

March 21, 2025

Dear Dr. Donges,

Many thanks for obtaining the second round of reviews on our manuscript. As the second reviewer had no further comments, we include below only the comments from the first reviewer, followed by our response (in blue).

I appreciate the time and effort you took to revise the manuscript in response to the three reviewers' feedback. Some changes were, in my view, very successful in addressing the concerns raised. I will admit that in other areas where you have sharpened your arguments, my disagreement has actually deepened.

Without going into much detail, this concerns mainly your arguments on how to disentangle social from physical processes to delineate the boundary and dynamics of the technosphere (and still its autocatalytic nature), and how you justify the end-use categories. I do not have the bandwidth right now to go into a detailed discussion, and I think it would also not be productive in changing your collective views on these issues.

That said, for the first issue, I do not think that it is currently possible for either side to argue our position from first principles, so there remains an element of judgment. The second issue is also one of judgment: whether or not the usefulness of the end-use categories justifies their shortcomings. It is your paper, not mine, so I think it is fair to concede these unresolvable points to you. The manuscript is now (somewhat) more reflexive, so it should be clear to readers that this is a contribution to efforts to "delineate the technosphere" and not the definitive answer in all regards. The manuscript is well written, and your positions are now argued clearly enough that future research can agree or disagree with them. Given the complexity and scope of the paper, I think this is very laudable and well justifies the publication of the manuscript in its present form.

I was going to leave it at that, but there is one thing that I cannot leave uncommented. Particularly considering the involvement of three preeminent scholars in social metabolism research from ISE/BOKU, I was reading the paragraph starting in line 424 in open-mouthed disbelief.

We were disappointed to hear that the end-use categorization remains unsatisfying, but also recognize that there can be no universal solution, and agree with the reviewer that multiple approaches will ultimately be helpful. Nonetheless we took this opportunity to attempt an improvement of the categorization and its description, and have made one last revision of the text to strengthen the reflexivity and further clarify the conceptual basis.

As part of this we shifted the language away from activity-centered to motivation-centered, as we feel this is easier to understand. We included text to clarify what we mean by ‘motivation’, given that this could be confused with aspects of psychology theory.

We also significantly rewrote the final paragraph of section 5 (starting line 424 in the prior version), with substantial input from the BOKU members of our team. Although we are not completely confident that we understand why the reviewer’s mouth was open when reading, our guess is that the previous version was too simplistic, and did not cite appropriate references. We hope the new paragraph does a better job.

Many other small adjustments were made throughout, including minor vocabulary adjustments and text rearrangements. In general these are to improve clarity, accuracy and readability, and have no bearing on the results or conclusions. Most notably the ‘catalytic’ section was moved from part 3 to section 5.1. Additional changes include:

- Changed pedosphere to regosphere, which is more appropriate according to the description of terms in Huggett (2024)
- Added headings to the principles, and streamlined them (section 3.4)
- Combined the Tier 1 MEUTEC categories Deliberate neural restructuring and Experience oriented, to form ‘Information, organization and neural interaction’ (since they really aren’t well distinguished) and expanded the discussion of how hard these are to categorize
- Separated the ‘ambient context’ category to be clearly unassociated with activities
- Accordingly we revised Figure 2, and simplified and rearranged it for legibility.
- Revised Figure 3 and tables to match adjusted categorization
- The supplement was updated, and reformatted to be tidy.

We hope that these largely-aesthetic improvements will be appreciated by the reader.

Warm regards,

Eric Galbraith, on behalf of coauthors