Sensitivity and Uncertainty Analysis with FUND

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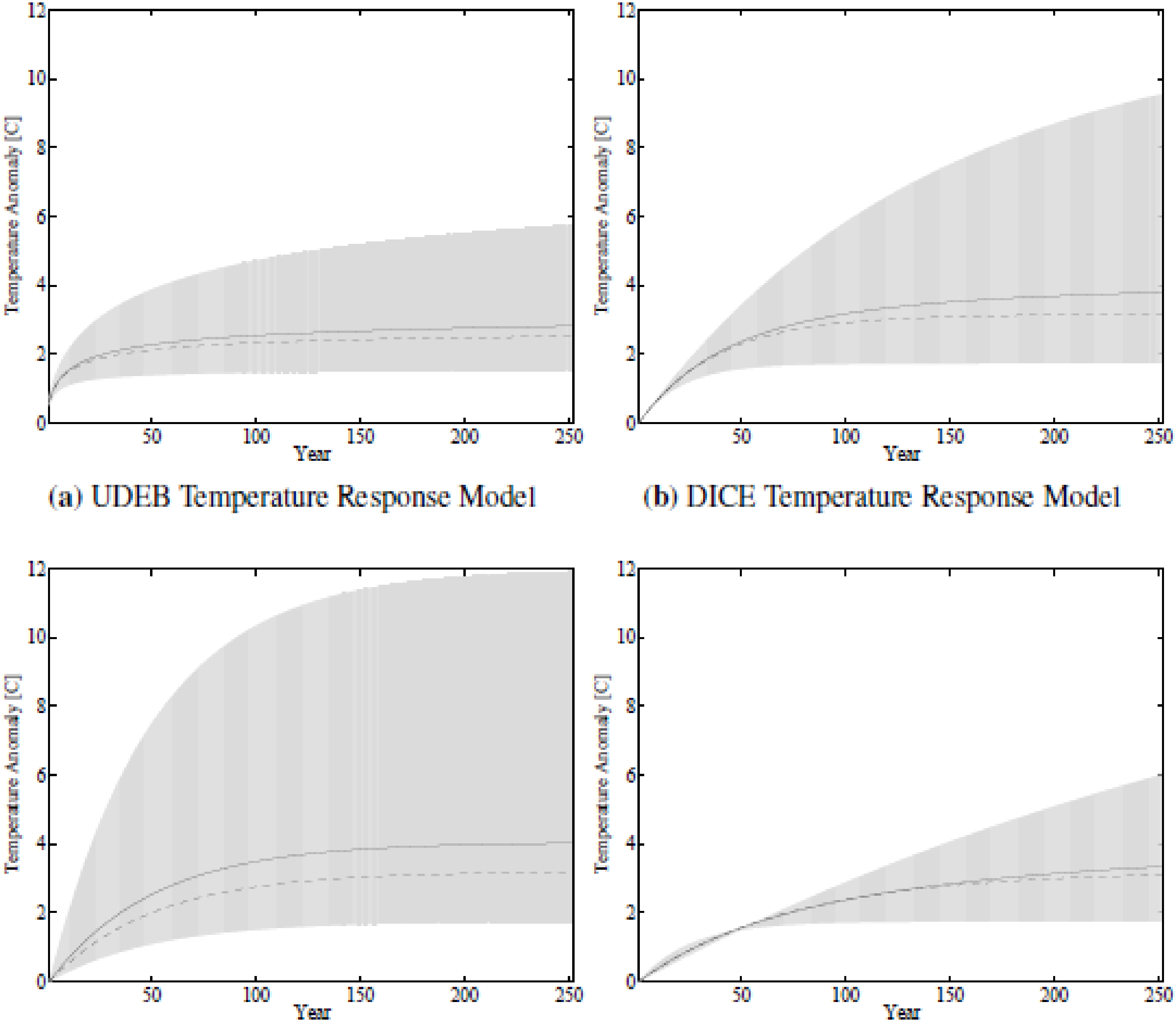
Introduction

- MUG protocol is model diagnostics
- Results unpublishable for single model because attention spread over too many processes
- Multi-model diagnostics works for comparable models only, and requires focus

- That's not to say that we're not interested
- Model comparison example by Alex Marten
- Model diagnostics on SCC with FUND
- How to build a PDF?



(a) UDEB Temperature Response Model

(b) DICE Temperature Response Model

(c) PAGE Temperature Response Model

(d) FUND Temperature Response Model

Figure 3: Temperature Response to a Sustained Doubling of CO_2 Marten, 2011, EcEjrn

Figure 2. The ten most important parameters that determine the social cost of carbon and their standardised regression coefficient for a 1% pure rate of time preference and a 1.5 rate of risk aversion.

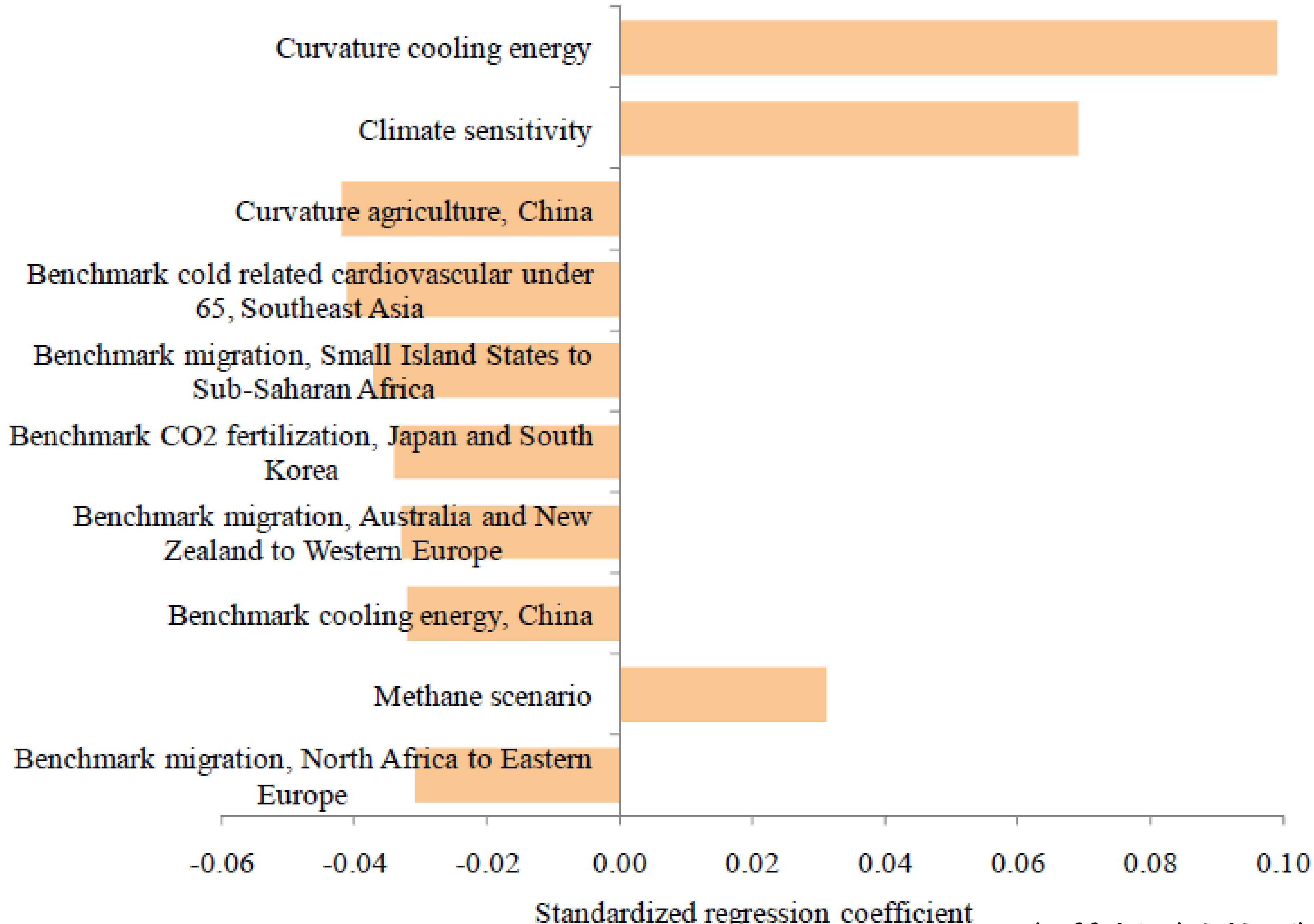


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Figure 1. The relationship between the standardised regression coefficient and the correlation coefficient between the input parameter and the social cost of carbon for a 1% pure rate of time preference and a 1.5 rate of risk aversion.

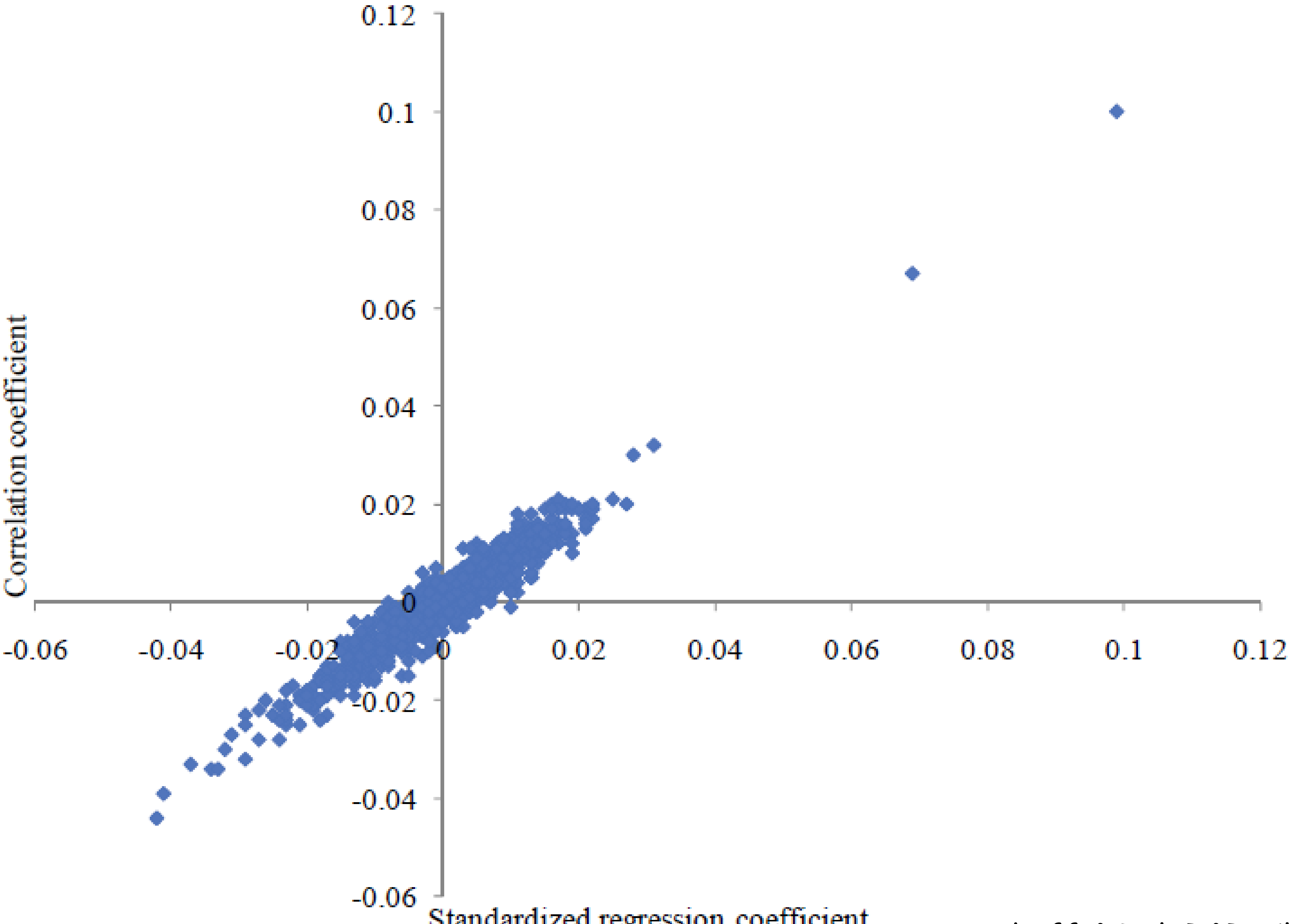

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Table 4. The top 10 most important parameters according to the standardized regression coefficients for various pure rates of time preference and rates of risk aversion.

Pure rate of time preference (%)	1.0	0.1	3.0	1.0	1.0
Rate of risk aversion	1.5	1.5	1.5	1.0	2.0
Curvature cooling energy	1	1	1	1	1
Climate sensitivity	2	2	3	2	2
Curvature agriculture, China	3	15	4	10	3
Benchmark cold related cardiovascular under 65, Southeast Asia	4	3	32	3	8
Benchmark migration, Small Island States to Sub-Saharan Africa	5	4	47	4	10
Benchmark CO2 fertilization, Japan and South Korea	6	12	7	10	7
Benchmark migration, Australia and New Zealand to Western Europe	7	5	92	5	11
Benchmark cooling energy, China	8	43	6	40	5
Benchmark migration, North Africa to Eastern Europe	9	6	150	6	12
Methane scenario	9	34	9	29	6
Benchmark migration, North Africa to USA	11	7	542	6	16
Benchmark migration, South America to Sub-Saharan Africa	11	8	207	9	14
Benchmark migration, Australia and New Zealand to USA	11	9	124	6	16
Income elasticity cooling energy	14	171	5	180	4
Benchmark migration, South Asia to Japan and South Korea	15	10	444	10	26
Asymptotic value of biodiversity, Southeast Asia	15	10	207	10	26
Benchmark CO2 fertilization, Southeast Asia	145	579	2	825	9
Benchmark CO2 fertilization, Western Europe	351	705	8	779	46
Benchmark CO2 fertilization, China	456	772	10	825	66

Anthoff & Tol, R&R, ClCh

How to construct a PDF?

- Imputation + kernel density estimator

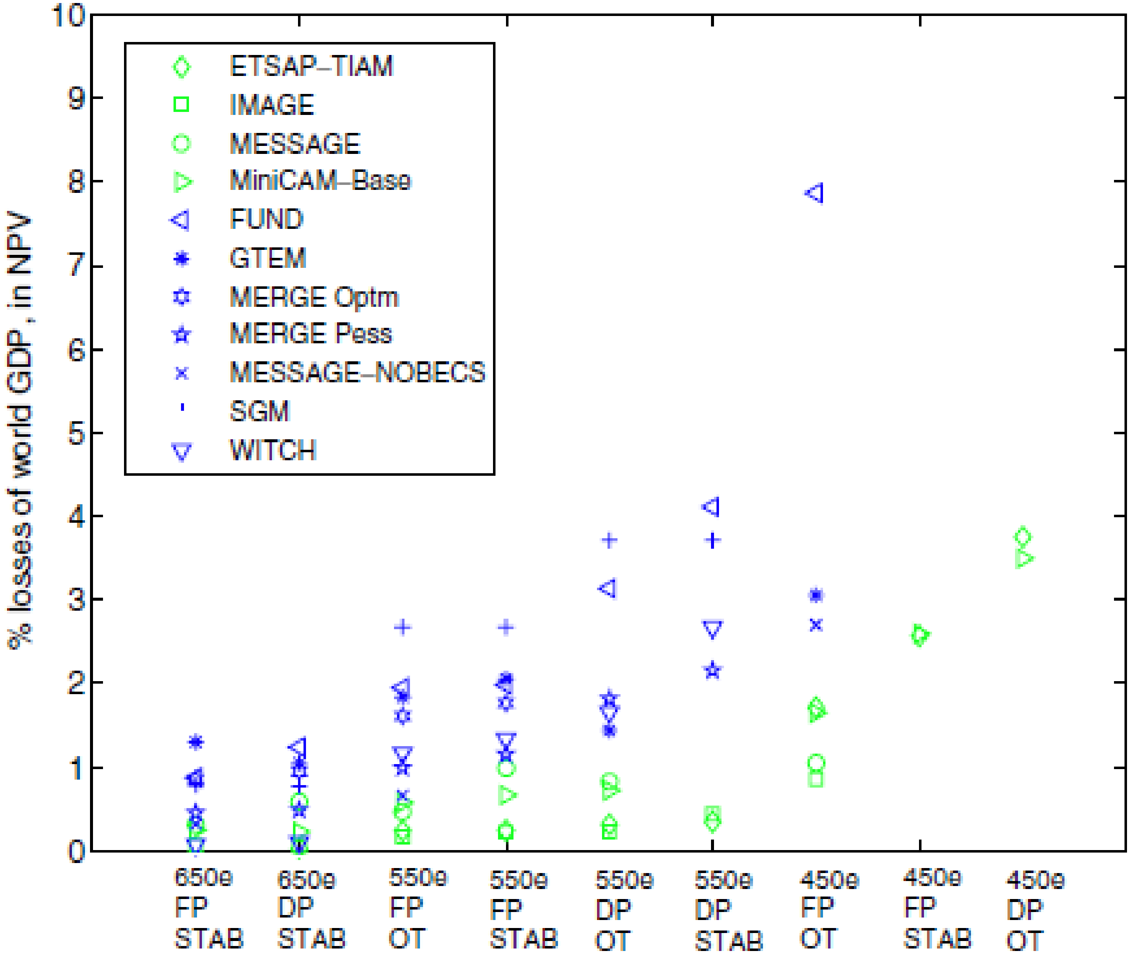


Fig. 1 Policy costs for the EMF22 data set by model run. *Green colors* indicate models with BECS and blue models without BECS. Scenario legend as in Table 1

Tavoni & Tol, 2010, *CCL*

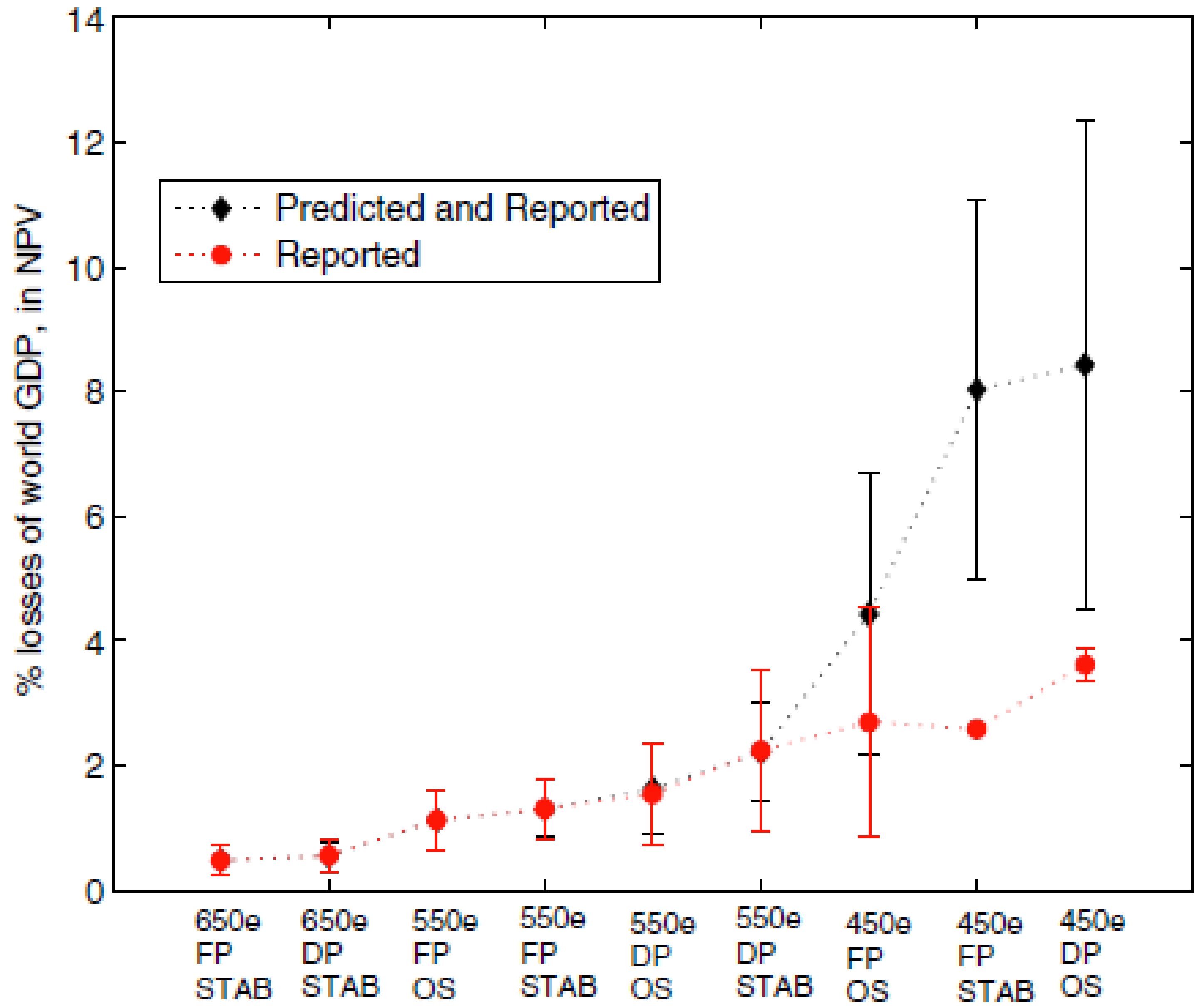


Fig. 2 Policy costs: mean and two standard errors of the mean (95%), for the original EMF22 data set (*reported*) and the one where missing values have been predicted (*predicted and reported*)

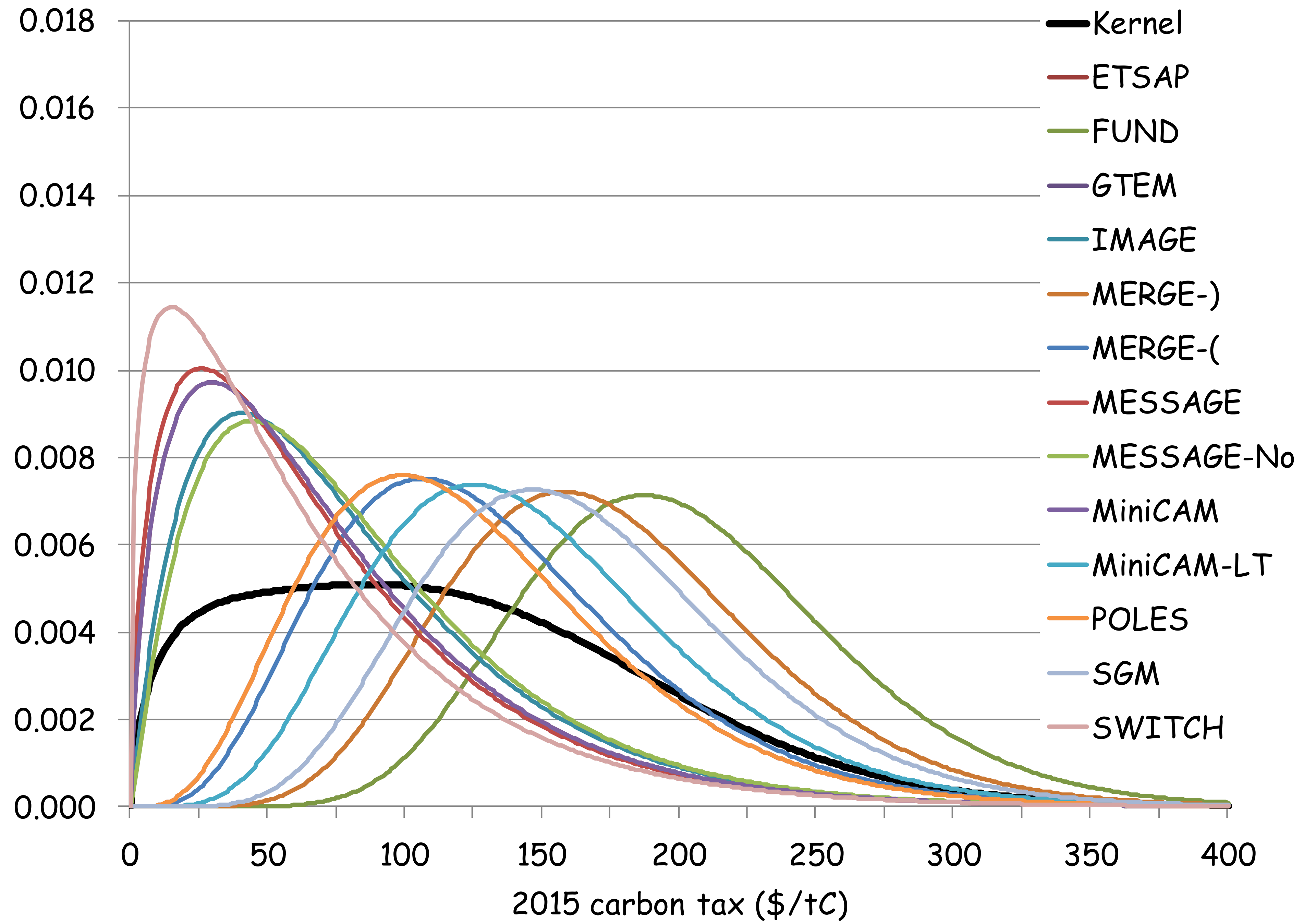
Tavoni & Tol, 2010, *CCL*

How to construct a PDF?

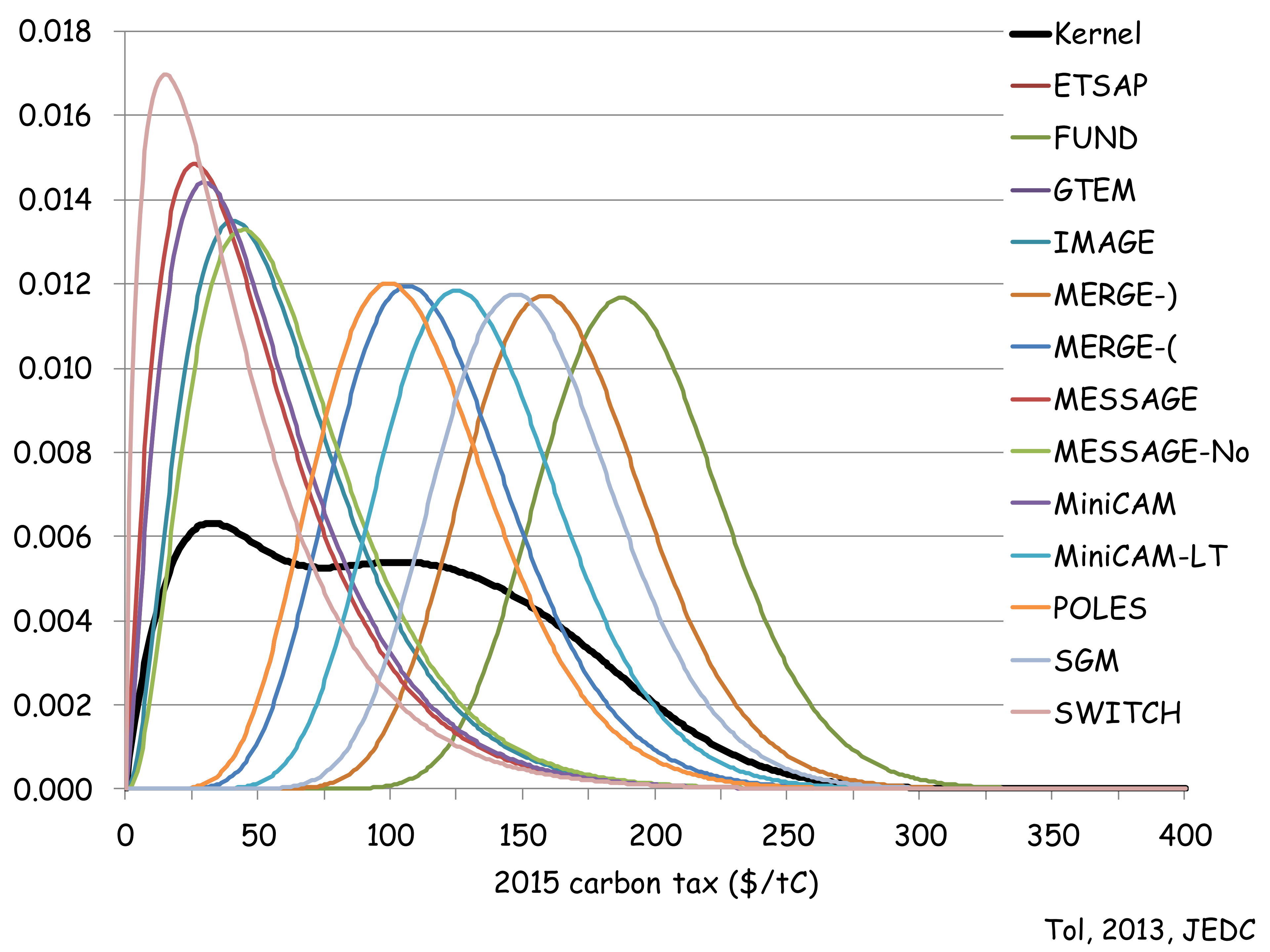
- Imputation + kernel density estimator
- Observe $x_1, x_2, \ldots, x_n$ then the KDE is

$$f(x) = \frac{1}{n}\sum_{i=1}^{n} g(x; x_i, \sigma)$$

- Typically, the spread is chosen to maximize fit ($\sigma \approx \hat{s} n^{-1/5}$), but since our knowledge is so incomplete I prefer the empirical standard deviation ($\sigma = \hat{s}$)



Tol, 2013, JEDC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50
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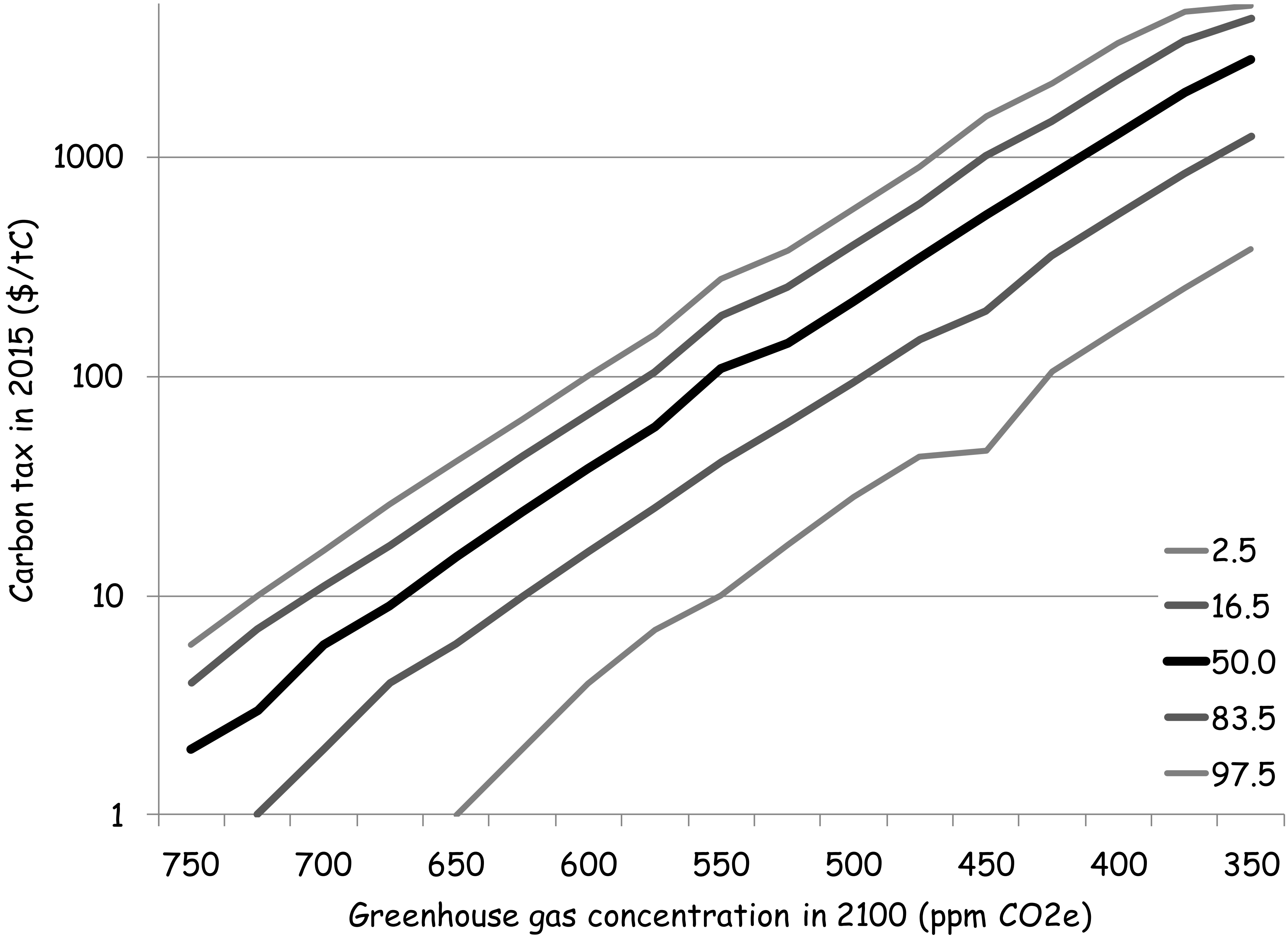
200
250
300
350
400
2015 carbon tax ($/tC)
Kernel
ETSAP
FUND
GTEM
IMAGE
MERGE-)
MERGE-(
MESSAGE
MESSAGE-No
MiniCAM
MiniCAM-LT
POLES
SGM
SWITCH
Tol, 2013, JEDC



Tol, 2013, JEDC

Conclusion

- Interested in topic and working on it
- Study design needs work