) No. Authors, **2.50** per Pub.	(E) % of Highly Cited Pubs.	(F) % of Authors
Agriculture	282	1506	5.34	705.6	7.3%	7.3%
Business and Economics	257	643	**2.50**	643.0	6.7%	6.7%
Environmental Sciences and Ecology	1873	8932	4.77	4686.1	48.6%	48.6%
Geology	629	3787	6.02	1573.7	16.3%	16.3%
Meteorology and Atmospheric Sciences	815	4919	6.04	2039.1	21.1%	21.1%
Total	3856	19,787	4.93	9647.5	100%	100%

Note: In (D), (E), (F), % of authors matched to % of highly cited publications in each area.

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- **Q3**: Under BAU, what is the probability that 50 years from now, climate change will cause a reduction in world GDP of *at least 2%*? At least 5%? At least 10%? At least 20%? At least 50%?

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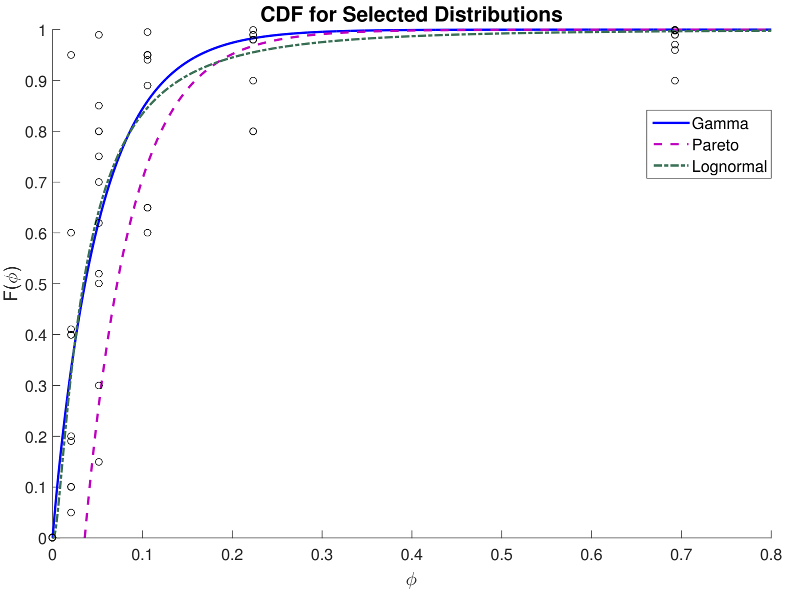
- Figure shows least-squares fit of gamma, generalized Pareto, and lognormal cumulative distribution functions to the 11 responses to Question 3.

Responses from 11 Experts

Expert	Q1 (m_0)	Q2 ($\bar{z}_1$)	Q3 $\geq 2\%$	Q3 $\geq 5\%$	Q3 $\geq 10\%$	Q3 $\geq 20\%$	Q3 $\geq 50\%$	Q4 ($\bar{z}_2$)	Q5 (m_1)	Q6 (R)
1	.02	.04	.60	.20	.05	.01	.001	.10	0.00	.025
2	.03	.06	.59	.48	.35	.20	.04	.33	−.03	.0225
3	.02	.08	.90	.50	.05	.01	.00001	.33	−.04	.031
4	.02	.05	.80	.30	.05	.02	0.0	.15	0.00	.010
5	.02	.03	.95	.25	.06	.02	.002	.15	0.00	.025
6	.01	.04	.81	.38	.11	.02	0.0	.18	−.01	.0229
7	.02	.09	.90	.85	.35	.20	.10	.65	0.00	.020
8	.01	.02	.40	.15	.05	.02	.01	.10	.01	.020
9	.02	.06	.90	.70	.40	.10	.03	.15	0.00	.025
10	.01	.01	.05	.01	.005	.0005	.00001	.05	−.01	.020
11	.02	.04	.60	.20	.05	.02	.01	.08	−.01	.040
Avg.	.020	.047	.682	.365	.139	.056	.018	.21	−.010	.0238

Three Cumulative Distributions Fit to Responses from 11 Experts



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- Next step: elicit opinions of several thousand experts.

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- Survey is now being implemented. Stand by for results.