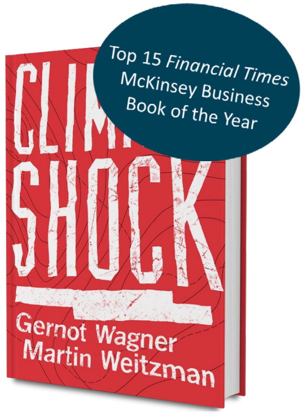
Applying Asset Pricing Theory to Calibrate the Price of Climate Risk



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$40

12 agencies

3 models

Cass Sunstein

~$40 Social Cost of CO_2

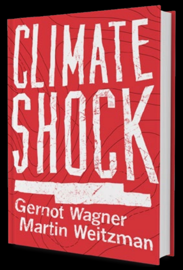
Based on 3% constant discount rate, and an average of 3 climate-economy models, including DICE

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

~$40 Obama White House SC-$CO_2$
> 10x official Trump figure

Source: "Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866" (November 1, 2013; updated 2016).

>>$40, two ways:



Tail risk

"Proper" preference calibration

NBER WORKING PAPER SERIES

APPLYING ASSET PRICING THEORY TO CALIBRATE THE PRICE OF CLIMATE RISK

Kent D. Daniel
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Working Paper 22795
http://www.nber.org/papers/w22795

Four novel conclusions:

1. Increased risk aversion *increases* the optimal CO_2 price

   in contrast to most standard models employing power utility functions, where increased risk aversion implies a higher discount rate implies a lower optimal CO_2 price

2. Optimal CO_2 price *declines* over time

   in contrast to most standard models with the exception of Ulph & Ulph (1994) [producer behavior], Acemoglu et al (2012) [shift from “dirty” to “clean”], Lemoine & Rudik (2017) [inertia]

3. Increased risk aversion increases risk premium relative to expected damages

   in contrast to standard models due to their use of power utility functions and (typically) lack of possibility for ‘catastrophic’ damages

4. Enormous social costs of delay

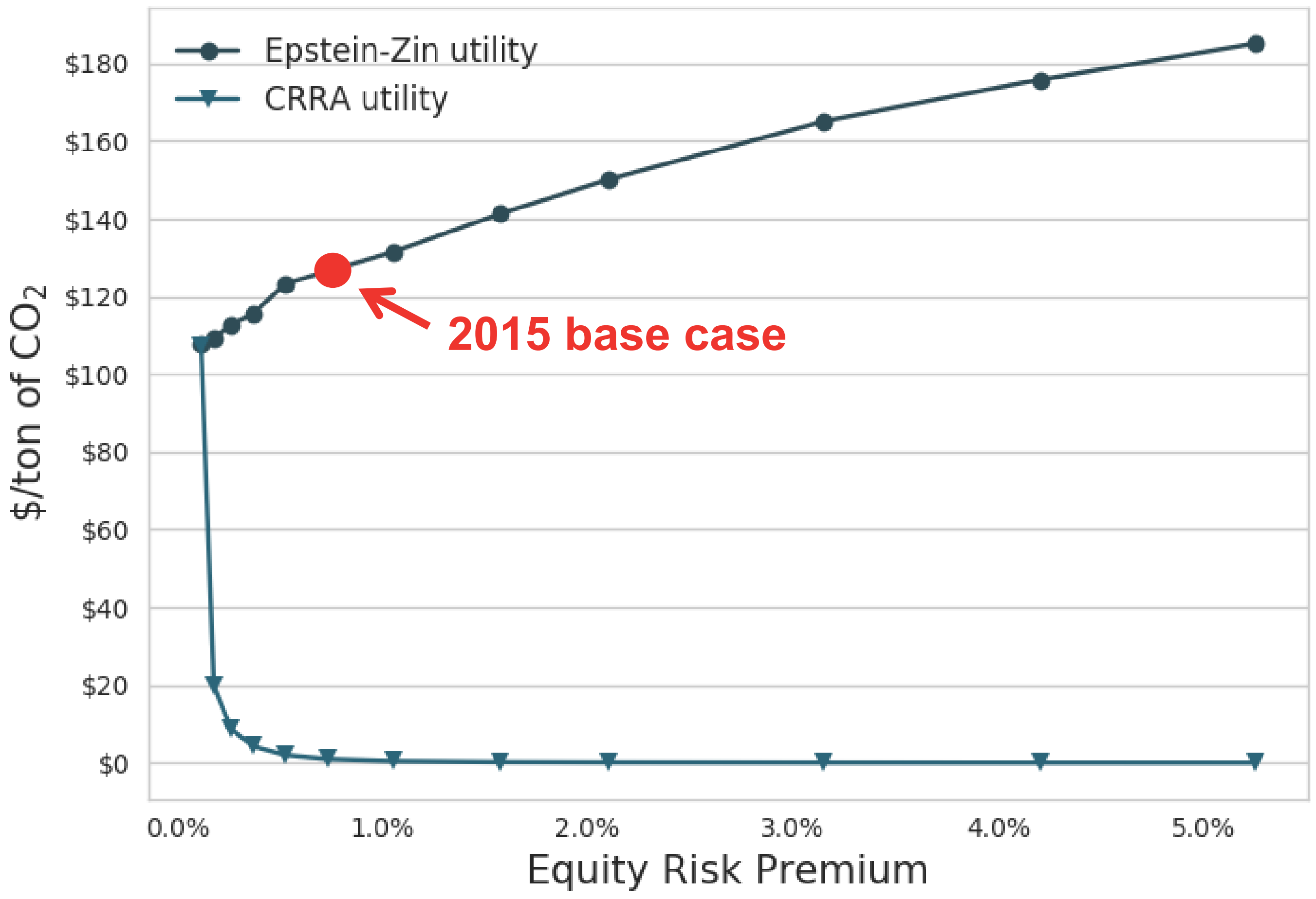
   in contrast to most standard models, which often estimate cost of delay based on (rising) ‘optimal’ CO_2 price over time in any given year (e.g. Nordhaus 2017, Changes in the DICE model, 1992 – 2017)

Source: Daniel, Litterman & Wagner (NBER October 2018), gwagner.com/ezclimate

Standard utility specifications misrepresent (climate) risk

1

Constant Relative Risk Aversion (CRRA) utility conflates risk across time and across states of nature



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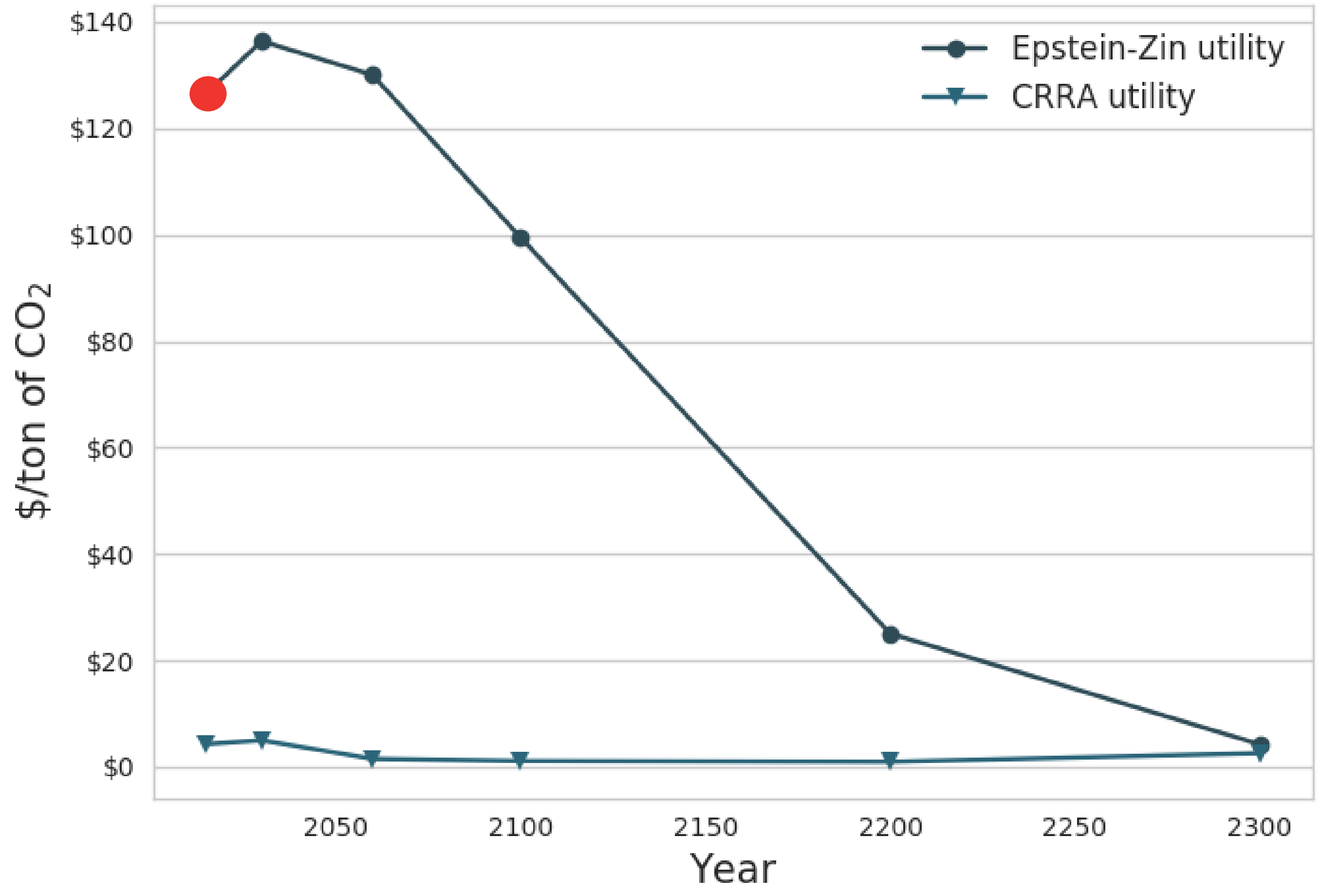
2 Optimal CO_2 price declines over time

Optimal price starts $>100, declines as uncertainties clear up



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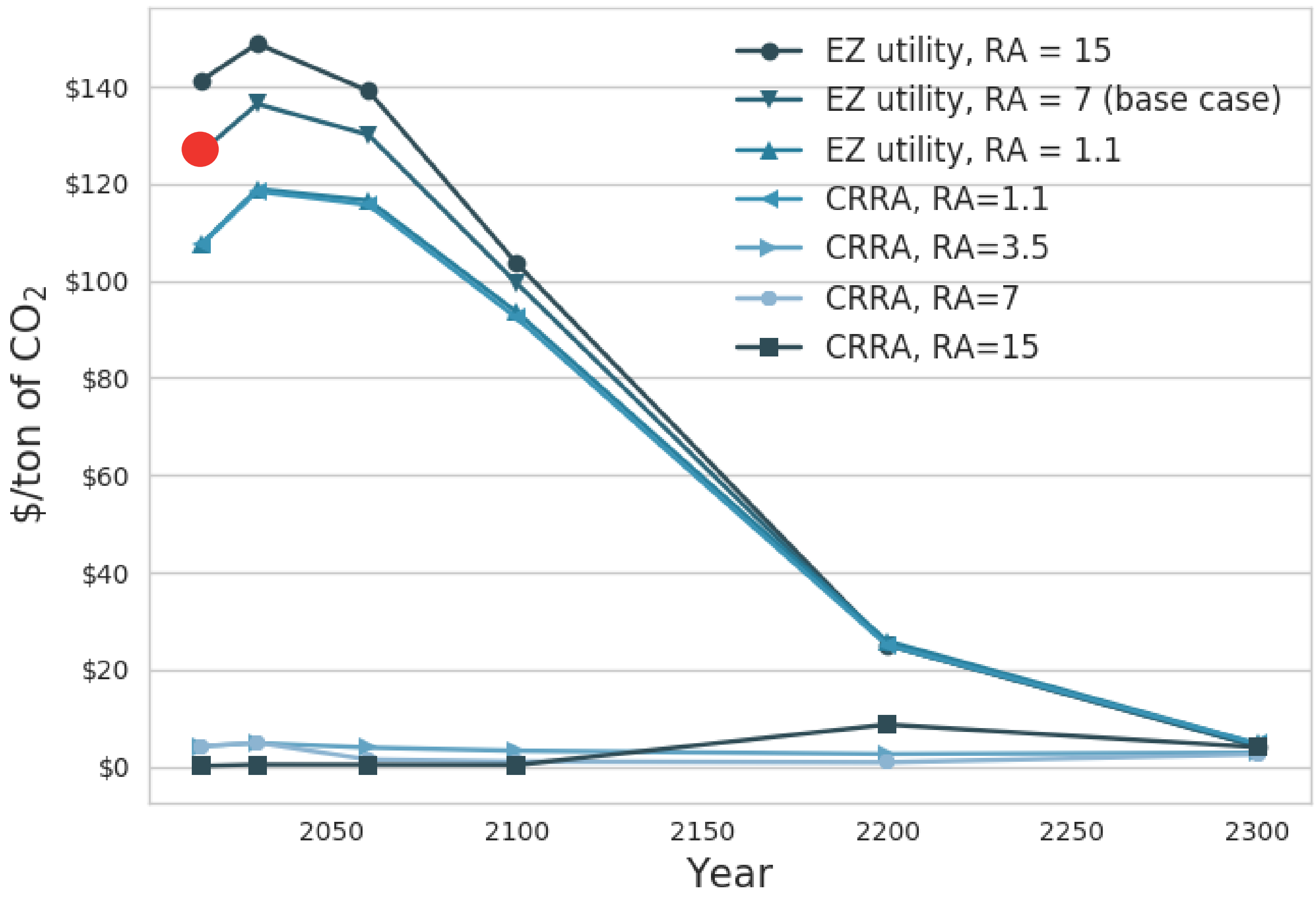
2 Optimal CO_2 price sensitive to utility specification for ‘reasonable’ RA values

No difference between CRRA and EZ utility at RA=1.1, large differences for RA>~3



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3 We decompose optimal CO_2 price into two components

Optimal CO_2 price = expected damages + risk premium

Optimal CO_2 price reflects future state-dependent damages, $D_{s,t}$, weighted by their probability, $\pi_{s,t}$, and pricing kernel $m_{s,t} = \left(\frac{\partial U}{\partial c_{s,t}}\right) / \left(\frac{\partial U}{\partial c_0}\right)$:

$$\sum_{t=1}^{T} \sum_{s=1}^{S(t)} \pi_{s,t} m_{s,t} D_{s,t} \left(= \sum_{t=1}^{T} E_0\left[\widetilde{m}_t \widetilde{D}_t\right] \right)$$

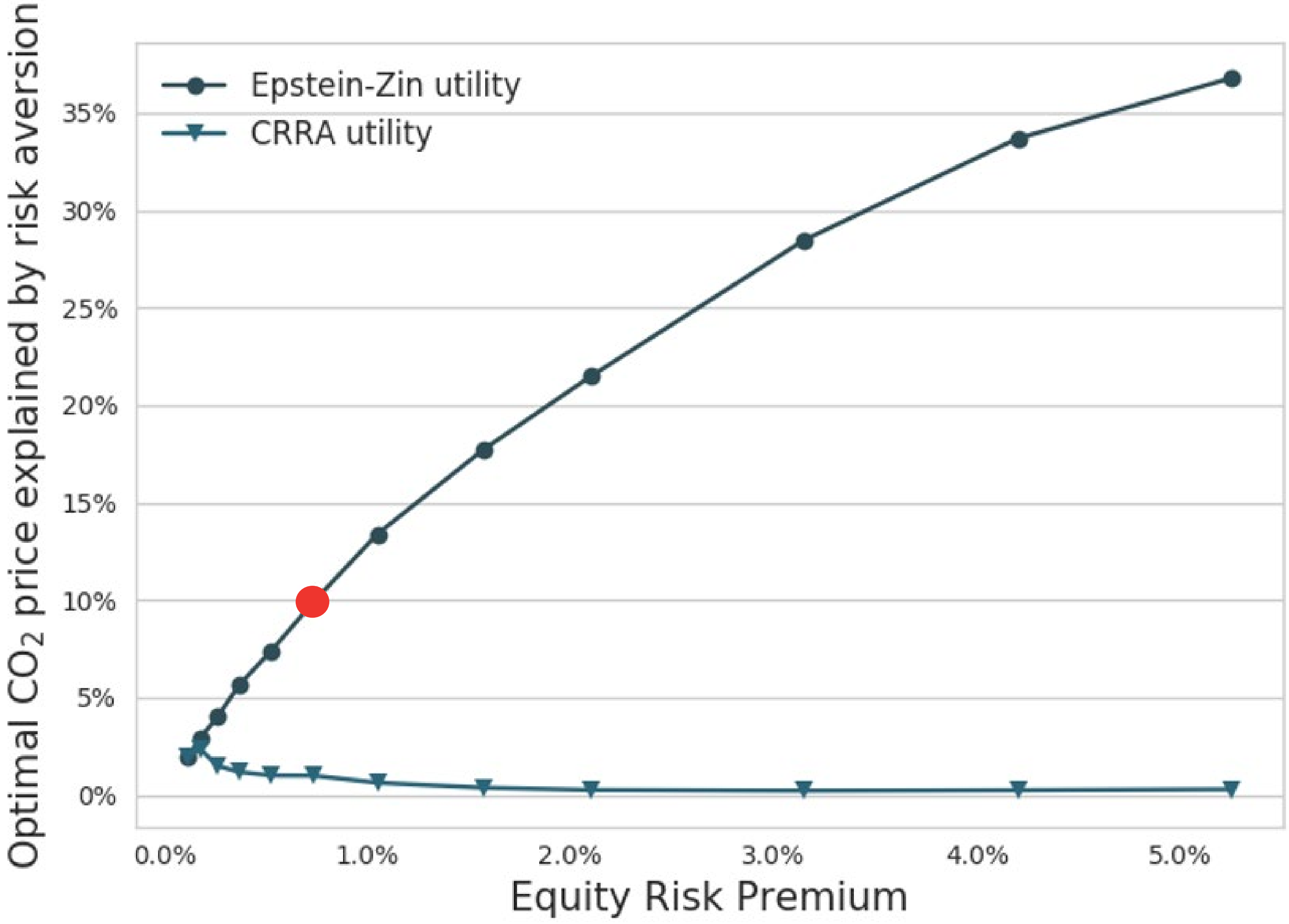
which we rearrange as:

$$\underbrace{\sum_{t=1}^{T} E_0[\widetilde{m}_t] \cdot E_0\left[\widetilde{D}_t\right]}_{Expected\ Damages} + \underbrace{\sum_{t=1}^{T} cov_0\left(\widetilde{m}_t, \widetilde{D}_t\right)}_{Risk\ Premium}$$

Source: Daniel, Litterman & Wagner (NBER October 2018), gwagner.com/ezclimate

3 Epstein-Zin utility allows risk premium to play a significant role

Increased risk aversion increases risk premium relative to expected damages



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4 Enormous social costs of delay

Cost of delay increases roughly with the square of time

Q: How much additional consumption is required throughout the first period to bring the utility with first-period mitigation set to zero up to the unconstrained level?

First-period length	Annual consumption impact during first period
5 years	11%
10 years	23%
15 years	36%

Each year of delay causes the equivalent consumption loss *over the entire first period* to increase by roughly 2.3%

Source: Daniel, Litterman & Wagner (NBER October 2018), gwagner.com/ezclimate

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