Expanded Comment: Young People's Burden: Requirement of Negative CO_2 Emissions

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Introduction

The central point made by the authors is that in the absence of a rapid phasedown in carbon emissions our children and grandchildren will face a crippling burden of carbon extraction. This argument rests on two claims. The first is that sustainable global temperature is its Holocene average, which according to the authors was reached in 1985. If global temperature continues to exceed this benchmark, irreversible feedbacks may be seeded with catastrophic consequences. The second is that the authors have used the correct model to calculate the young people's burden.

Their benchmark for sustainable temperature needs further justification. Also, they do not carry out validation tests of their model, which meet contemporary scientific standards. Furthermore, their analysis of intergenerational justice, which is one of their keywords, is incomplete and ignores the extensive literature on this subject, including the Stern Review (Stern 2007), which refers specifically to the issue discussed by the authors.

The Hiatus in Global Warming?

The authors write (p 5), "One effect of recent warming is to remove unequivocally the illusion of a global warming hiatus after 1997-8 El Ninõ." This strong claim is based on the fact that in 2015 global temperature was fractionally higher than in 2011, and that by August 2016 it was 0.1^{o} C higher (Fig 2). The data for 2016 are incomplete, and Figure 2 even suggests a large increase in global temperature in 2017. The data for 2015 do not show "unequivocally" that the hiatus has ended, or even there was no hiatus to begin with. Even if the data for 2016 remain at their current level, a single year's data does not justify the claim that the hiatus has unequivocally ended, or never even existed. Matters would be different if by 2020 global temperature was about 0.7^{o} C higher than today according to the projections of IPCC.

The fact that some claim (p 5) that, "…temporary plateaus are consistent with expected long-term warming due to increasing atmospheric GHGs" when others do not, is not a sufficient argument that all is well with the anthropogenic theory of global warming upon which the authors completely rely. The authors' pronouncements regarding the end of the hiatus is premature to say the least.

Drawing major conclusions from short-term changes in global temperature has characterized climate science during the last 50 years. In the 1970s climate scientists pronounced the onset of New Ice Age following the cooling that took place in the 1960s (figure 2). President Nixon was persuaded by climate scientists to set-up a special committee to study the problem, but by the end of the 1970s the increase in global temperature eliminated the scare of a New Ice Age. Between the mid 1970s and mid 1990s global temperature increased once more by 0.5^{o} C. The scare of a New Ice Age was rapidly replaced by the scare of anthropogenic global warming. However, as Figure 2 shows, between the mid 1990s and mid 2010s global temperature stabilized despite the acceleration in GHG forcing noted by the authors (Fig 6 – 8). By 2015 global temperature should have increased by about another 0.7^{o} C according to IPCC projections, but all the major climate change models over-predicted global temperature (Beenstock, Reingewertz and Paldor 2016). Policy makers understandably question whether in ten years' time the latest climatic scare won't be replaced by another.

The Holocene Benchmark

The authors assume that the benchmark for sustainable global temperature should be the Holocene average. There are two issues here. Whereas global temperature has been measured directly since 1880, global temperature during the Holocene is measured indirectly. The second is why the Holocene average rather than some other benchmark?

Presumably the bars in Figure 3(b) represent confidence intervals, which as the authors recognize are small (0.25^{o} C). Since the Holocene benchmark is a crucial parameter in their analysis, they need to explain in depth how direct measures of temperature for 1985 can be compared with reconstructed temperatures during the last 18,000 years. Common sense suggests that reconstructions from thousands of years ago must be highly speculative. The controversy over the Hockey Stick Theory shows that even what happened only a 1000 years ago is subject

to widespread disagreement. So how reliable can the claim be that current global temperature is the hottest it has ever been in the last 10,000 years or so?

Suppose, for argument's sake, that there is no measurement error in global temperature during the Holocene. Why should global temperature during the Holocene be relevant for establishing sustainable temperatures in the 21st and 22nd centuries? The authors need to answer this question first. Why should the average serve as the right benchmark? Why not the maximum, which occurred about 7000 years ago? Since the issue is sustainability, the authors need to show why global temperature was not sustainable 7000 years ago. The authors do not provide adequate justification for their benchmark. They simply remark (p7), "A danger of the 1.5° C and 2° C temperature targets is that they are far above the Holocene temperature range. If such temperature levels are allowed to long exist they will spur "slow" amplifying feedbacks, (references) which may have potential to run out of humanity's control." In this context, they mention ice sheet melt, sea level rise and methane release, all of which are speculative. The truth is that we do not know. It is perfectly legitimate to speculate about "unknown unknowns" as do the authors, but it is quite a different matter to base strong policy proposals on such speculations.

The authors are not alone in making the implicit assumption that the unknown unknowns must always be adverse. History is replete with resolutions to unknown unknowns, which have benefited mankind, and with the discovery of solutions to what appeared to be social and economic time-bombs. For example, in 1866 the renowned British economist W.S. Jevons predicted that by 1900 the Industrial Revolution would come to an end as the world ran out of coal. In the 1970s Club of Rome scientists (Meadows et al 1972) predicted that the world was running out of natural resources, which among other considerations prompted the UN initiative on the establishment of a New International Economic Order. In 1975 the UN Conference on International Cooperation was launched to deal with these issues.

Model Validation

Beenstock, Reingewertz and Paldor (2012. 2016) observe that climatologists do not, on the whole, use contemporary statistical methods to analyse their data.and to validate their models empirically. They rely instead on validation methods, which were vitiated by statistical theory in the 1970s and 1980. Specifically, global temperature, GHG forcings, solar irradiance, and other variables that are hypothesized to be related, are nonstationary. Variables are nonstationary when

their sample moments, such as means and variances, depend on time. For example, because global temperature has been increasing, its sample mean must increase. The same applies to GHGs, which have been increasing over time. It has been known since Yule (1897) that nonstationary time series may be spuriously correlated. Spurious correlation arises when independent time series happen to be correlated simply because they depend on time. It is well known that spurious correlations may even exceed 0.95 despite the fact that the variables involved are completely unrelated.

In Beenstock et al (2012) we explained that the methodological solution to the spurious regression problem was discovered by Granger and Engle (1987) for which they were awarded the Nobel Prize in Economics in 2004. We noted there that whereas global temperature and solar irradiance are difference stationary (their changes are stationary), anthopogenic forcings such as GHGs and aerosols are not. In fact, they are stationary in second differences (changes in changes). This phenomenon greatly complicates testing the anthropogenic theory of global warming. Our main result was that the partial correlation between global temperature and GHGs is a spurious regression phenomenon. On the other hand, we found that global temperature depends on solar irradiance and the change in GHGs rather than their levels. The latter result is, however, inconsistent with the anthropogenic theory of global warming because it implies that an increase in GHG concentrations has only a temporary effect on global temperature; it does not affect global temperature in the long-term. Alternatively, it means that to reduce global temperature, the growth rate in GHGs must be negative, i.e.it is insufficient to lower the growth in GHGs and carbon extraction must be permanent and on-going.

In Figure 6(b) the authors show that since 1960 the growth in CO_2 is correlated (after 8 months) 0.51 with the level of global temperature. This result is consistent with the one reported in the previous paragraph. However, the authors fail to appreciate that it is inconsistent with the anthropogenic theory of global warming, which hypothesizes a relationship between the level of global temperature and the level of CO_2 instead of its rate of growth. Nor are they worried by the fact that their result does not apply at longer or shorter lag orders than 8 months. Cherry-picking the largest correlation, as they do, does not establish what they wish to claim, especially when some of the correlations are negative. Moreover, these simple correlations ignore third variables, such as other GHGs, aerosols and solar irradiance with which CO_s forcings are

correlated. The effect of these third variables might be intermediated by CO_2 forcings. Finally, a correlation of 0.51 means that only 25 percent of the variance in global temperature is associated with CO_2.

The authors need to use multivariate statistical methods, in which global temperature is related to CO_2 as well as other GHG forcings and solar irradiance. The analysis in Figure 6(b) does not meet contemporary statistical standards as represented e.g. by Estrada, Perron and Martinez-Lopez (2013) and the numerous references in Beenstock et al (2012). A related methodological criticism applies to Figure A4 in which the authors report the historic tracking of their model with respect to global temperature during 1880 – 2000. The model appears to track well, but on closer inspection there are some problems. The model systematically over-predicts during 1880 – 1905 after which it under-predicts until the late 1940s. Since 1960 the model appears to track better, but is difficult to see from Figure A4. Note that the model solutions are hindcasts rather than forecasts; the authors calibrated their model to track the past, so the fit should be good. In Beenstock, Reingewertz and Paldor (2016) we propose a methodology for testing historic tracking of outcomes, such as global temperature, that are nonstationary. This methodology tests whether hindcasts are merely spuriously correlated with the data. We applied this methodology to 22 climate change models used by IPCC. All 22 models turned out to be spuriously correlated with the data, despite the fact that the correlations varied between 0.96 and 0.98. To persuade readers that their model is not merely spuriously correlated with the past, the authors need to establish that their hindcasts of global temperature are genuinely correlated with actual global temperature. This is crucial for policy makers because climate models, which fail to track the past can hardly be relied upon to predict the future.

The authors have overlooked important methodological developments in the statistical analysis of nonstationary time series data, such as climate data, despite the fact that they were introduced into climate science almost 20 years ago (Stern and Kaufmann 1997). The authors are not alone in this.

Pascal's Wager and Intergenerational Justice

Pascal reasoned that man should act as if God exists because if He does exist, man will spend an eternity in heaven rather than in hell. Pascal's wager has been use by climatologists too. Even if you have doubts about the anthropogenic theory of global warming, act as if you believe in it

because if you don't, future generations might end up in hell on earth contending with carbon extraction costs, according to the authors, of up to $570 trillion.

Modern history shows that younger generations tend to be better-off than their parents and grandparents thanks to scientific progress in medicine, technology and economic growth. The young people, to which the authors refer, will be much better-off than us even according to the more pessimistic projections of the economic effects of climate change reported in the Stern Review (Stern 2007). Just as we are more resilient than our parents and grandparents, so future generations will be more resilient than us. Even a carbon clean-up cost of $570 trillion will be but a fraction of world GDP, especially when this burden is annuitized.

This is not to belittle the issue, but simply to place it in its correct economic proportions, and in the context of intergenerational equity with which the authors are concerned. The authors of the Stern Review (Stern 2007) grappled with this problem because they understood that it might be easier for future generations to cope with clean-up costs bequeathed to them, than it is for the current generation to prevent them. The central issue in this context is the determination of the intergenerational discount rate, which compares monetary values today in terms of monetary values in the distant future e.g. 2116. The intra-generational discount rate takes into account two factors, which translates future monetary values into current monetary values. Because of rising living standards over the life-cycle an individual prefers a dollar today to a dollar when he or she is older. But, even if living standards do not rise, the same individual might prefer today's dollar to one in the future because human beings are impatient; they have a positive rate of time preference. Also, the bird in the hand is worth more than two in the bush; a certain dollar today is worth more than an uncertain dollar in the future.

If, e.g. the discount rate is conservatively set at 3 percent per year, a dollar in 30 years' time is worth 41 cents today. A dollar in 100 years' time is worth only 5.2 cents today. In the Stern Review it was suggested that the intergenerational discount rate should be smaller than its intra-generational counterpart because interpersonal comparisons of time preference between generations are invidious. This controversial suggestion reduced the intergenerational discount rate in the longer term to about 2 percent at which a dollar in 100 years' time would be worth 13.8 cents today. This would mean that the cost of carbon abatement to the current generation must be less than 14 percent of the mitigated burden to our progeny in 100 years' time, if

intergenerational justice requires the current generation to undertake the carbon abatement polices proposed by the authors.

The authors' analysis of intergenerational justice is seriously lacking. Just because a future burden happens to be large does not necessarily mean that the current generation must undertake sacrifices in the name of intergenerational justice to prevent it. If, in addition, the future burden is uncertain e.g. because the authors' model does not represent the truth, but the cost of carbon abatement is more certain, this reasoning applies a fortiori.

Conclusion

The main suggestions to the authors are summarized:

1. Qualify the claim regarding the end of the hiatus in global temperature.
2. Provide further justification for the claim that the average temperature during the Holocene serves as a benchmark for sustainability.
3. Provide empirical evidence that the historic simulations of their model regarding global temperature are not spuriously correlated with actual global temperature.
4. Improve the discussion of intergenerational justice by integrating the intergenerational discount rate into the analysis.

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