Climate change impacts on agriculture using improved multi-region input-output framework

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Agricultural sector plays a central role in the climate change adaptation and mitigation strategies. As it is one of the key global emitters of greenhouse gasses (GHGs), much effort has to be put in order to reduce its carbon footprint. At the same time, according to many studies, it is arguably the most vulnerable sector to face the impacts of global warming with both land and water availability, as well as yields productivity, being under pressure. One of the approaches that attempts to consistently cover the global interactions between climate-related adaptation and mitigation strategies in the agricultural sector is a multi-region input-output (MRIO) framework.

This study assess climate change impact on the agricultural sectors under different quantitative projections of the Shared Socioeconomic Pathways (SSP) database. To this end, we dramatically improve the agricultural representation of the Global Trade Analysis Project (GTAP) Data Base. This database can be considered an MRIO, which when reconciles its data inputs focuses on international datasets more than in the various Input-Output (IO) tables at its core.

Any MRIO framework usually faces several limitations mostly driven by data availability issues. These include both low regional coverage and insufficient level of agricultural sector disaggregation. Moreover, even if an IO table has the required level of sectoral representation, it may be outdated and thus in need for updates. Several approaches are applied to overcome these issues. In particular, the GTAP Data Base, which sectoral classification includes 12 agricultural and 8 processed food sectors for 121 countries and 20 aggregate regions, uses a two-step procedure.

First, a special agricultural and food IO table is developed. It is based on the set of IO tables from representative countries as well as Food and Agricultural Organization (FAO) data and is used to split up agricultural sectors and related activities in the IO tables that require disaggregation. Second, selected countries are subjected to an agricultural production targeting (APT). The purpose of this procedure is to update the IO tables to match the agricultural production targets mainly in Organisation for Economic Co-operation and Development (OECD) countries and some large agricultural producers (46 countries in total). Key data is sourced from the OECD database and provided by the Joint Research Center (JRC) for EU countries based on Eurostat data. While providing a valuable contribution to the GTAP Data Base development framework, the current approach to the APT targeting has some limitations and potential for further improvements.

First, following the OECD agricultural commodity classification, input data includes high share of unclassified/undistributed (non-MPS) commodities, which should later be distributed among agricultural sectors. According to 2011 data, an average share of the non-MPS commodities for 25 non-EU regions represented in OECD database was 27%. Second, while covering 46 regions (corresponding to the 70% of global agricultural output), the APT process used in latest available GTAP version 9 (released in 2015) still missed most developing countries and some major agricultural producers, like India. Finally, because the OECD data does not cover all agricultural commodities, some food commodities output are used to complement the dataset.

Such limitations of the agricultural sector representation in the GTAP MRIO potentially have a significant impact on the results of the climate change policy simulations, influencing both sectoral and regional distribution of outcomes. In an attempt to overcome these shortcomings and provide a more consistent assessment of climate change impacts on global agriculture, we develop an approach to APT values estimation, which is based on the FAO database and some additional data sources. 5-step approach used in our study allows to estimate the APT values for 133 regions of the GTAP MRIO.

The newly developed APT targets combined with the JRC-based agricultural data for EU countries

are used to produce an alternative GTAP Data Base, which is used to explore the impacts of climate change on the global agriculture with a dynamic computable general equilibrium model. We show how and improvement of agricultural sector representation in the GTAP MRIO affects the results of the assessment of climate change impact on crop yields by countries and sectors.

This paper hopes to contribute to the ongoing efforts on improving the representation of the agricultural sector in the MRIO framework by taking advantage of the international datasets. Utilizing the benefits of agricultural sector representation, our study also intends to extend the literature on the assessment of long-term climate change impacts on agriculture.