

## ***Interactive comment on “The impact of uncertainty on optimal emission policies” by Nicola Botta et al.***

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Thank you for the review and for the detailed comments and corrections of the supplementary document!

We are going to prepare a major revision of the original manuscript and implement your recommendations and those of Referee 1. In the following, we have listed a number of TODOs. The idea is to provide you with an account of our revision plans. We will use the list as a guideline for revising our original manuscript. If new reviews and comments will become available, we will update the list accordingly.

TODO (first manuscript revision, status 2017.12.13):

00. Correct typos and errors according to RC1 and EC1 (supplement).

C1

01. Explain more clearly the differences between plain mathematical notation (e.g., set comprehension in  $T = \{A, U\}$ ), functional notation (e.g.,  $State : Nat \rightarrow Set$ ) and Idris specific formulas (EC1). Perhaps introduce a short "Notation" section after the introduction and before section 2 "Sequential emission problems"? Explain that the article comes with a git repository and give the URL of IdrisLibs (EC1).

02. Summarize the results of Botta et al. (2017a,b) in an appendix of the revised manuscript (RC1.GC4). Move the formal monotonicity condition to the appendix. There, give the type of `fmap` and an example, e.g., for lists (EC1).

03. Discuss the differences between *best*, *worst* and *average* (expected value) as measures of uncertainty in more detail (EC1). Perhaps link this discussion to the problem of finding sensible influence (responsibility) measures in sequential decision problems under uncertainty.

04. When discussing basic facts about optimal emission policies (in the beginning of section 5), stress the importance of making decision makers aware of the consequences of (often implicit) assumptions. In particular, explain that the last decision step needs a special care if one wants to avoid apparently inconsistent results (reducing emission at the last step is never optimal, EC1) or just account for meaningful boundary conditions. Perhaps formulate a sustainability principle?

05. In the introduction, explain more clearly that one would like to tackle the problem of computing optimal emission policies for individual countries as a (mixed sequential and simultaneous) coordination game with a finite number of decision makers over a finite (but not necessarily known) number of decision steps and under different sources of uncertainty (RC1.GC1). Recall that (to the best of our knowledge), no theory (let apart a computational theory) is available for such problems and that a very common approach is that of slicing the problem into the questions:

a) *When* and by *how much* should global GHG emissions be reduced to avoid unmanageable future states?

C2

b) *How* to make sure that (fair, optimal, etc.) emission reduction quotas, consistent with given optimal global reduction, are actually implemented by individual countries or regions?

which, in a holistic approach, would have to be answered simultaneously. Answers the role of control-theory and of game-theory in a), b).

06. In section 3, explain in more detail that applying a verified computational method for computing optimal policies is crucial because optimality (e.g., of supposedly optimal policies) cannot, in general, be tested (sometimes proving is easier than testing, RC1.GC2).

07. Make the context of our contribution more clear and compare our results to, among others, those presented by M. Webster (RC1.GC3).

08. Explain (when referring to the new appendix, see TODO 02.) that the theory presented in Botta et al. (2017a,b) is based on the notion of *monadic* dynamical systems originally introduced by Ionescu in his PhD thesis. Explain that monads allows one to treat deterministic, non-deterministic, stochastic, fuzzy, etc. problems with a seamless approach in which the differences are captured by a single problem parameter and all computations (e.g. of optimal policies, possible trajectories, rewards, etc.) are generic with respect to this parameter (RC1.SC0).

09. In summarizing the results of Botta et al. (2017a,b) in an appendix (see TODO 02.), explain that a sequential decision problem cannot be described as a sequence of pay-offs: one has to give a function that returns one payoff for every suitable combination of current state, selected control and next possible state (RC1.SC1).

10. Add a revised version of AC1 (comment "On a legitimate criticism to our contribution") to section 5 (6?) of the revised manuscript (RC1.SC2).

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