Earth Syst. Dynam. Discuss., 2, C81–C85, 2011
www.earth-syst-dynam-discuss.net/2/C81/2011/

Earth System Dynamics Discussions

Interactive comment on "No way out? The double-bind in seeking global prosperity along with mitigated climate change" *by* T. J. Garrett

T. Garrett

tim.garrett@utah.edu

Received and published: 20 April 2011

The second referee disapproves of this article because it does not comport with traditional Integrated Assessment Models. If traditional Integrated Assessment Models were based on universal thermodynamic principles that represent physical flows down potential gradients, and they provided falsifiable hypotheses that were then subjected to rigorous empirical validation, I would use those models. Climate models are subjected to this standard. Ideally, if traditional economic models are to be coupled to climate models, I believe they should be subjected to this standard as well. Yet, as far as I am aware, none of them are.

In any case, the goal of this study is not to provide policy guidance, as is the goal of IAMs, but rather to provide physically constrained deterministic solutions for the

coupled evolution of civilization and climate, where the underlying basis is subjected to empirical validation. Given a choice between developing an economic model that is consistent with physics and is observationally validated, and one that is consistent with traditionally non-physical economic approaches, I chose to explore the implications of the former. Specific responses follow:

The central idea of the model is that there is a strong relation, supported by data, between fossil energy consumption and global accumulated wealth.

No this is incorrect. The central idea is that there is a strong relation, supported by data, between **total** primary energy consumption and global accumulated wealth.

One can, of course, develop any number of simple models that relate the dynamics of these variables to the available data, if one focuses only on these simple variables.

This is hardly true. I could postulate to my heart's content that the energy of photon is related through a constant to its wavelength, but observations will never support this. Historically, physical intuition guided a hypothesis (by Planck) that energy is related to photon frequency (or the inverse of wavelength), and this what was subsequently validated through observations. Here, I have done nothing different, which is to postulate based on physical intuition that global wealth is tied to a global rate of flow of energy consumption, and then to test this hypothesis using available data. I am unaware after discussions with economists of any similarly simple and empirically validated relationship linking economic quantities to physical quantities.

One can then extrapolate the models into the future, with dire consequences for the future or our planet

The model that is described here is not mere extrapolation, as it is fully coupled, and includes negative feedbacks on CO_2 emissions that might be associated with civilization decay from global warming.

But this is not the point of developing IAMs. We all agree that the path pursued in

ESDD
2, C81–C85, 2011

the past cannot be projected into the future. The point is to evaluate alternative evolution trajectories in which the relation between energy use, CO2 emissions and global wealth are changed because investments are channeled into renewable energy and energysaving technologies rather than simply used to expand the fossil-based system. This central question is not addressed by the model, and the question that is addressed, in the view of this referee, is not of interest.

This paper does in fact address to a great extent the role of energy efficiency and shifts in energy carbonization on the coupled evolution of civilization and the atmosphere. See for example, the discussion on pp. 319-320, 323-324, and Figures 6 and 7. What traditional IAMs are directed at is policy measures. Here the approach is to explore the range of possible trajectories that is consistent with fundamental thermodynamic laws. A policy measure can be prescribed, but it will go nowhere if it violates the Second Law. As it turns out, it looks like all SRES models provide trajectories that violate the Second Law, and are therefore physically impossible. Hopefully, the physical plausibility of a policy prescription is of interest to some, because if there is a way out of this mess, it's not going to come by defeating thermodynamic laws.

...the model presented is deficient in many respects. Thus the central assumption that global wealth is given by the integral of GWP (eq. 7) contradicts standard economic theory. In simple economic growth models, GWP is normally set proportional to a combination of physical capital and human capital, which are the basic means of production, and both of which are proportional to global wealth. Thus global wealth is directly proportional to GDP, not to its integral value. Of course, if the growth is exponential, one can get away with the author's assumption, but this needs to be justified (for example, by discussing away depreciation rates, etc. etc.).

Actually, the traditional Solow growth model does have global wealth (or capital) as an integral of GDP, since it portrays the GDP as the differential addition to capital. Of course, consumption and depreciation are subtracted from this, but nonetheless the model has GDP as a "source" that adds to total wealth. Further, the Cobb-Douglas

ESDD

2, C81–C85, 2011

production function that is commonly used in IAMs portrays economic production (or GDP) as a function not only of human and "physical" capital, but also of a coefficient that changes as some measure of technological progress.

Here the approach is essentially identical, with the one major exception that human and physical capital are combined into a single representation of wealth at global scales, and further, a fundamental link is provided between global wealth and global physical flows. The economic growth model is not based just on Eq. 7, but also Eq. 10, which does indeed express GDP as being proportional to wealth, through a time varying coefficient η that is related to the energy efficiency of the system through Eq. 3. It is only through the combination of these equations that modelled growth (and decay) can occur. Depreciation is also included, through the decay of wealth. This is shown in Eq. 18, which is very closely analogous to the traditional growth model for capital growth.

A deeper discussion comparing the two approaches is provided in Appendix B of (Garrett, 2011).

Similarly, the extensive discussion of the inflation rate is irrelevant for an economic growth model. The fact that the unit of currency used to define a given basket of goods can change with time is important for a central bank trying to control it, but for a growth model one can simply redefine the value of currency to an abstract inflation adjusted unit, and the problem goes away.

This makes inflation sound like a non-issue for economies, which I'm not sure history supports. Still, I was very careful in the manuscript to address this issue on p. 325, and through the consistent discussion of environmental decay being an inflationary *pressure*. The idea here is that environmental damages will act to drive up costs. Of course, as mentioned in the paper, the central bank may respond by reducing the monetary supply. Still the inflationary pressure existed at some point, as I am sure people who have survived natural disasters can attest. And whether the central bank devalues existing money, or environmental pressures drive up inflation, in this frame-

ESDD
2, C81–C85, 2011

work the negative impact on real, inflation-adjusted wealth will be equivalent. We're all incrementally poorer one way or another.

In summary, the model tries to redefine economics. This is a valiant undertaking, but as a non-economist who is also not always happy with the way economists treat their subject, the attempt in my view is not successful. It will not convert economists or climate scientists trying to understand the interactions between climate change and the economic system to a new way of integrated assessment modeling.

Actually, it was never a goal to redefine economics, only to find a physically sensible way to understand a problem that will ultimately affect us all. I have found that many people are open to this perspective, and I hope the reviewer too might give the manuscript a second look.

Garrett, T. J.: Are there basic physical constraints on future anthropogenic emissions of carbon dioxide?, Clim. Change, 3, 437–455, 2011.

Interactive comment on Earth Syst. Dynam. Discuss., 2, 315, 2011.