Tracking of land flows embodied in global non-food supply chains using a Hybrid-MRIO approach

Guenther Fischer [1], Sylvia Tramberend [1], Bruckner Martin [2], Mirko Lieber [2]

[1] International Institute for Applied Systems Analysis, Laxenburg
[2] Vienna University of Economics and Business, Vienna

Summary

In this paper we apply and discuss hybrid (mixed-unit) input-output analysis for the case of land flow accounting by integrating agricultural and forestry statistics on production, trade and utilization quantities in weight units for the years 1995-2011 with a multi-regional input-output (MRIO) system in monetary units. Thereby we add further detail to the bio-based sectors of the economy and trace actual physical flows, thus avoiding the uncertainties introduced by the homogeneity and proportionality assumptions in conventional (monetary) IO analysis. Further utilization and trade of bio-based commodities not covered in agricultural statistics in physical units, in particular non-food industrial commodities, are traced further to final consumers by integrating the physical system with a monetary MRIO table (EXIOBASE 3.0). The resulting global MFA-MRIO system can be used to solidly trace direct and indirect flows of biomass and related land use through international supply chains.

Extended Abstract

The larger part of global biomass production is harvested with the purpose of providing food for humans, including indirect use through livestock feed. However, a non-negligible part is used for non-food and non-feed production, which is likely to increase in case of a growing bio-economy. This part may either comprise primary commodities produced with the only purpose of industrial use or with the objective to be used in both, food supply and non-food supply. Major examples for the former are cotton, natural rubber, tobacco, wool, among others, and for the latter sugar used for ethanol, starch for chemical products, animal fats for cosmetics, or oil crops for biodiesel.

Tracking land use embedded in global trade has been significantly advanced in recent years, analysing detailed data on biomass production, trade and use in physical and monetary units. Various approaches and models exist for the calculation of land use embodied in trade and final consumption of products (see, for example, Kastner et al. 2011; Weinzettel et al. 2013; Wilting and Vringer 2009; Yu et al. 2013). Calculations undertaken so far have shown discrepancies in the resulted estimations, particularly when including grassland and forest land (Bruckner et al. 2014; Kastner et al. 2014) which illustrates a potential for further enhancement in the underlying methods and assumptions.
In this paper we apply and discuss a hybrid accounting approach by using supply utilization accounts (SUA, see FAO 2001) for the years 1995-2011, provided by FAOSTAT (2014) in weight units, and integrate it with a multi-regional input-output (MRIO) system in monetary units. This allows for a consistent approach to obtain an improved accuracy in the allocation of product flows which are not reported in agricultural statistics, i.e. non-food industrial commodities. We go one step further than previous hybrid IO models (for example, Weinzettel et al. 2013), which integrated physical data into

an IO model for flows from agriculture to the first processing stage, by using the available agricultural statistics in its entirety, in many cases covering flows to the second or third processing step.

The physical model tracks land from production (i.e. harvest) to final utilization following the supply chains reported in the SUA. In the case of food products, all flows are captured in the SUA to the point of consumption. However, information in FAO statistics focuses on food products and aggregates non-food products into a utilization separate category, which is only traceable to the first processing stage, truncating any further flows of these goods. All bio-based industrial commodities which are further processed in sectors other than the agricultural sectors covered by the SUA therefore cannot be tracked any further; a fact that was ignored in many previous studies (for example, Kastner et al. 2011). To overcome those boundaries and obtain a better representation of the land footprints associated with such commodities, these flows are linked to a MRIO model which makes it possible to track direct and indirect flows in detail through international supply chains.

The applied MRIO database EXIOBASE 3.0 (Tukker et al. 2013) covers the global economy in a detail of 44 countries and 5 'rest-of' regions, each subdivided into 200 products. The land flows associated with non-food supply chains are allocated to manufacturing industries according to the respective monetary supply und use structure in each of the regions in the MRIO model. This allocation occurs in two ways, either directly from agriculture to non-food industries in case of industrial crops like fibres and rubber, or as a by-product flow from food sectors to non-food industries for industrial commodities which are produced from food crops.

Hybrid approaches are considered to be particularly promising for the analysis of land flows embodied in non-food land-based products (Bruckner et al. 2014; Weinzettel et al. 2014). The underlying approach combines the advantages of high detail for commodities with a low level of manufacturing reported in agricultural statistics and of the full coverage of the whole economy reported in economic statistics. It therefore enhances accounting techniques purely based on agricultural statistics while going one step further than previous hybrid IO models in the integration of physical statistics into the IO framework for the study of global land footprints.

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