The Aggregation Dilemma in Climate Change Policy Evaluation

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Research question:
Assume we have good regional data, what is the implication of ignoring this data and relying on aggregative models?

- What is the Aggregation Dilemma?
- A stylized model
- Empirical estimate of Aggregation Dilemma
- Some conclusions

The Aggregation Dilemma

Advantages

- analytical reasons (e.g. closed-form)
- less error prone
- easy presentation
- data availability
- etc.

+ We love simplicity and thus want to aggregate as much as possible

Disadvantage

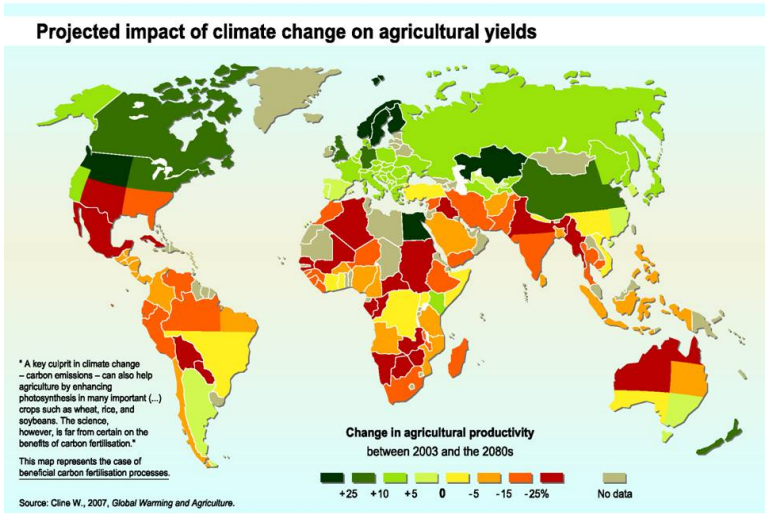
- averages differences away

- Higher aggregation averages differences away that may nevertheless be important at the aggregate

The main issue with the average

Results in article rely on two assumptions

decreasing marginal utility



asymmetric climate impacts

A stylized model

- 2 periods. N individuals
- Endowment w in $t = 1$, $(1 + g)w$ in $t = 2$
- Asymmetric climate impact, as proportion of period 1 endowment
- Climate impact can be reduced via abatement expenditure
- $\psi_i(\sum_i A_i) > 0$, $i = 1, ..., N$
- utility $u(c_{i1}) + u(c_{i2})$

Two assumptions

Assumption

Function $\psi_i(\sum_i A_i)$ *follows* $\psi_i(0) > 0$, $\psi_i'(\sum_i A_i) < 0$, $\psi_i''(\sum_i A_i) > 0$, $\psi_i(\infty) = 0$ *and* $\psi_i'(0) < \infty$.

Assumption

$\psi_i'(\sum_i A_i) = \psi_j'(\sum_i A_i)$, $\forall\ i = 1, ..., N$ *and all* $j = 1, ..., N$.

Define two social welfare functions:
The **aggregated consumption function** is given by

$$U\left(\sum_i c_{1i}, \sum_i c_{2i}\right) = u\left(\sum_i c_{1i}\right) + u\left(\sum_i c_{2i}\right). \qquad (1)$$

The **aggregated utility function** is given by

$$U\left(c_{1i}, ..., c_{1N}, c_{2i}, ..., c_{2N}\right) = \sum_i u(c_{1i}) + \sum_i u(c_{2i}). \qquad (2)$$

Both SWFs are maximized subject to

$$w/N = c_{1i} + A_i, \qquad (3)$$

$$c_{2i} = \left(1 + g - \psi_i\left(\sum_i A_i\right)\right) w/N, \qquad (4)$$

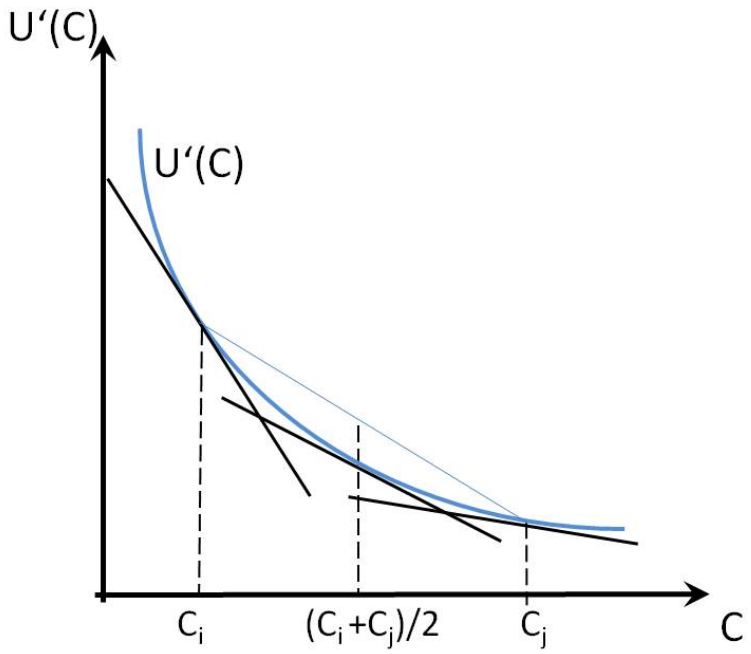
which hold $\forall i = 1, ..., N$.

Proposition

Under assumptions 1 and 2, optimal abatement expenditure is larger in the aggregated utility model than in the aggregated consumption model.

Intuition:

Figure: Sketch of proof



Adding two additional extreme yet realistic assumptions:

Assumption

We assume that $\exists k \in \mathbb{Z}(N)$, *s.th.* $\forall\ i \geq k$, $\psi_i(0) \geq 1 + g$.

Proposition

If assumption 3 applies then the marginal benefit from abatement effort is infinite in the aggregated utility model but finite in the aggregated consumption model.

Assumption

Assume that $\exists h \in \mathbb{Z}(N)$, *s.th.* $\forall\ i \geq h$, $\psi_i(\sum_i w_i) \geq 1 + g$.

Proposition

If assumption 4 applies then the marginal benefit from abatement effort is infinite in the aggregated utility model but finite in the aggregated consumption model **at every feasible level**.

Simulation exercises

Aggregated consumption model

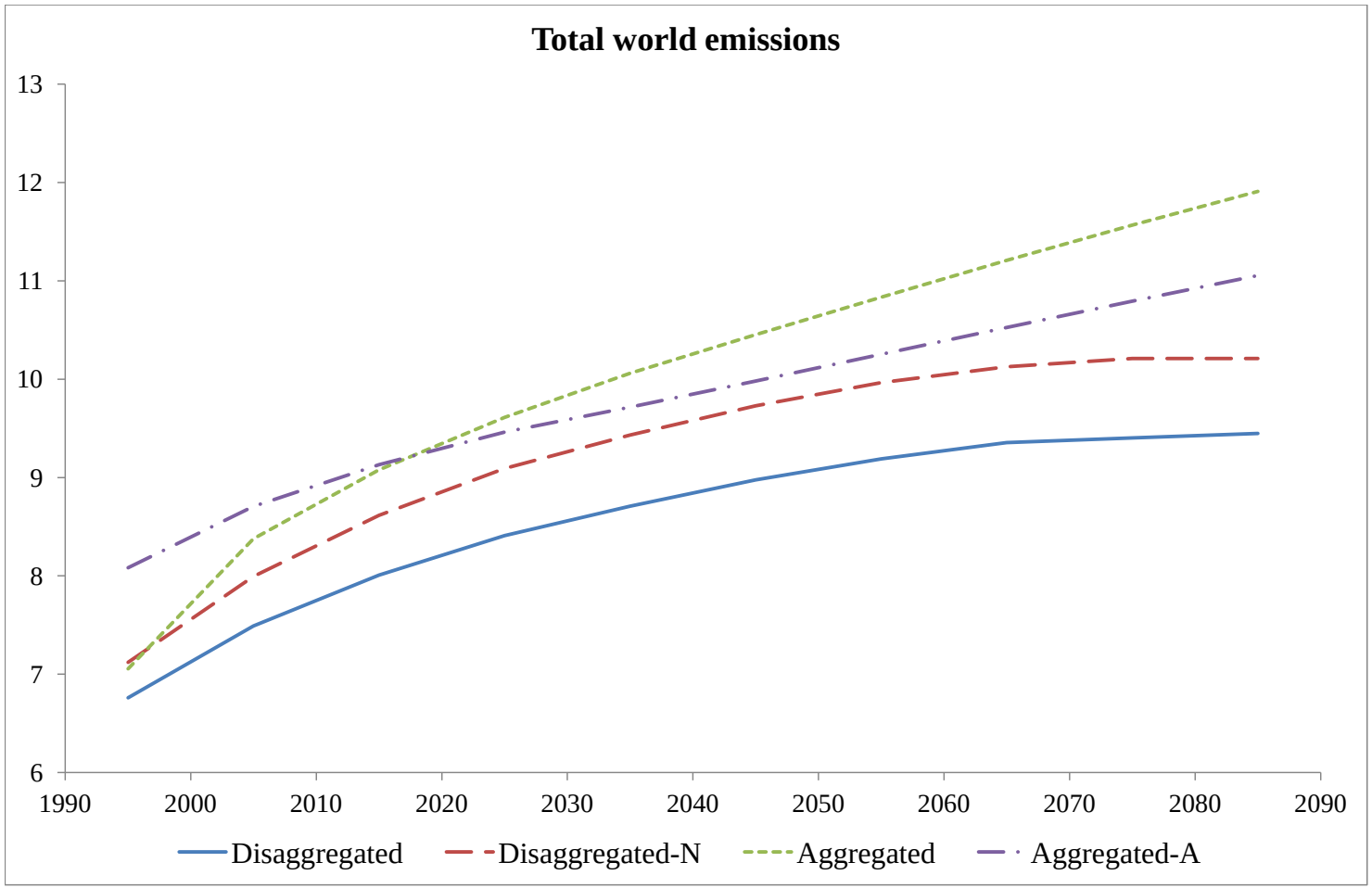
$$U^{ac} = \sum_{t} 10 * R(T)P(T) \log \left(\sum_{N} \frac{C(T,N)}{P(T)} \right). \quad (5)$$

Aggregated utility model (with and without Negishi weights)

$$U^{auN} = \sum_{T} \sum_{N} 10 * R(T)P(T,N)W(N) \log \left(\frac{C(T,N)}{P(T,N)} \right). \quad (6)$$

- Simulation via RICE-99
- no changes to original model
- Aggregate-A case refers to also aggregated production function
- study differences resulting from different SWFs

Figure: Integrated Assessment results (modified Rice-99 model)



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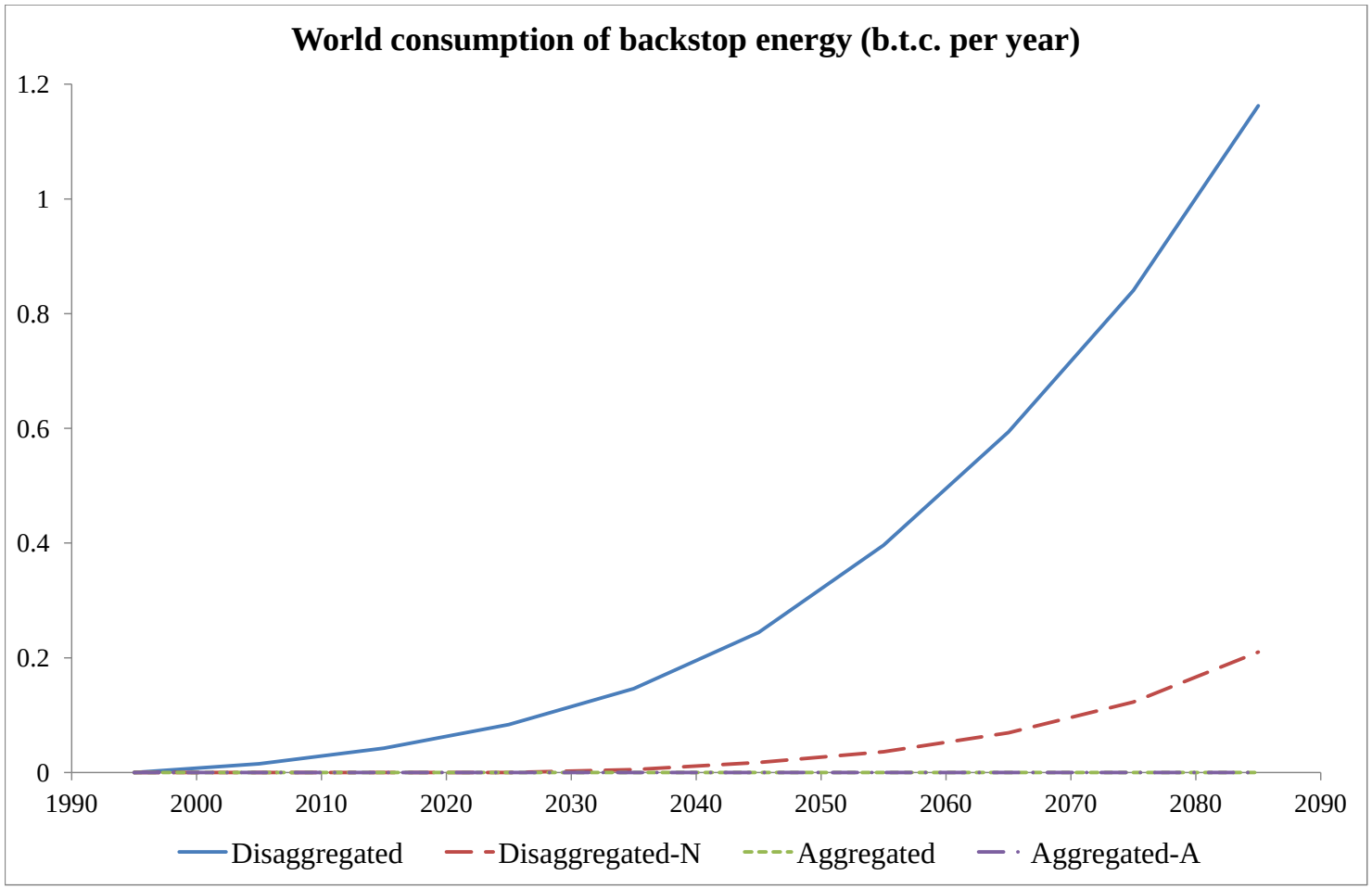

Conclusion

- Aggregation matters if 1) climate impacts are asymmetric; 2) decreasing marginal utility.
- Policy intervention vastly underestimated in aggregated models
- side issue: Simulations here show that results between DICE and RICE *should* be significantly different (but based on Nordhaus are not...)
- Question: What is a good way to aggregate? (Look at paper please)
- Work-in-progress: Country-specific RICE model