Reviewers Hanley, Fix, and Jarvis each misrepresent the methods employed in Garrett et al. because they did not considered in its entirety the Methods section of the paper in question. Within that relatively brief Methods section was reference to a more detailed description of how cumulative production was calculated contained in *Garrett et al.* (2020). In any critique, it should be incumbent that it the methods being criticized be accurately represented, as well as the motivation used.

As a more general point, there seems to have been inadequate attention paid in the comments to the issue of how to add dimensioned quantities. For the question of adding rates of energy consumption it is clear enough, and there appears to be consensus. A rate defined in units of energy per time cannot mix e.g. exajoules per year with millions of barrels of oil equivalent per month. For questions of production and cumulative production, less care was taken. The essence of the calculation of the quantity of cumulative production W (units currency) is that it is a time integral of real, (mostly downward) inflation-adjusted Market Exchange Rate (MER) production (units currency per time). The statistics for production are provided not as a continuous function but in discrete units of currency per year. The challenge is that the units of currency in the sources provided are sometimes not inflation-adjusted (i.e. nominal rather than real) and sometimes in purchasing power parity (PPP) units rather than MER units. Further there is the question for a cumulative quantity of how to initialize the integral and when.

What is essential when adding is that the units be consistent. Production in nominal units from one year cannot be added to production in nominal units from another year without first adjusting for inflation. PPP dollars cannot be added to MER dollars. It's not even clear that PPP dollars for one country can be added to those from another country since the people are different and an adjustment was made for their respective standards of living.

Hanley and Fix in particular miss these points, in particular the methods used. Hanley further misses the approach taken in Garrett et al. with respect to the initialization in 1 C.E. The methods section clarifies what was actually done in Garrett et al. (2022). The reference contained therein to Garrett et al. (2020) is repeated here. The datasets used in Garrett et al. (2022) are modestly different, but the essential approach is the same. There is plenty to reasonably raise questions about within the methods that were adopted without misrepresenting it.

Calculation of cumulative production (from Garrett et al., 2020)

Market exchange rate estimates of Y_i, inflation-adjusted to "real" constant year 2010 dollars, are available from the World Bank and the United Nations for the years between 1970 and 2017 (*The World Bank*, 2019; UNs, 2020). Estimates of real GDP adjusted for purchasing power parity (PPP) 1990 USD are available for each year between 1950 and 1992, and in larger intervals extending back to 1 CE (*Maddison*, 2003). To calculate W these estimates are converted to market exchange rate MER inflation-adjusted 2010 values. For the time period between 1970 and 1992 for which concurrent MER and PPP statistics are available, the mean inflation-adjusted ratio PPP/MER is 1.205 with no clear trend.

A historical reconstruction of the annual global GDP is obtained by applying $\kappa(t)$ to the Maddison PPP values between 1 C.E. and 1970 C.E, applying a cubic spline between sparse data points to obtain annual values, and using World Bank statistics for more recent years (*The World Bank*, 2019). The value of world cumulative production W is then

$$W(t) = W(1) + \sum_{1}^{t} Y(t) \tag{1}$$

where $W(1)$ refers to total accumulated world cumulative production to date in 1 C.E. To obtain a value for $W(1)$, it is assumed that W and world population grew equally fast at that time. Available statistics suggest a population in ca. 1 C.E. (United States Census *United States Census Bureau*, 2021) that was 170 million and growing by 10 million every hundred years, at a rate of η_{pop} =0.059 % per year. The estimated value for the real MER GDP in 1 C.E. is 0.147 trillion 2010 USD. Assuming that civilization population and wealth grew at the same rate, i.e., $\eta_{pop} = \eta_W$, then from Eq. 19 it follows that $W(1) = 250$ trillion 2010 USD.

One criticism might be that MER dollars should be adjusted to PPP dollars (*Cullenward et al.*, 2011) since market exchange rates fail to account for differences in how people in different countries value equivalent baskets of goods. One rebuttal has been that such equivalents do not exist because different cultures value goods differently and that any discrepancies tend to diminish over time with a half life of three to five years due to the pressures of international and domestic trade (*Rogoff*, 1996). In the case of the work here, there is another counter-argument which is that there is no intent to address short-term inequalities between nations, only the global sum of all of civilization and its evolution over they long-run. Effectively, there is only one "basket of goods", and that is humanity taken as a whole, including all its social and physical networks.

Rates of global primary energy consumption from all sources $\mathscr{E}$ are available from the U.S. Department of Energy (DOE) Energy Information Administration (EIA) for the time period 1980 to 2016 and from British Petroleum between 1965 and 2017 (*DOE*, 2011; Bri, 2018). Rates of global primary energy consumption and production provided by the EIA have a mean ratio of 99.83% so here it is assumed that the two are equivalent.

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