Mitigation and Climate Engineering under deep Uncertainty

Vassiliki Manoussi Anastasios Xepapadeas

Athens University of Economics and Business

INTRODUCTION

Mitigation

•Climate change mitigation generally involves reductions in human (anthropogenic) emissions of greenhouse gases (GHGs).

•**Disadvantages** :

i. Problems of cooperation: The politics of mitigation emissions are difficult because deep cuts in emissions are possible only with cooperation of many nations with diverging preferences (Victor, 2008).

ii. Free Riding: Supplying the global public good of averting global climate change by means of reducing emissions is vulnerable to free riding. Too few countries are likely to participate in such an effort, those that do participate are likely to reduce their emissions by too little, and even their efforts may be overwhelmed by trade leakage.

iii. Political Economy Perspective: With today's technologies, achieving a deep cut in emissions will require costly investment for uncertain benefits that accrue mainly in the distant future - attributes that tend not to be rewarding for politicians (Victor, 2008).

Solar Radiation Management

•A deliberate intervention in the planetary environment of a nature and scale intended to counteract anthropogenic climate change and its impacts.

• The approach of the injection of sulfate aerosols into the atmosphere, mimics what occasionally occurs in nature when a powerful volcano erupts. For example, the Mount Pinatubo eruption in 1991 injected huge volumes of sulphur into the stratosphere. The particles produced in subsequent reactions cooled the planet by about 0.5℃ over the next two years by reflecting sunlight back into space. They are expected to act rapidly once deployed at the appropriate scale, and could potentially reduce surface global temperatures within a few months or years if this were considered desirable.

•**Advantages** : i) It could produce global cooling. ii) It is inexpensive. iii) It can be undertaken unilaterally.

• **Disadvantages :** i) We do not really know the consequences of SRM. ii)The knowledge of geoengineering's ability to cool the climate will reduce the incentive to cut emissions (moral hazard argument).

iii) Addiction to it.

UNCERTAINTY

➢Geoengineering itself is highly uncertain ⟶ No large scale experiments have been conducted in order to assess the full potential to counteract global warming.

➢Frank Knight introduced a concept of uncertainty in order to represent a situation where there is ignorance, or not enough information to assign probabilities to events.

➢The concept of Knightian uncertainty or ambiguity ⟶ A decision maker is trying to make good choices when he has concerns about possible misspecifications of the correct model and wants to incorporate these concerns into the decision-making rules.

MODEL

➢ We study an ambiguity model of climate policy design in terms of emissions and solar radiation management (SRM) under deep uncertainty.

➢Ambiguity is modeled in terms of a robust control problem.

➢The standard expected utility maximizing model could be derived as a special case of the robust control model when the regulator has no concerns about model misspecification and completely trusts the benchmark model.

➢Geoengineering reduces global average temperature by controlling the incoming solar radiation.

We seek to characterize cooperative and noncooperative mitigation (or equivalently GHGs emission) and SRM strategies in the framework of a robust control problem.

➢Cooperation ⟶ Coordination between the two countries for the implementation of geoengineering and the level of emissions in order to maximize global welfare.

➢Feedback Nash ⟶ Each government chooses SRM and emissions policies noncooperatively.

➢We focus on uncertainty surrounding geoengineering and in particular its accumulation dynamics.

➢Uncertainty is introduced in the diffusion process, reflecting concerns about our benchmark probabilistic model.

Uncertainty – Cooperation

▪ As $\theta \to \infty$: $(E^*,\zeta^*,G^*,T^*) \to$ Benchmark

▪Emissions & geoengineering are decreasing in uncertainty (θ).

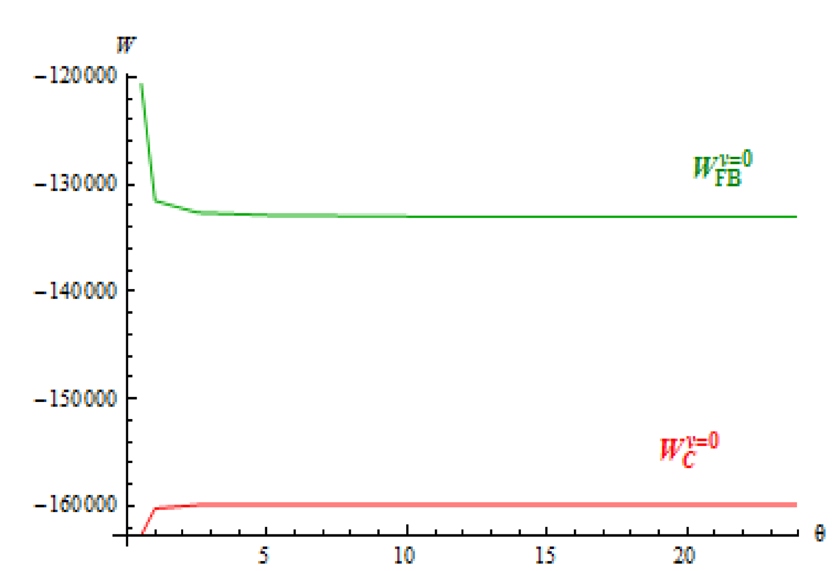
▪High concerns about model misspecification (High v) : choose mitigation over geoengineering ⟶ low E, G and T

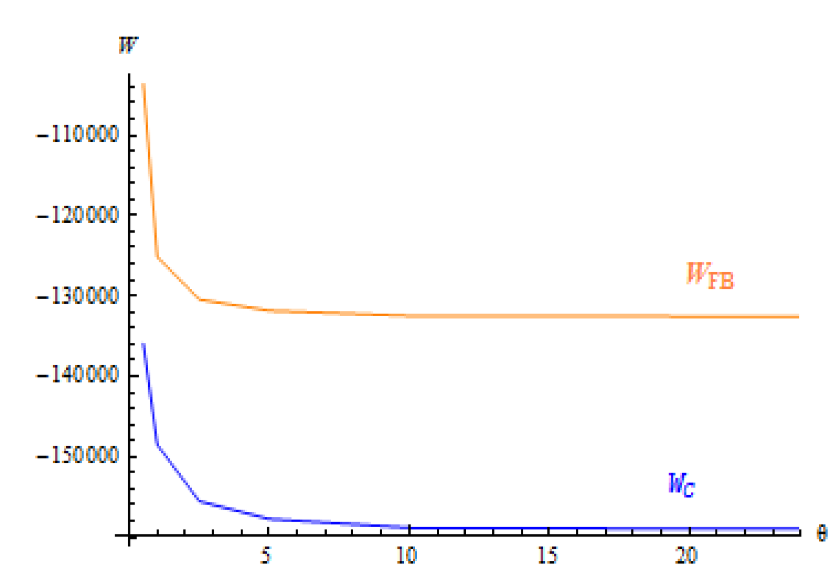
▪The worst-case model misspecification ($v \geq 10$) : $\zeta<0$ and low E.

▪As $\theta \uparrow \Rightarrow v \downarrow \Rightarrow$ (E and ζ) ↑ ⇒ G↑ and ↑ W

θ	G	E_t	ζ_i	T	v	W
1000	968.787	4.02047	4.65764	17.1974	0.0311	-159892
100	968.525	4.01938	4.48199	17.1962	0.2531	-159893
10	965.826	4.00818	2.69665	17.1836	2.53935	-159896
5	962.709	3.99524	0.655355	17.1689	5.09765	-159902
2.5	956.058	3.96764	-3.62367	17.1367	10.274	-159934
1	931.714	3.86662	-18.2818	17.0097	26.3337	-160250

Uncertainty – Welfare





MODEL

Uncertainty - Feedback Nash

▪For low degree of uncertainty ($\theta \geq 10$) : E, G and T do not seem to be very sensitive to changes of θ.

▪For high ζ : incentives to mitigate weaken ⇒ (E, G)↑

▪As θ↓ ⇒ ↑ W

▪$(\zeta, E, G, T)_{Coop.} < (\zeta, E, G, T)_{FBNE}$ for the same degree of uncertainty.

▪So when the countries are not forced to cooperate they will choose to substitute mitigation with geoengineering.

θ	G	E_i	ζ_i	T	v_i	W_i
1000	2435.64	10.1079	69.0479	32.5373	0.0202	-133092
100	2435.27	10.1064	68.7103	32.5364	0.2026	-133039
10	2431.49	10.0907	65.2702	32.5276	2.045	-132479
5	2427	10.0721	61.2991	32.5161	4.13374	-131830
2.5	2417.13	10.0311	52.8541	32.4881	8.45217	-130439
1	2376.32	9.86175	22.6575	32.3278	22.7368	-125152

CONCLUSIONS

➢If we consider geoengineering as a comparable cheap and effective alternative to traditional mitigation, then this possibility will affect the choice of the optimal climate change policies.

➢Concerns about model misspecification induce conservative behavior and this behavior leads to low geoengineering effort and emissions both at the cooperative and the noncooperative solution relative to the pure risk case.

➢ The use of geoengineering can substitute the absence of a binding environmental commitment among countries and has the ability to moderate the welfare losses as concerns for model misspecification increase in the case of non-cooperation among countries.

CONTACT INFORMATION

E-mail:
amanousi@aueb.gr
xepapad@aueb.gr

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: "Thalis – Athens University of Economics and Business - Optimal Management of Dynamical Systems of the Economy and the Environment: The Use of Complex Adaptive Systems".