

Interactive comment on “A synthesis of carbon in international trade” by G. P. Peters et al.

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Thank you for the useful comments. The following responses (in Blue) explain the changes we have currently made to the manuscript to respond to the comments. We have made modifications based on nearly all the comments. We will thoroughly work through the document again before resubmission to ensure it reads well and fully and consistently responds to the comments of both reviewers.

General Comments

The manuscript "A synthesis of carbon in international trade" is a valuable contribution that achieves two important milestones in the literature on embodied carbon flows. First, it provides the first detailed and thorough quantitative comparison between studies on embodied CO₂ emissions (that use MRIO models) and second, it quantifies physical carbon embodied in international trade and addresses methodological issues with some comparisons to other work in the literature. The methodological comparisons are particularly useful as different dataset and model setups have been used with little insight to possible sources of variations in results.

My main criticism of the paper is that it appears too long. I don't know the length restrictions of this journal but the paper often reads more like a report than a journal publication. Some methodological comments and results are repeated several times. I have provided explicit examples in the specific comments below. My feeling is that the text could probably be shortened by a quarter and significantly streamlined.

- We have removed text in several places (see below), and believe it will be shorter in length (though we have no yet done a word count). As we fully revise the paper we will look for places where the text can be reduced further.

Conceptually, it is important to acknowledge and make it very clear that IO models ATTRIBUTE physical flows to certain economic activities. The authors rightly point out the different definitions of 'consumption' but another important difference between mass balance/MFA approaches and IO is that the first takes into account physical relocation whereas the second does not really (though there is a link of course). A comment on this should be included somewhere.

- We have a section on “embodied versus physical carbon”. We have moved this further forward and made it a more prominent section. We also made further emphasis on the distinction and refer to material flow analysis as an example.

Apart from that only some minor issues need attention as outlined below. I recommend publication after these and the length issue have been addressed.

Specific comments

Referring to line numbers ABOVE page numbers.

L20, p3952: maybe mention here that you will provide a more detailed explanation of 'apparent consumption' in the methods section.

- We do not mention this here, but a couple of paragraphs later we mention explicitly that we will "discuss different definitions of consumption"

L22, p3952: "... we are not aware of other analyses of physical flows of carbon that have used the more detailed and established models that have been developed and used to model embodied emissions." > one has just come out (Bruckner et al., in press) and I think one from the same author team is forthcoming in JIE. Please compare results.

- This paper, and some others, are now cited. See the following comment.

L2, p3953: "... previous studies that use "apparent consumption"..." > I wonder (but not totally sure) whether there are some more MFA/DMC studies that would fall under this category?! Please check e.g.: Steger and Bleischwitz, 2011; Steinberger et al., 2010; Schandl and West, 2010; Dittrich and Bringezu, 2010; Muñoz et al., 2009; Giljum et al., 2009; Bringezu et al., 2004; Weisz and Schandl, 2008.

- We rewrote the last few sentences of this paragraph to better represent the literature. It will now read something like:

"Relative to the literature on embodied emissions, there are considerably fewer studies tracking trade in biomass and the methods are often less developed. For instance, these studies often focus on "apparent consumption" which generally considers direct trade flows without processing (Ciais et al., 2007; Erb et al., 2009), or only a limited level of processing (Kastner et al., 2011b). There have been several studies on fossil fuel trade using apparent consumption (Bringezu et al., 2004; Dittrich and Bringezu, 2010; Steinberger et al., 2010), while Davis et al. (2011) and Bruckner et al. (2012) use more detailed models with processing. Davis et al. (2011) is the only study to consider fossil fuel extraction and trade in terms of carbon content and consider the processing of primary energy into secondary energy. As a generalisation, there has been more data and method development presented in the literature on embodied carbon flows compared to physical carbon flows."

Section 2.1.1.: important and very useful to have these definitions and examples!

L3, p3957: > "Exports... including the domestic supply chain only." > why only domestic supply chain? A full MRIO should include inputs from domestic and foreign economies to produce exports?

- The text was changed to "Exports: The production-based emissions occurring within X to produce exports to both intermediate and final consumption and hence including the domestic supply chain only"
- A new paragraph has been added

"Even though our method follows global supply chains, the exported emissions only consider domestic supply chains for total exports to both intermediate and final consumption. Other allocations can be used ([Peters, 2008](#); [Kanemoto et al., 2012](#)), but this method captures all global emissions whilst still retaining a direct link to monetary bilateral trade flows. This allocation scheme allows the emissions in each country to produce all exports to be determined. Another allocation scheme, for example, allocates global emissions to the export of final consumption only. This allocation scheme identifies the location of final production, but exports contain emissions from a variety of countries and thus lose the direct link to bilateral trade flows."

L15, p3958: "... this can be allocated in a variety of different ways..." > how for example?

- The sentence has now been removed

L8, p3959: rather than saying "emissions ... end... at" I would say 'emissions are allocated to'. The emissions actually don't move along the supply chain, they are just attributed to an activity.

- Fixed

Section 2.2.4: at what resolution are the crop data? Just total crops? Maybe a list of the crops could be included in an Appendix.

- We added, "...with around 160 crops included". We decided not to add the list to the appendix as it is quite long. Likewise, we did not add the GTAP sector and region names. These are all available from there references provided.

Section 2.2.5: what were the "additional calculations."?

- To be discussed later, comment added.

Bottom of page 3962: You could add that global totals need to be the same.

- Added

First para on page 3963: Para seems to say the same thing several times! Please prune!

- Not quite, the previous paragraph focused on the emission inventories, while this paragraph focuses on the definition (EEBT or MRIO). There is some overlap, but we think it is best to keep these paragraphs separate to avoid confusion. One sentence was pruned slightly.

p3963: I don't understand what is meant by "... this involves the method of compiling the data into an allocation model"?

- The paragraph was removed as it did not add that much.

Last para on page 3963: this para is not well written. Please rephrase and be clearer.

- This paragraph was reduced by about a half and rephrased. This should resolve any issues.

First sentence of section 3.2: Delete sentence. You can and have to be much more succinct. There is too much repetition.

- Deleted and rephrased

First sentence of section 3.2.1: It's about the sixth time I'm reading this sentence!

- Deleted

L11-15, p3967: yes. good.

Top of p3968: NAMEA has been defined before.

- We left this repetition as many of the readers may not know this acronym

Last para on page 3969: pls clarify. do you mean differences in direct emissions?

- We added a clarification in the opening sentence.

Section 3.2.2.: First Sentence superfluous.

- Removed

First line of page 3971: "... this thereby reduces the overall VARIATION IN consumption-based estimates". I think?

- Fixed

L9, p3971: it would be appropriate to cite Lenzen, 2011 here as well.

- Added

L19, p3972: ...using a comparison BETWEEN GTAP7.0 and GTAP7.1

- Added

L3, p3974: "... the variation in economic data may not be that important for consumption-based estimates...". True for NATIONAL footprints, but might be different at sector level.

- Fixed

Section 3.3. there is some duplication here as well. Not sure where this would be best placed but I think this could be streamlined, moved upfront or incorporated into the text.

- Yes, there was some repetition. We had mentioned a few things earlier, but now we incorporate it all into this section and we consequently shortened the text.

L24, p3975: is there no MFA study about fossil fuels?

- Yes, there are, having there are differences. We now have the following text:

"While several Material Flow Analyses (MFA) have investigated fossil fuels (e.g., Bringezu et al., 2004;Dittrich and Bringezu, 2010;Bruckner et al., 2012), Davis et al. (2011) remains the only analysis of the physical flow of carbon in traded fossil fuels; that is, Davis et al. aggregated the fossil fuels by carbon content and not mass or energy content. The MFA

studies generally use simplified trade analysis based on apparent consumption, while Davis et al. used a detailed MRIO attribution model including the conversion and trade in both primary and secondary fuels (e.g., refining of crude oil into gasoline). Thus, refined petroleum is allocated back to the country of primary fuel extraction (Davis et al., 2011)."

First lines on p3979: How much of that is embodied and how much is actual physical trade?! This is important to distinguish.

- It is all physical. We now explain this in more detail at the start of the section.

L1-3, p3981: this (good) example could be mentioned earlier

- A similar example was included in the section on "apparent consumption"

What is VXMD??

- We changed the name to TRADE (VXMD is a GTAP variable name)

L8-10, p3985: Again this is embodied carbon and not actual carbon as some would go into waste.

- We added a sentence to clarify this point, "Since the carbon flows considered in this section are based on the food intake by livestock, it is expected that we overestimate export flows as not all the carbon consumed by livestock enters trade flows".

P3987: "... Figure 12 shows the top-10 trade flows for CARBON IN HWPs, crops, and livestock..."

- Fixed

P3989/3990: carbon in office paper example appears twice > shorten pen-ultimate paragraph: "... we consider a higher level of processing...". You Could also say 'more intermediate steps', 'longer supply chains'.

- This sentence was deleted

Discussion and conclusions. Much text in discussion and conclusions is repeated!

- Both sections have been shorted slightly to avoid repetitions.

Table 3: Make clear that these are TERRITORIAL emissions

- Fixed

Table 8: I don't understand "... consumption of fossil fuel carbon (hence the production of emissions)..." Can you rephrase?

- Changed to "(equal to the territorial-based emissions)"

Fig 11: Very useful, definitions are important, i.e. Important to mention that differences are expected.

- This has now been emphasised throughout the paper.