Incorporating critical minerals and renewable energy technologies into the Multi-Region Input-Output framework: a case of GTAP

Topic: Input-Output Accounts (2)
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Decarbonization and digitalization will change the structure of the global economy. Decarbonization leads to a shift in demand away from fossil fuels and towards more sustainable energy sources, with renewable energy equipment heavily relying on critical minerals as inputs. Digitalization and the growth of artificial intelligence (AI) generate increased demand for semiconductors and other equipment, also fostering demand for critical minerals.

Multi-region input-output (MRIO) and Global Computable General Equilibrium (CGE) models are well-suited for the assessment of the impacts of decarbonization, digitalization, and the growth of AI on critical mineral supply chains. However, while being widely used to support the decision-making process in the part of mineral mining and downstream activities, most of the available MRIO-based assessment frameworks still lack essential details to facilitate the granular analysis in this area.

Building on the Global Trade Analysis Project circular economy (GTAP-CE) database version 11, this paper introduces critical minerals and downstream products, including equipment used to generate renewable energy, thus constructing the GTAP-CM (critical minerals) database, further extending previous developments in this area (Chepeliev et al., 2025). The extended database introduces 42 new activities to GTAP-CE, covering four stages of the mineral supply chains: (i) mining of critical minerals; (ii) refining of critical minerals; (iii) intermediate sectors such as batteries and magnets; (iv) downstream sectors such as solar panels, wind turbines, and electric vehicles. The paper contains a detailed description of the data employed, the methods used to reconcile different data sources, a comparison of raw data inputs, processed data inputs, geographic production shares, cost structure and sales structure, as well as descriptive statistics based on the constructed database, such as trade and production concentration indices.

In addition, the paper will discuss several ongoing data developments related to the GTAP-CM database updates.

1. Extension of GTAP-CM with 2023. Due to the rapid changes in the renewable energy and digital sectors, it is important to construct the GTAP-CM database for 2023, allowing for a more up-to-date and realistic starting point for the modelling assessments. The paper will feature ongoing efforts in this area and discuss some of the data challenges related to the parametrization of the critical minerals supply chains in the rapidly evolving economic and policy landscape.
2. Extension with semiconductors. So far, the data work has focused on renewable energy sectors and critical minerals essential for their production. To study the upstream effects of digitalization and AI, semiconductors should be explicitly included in the database representation. Incorporating these supply chains in the GTAP-CM database would be an important development, allowing for the analysis of semiconductor-related policies. In addition to the rich trade data (ITC, 2025) and industry information provided by the UNIDO (2025), selected national input-output (IO) tables for economies that provide detailed information to identify semiconductors could facilitate the parametrization of the semiconductor supply chains.
3. Investment matrix. To comprehensively study the emission effects of trade and other policies impacting the costs of renewable energy equipment (batteries, solar panels, wind turbines) the existing database and model have to be extended with sector-specific investments. Given that about 80% of inputs in the renewable energy sectors consist of capital, most of the renewable energy equipment used by these sectors is capital. At the same time, the conventional GTAP approach works with a capital accumulation equation at the national level, implying uniform composition of capital inputs across all sectors of the economy. By developing an investment matrix, distinguishing the sourcing of investments by sector, and including a sectoral capital accumulation equation into

the GTAP-based modelling framework, this omission can be addressed. Such development would allow for a more realistic assessment of the energy transition and mineral-related policies. A number of available data sources could facilitate the development of such investment matrix, and the paper will discuss ongoing work in this area.

4. Reserves of minerals and extraction curves. The database constructed for 2017 (and later for 2023) only contains information about current production structures. However, production can expand and shift depending on demand and policies. To study this, we need to incorporate a database of reserves of critical minerals combined with extraction curves indicating how responsive supply is to changes in prices. The paper will discuss available data sources, potential for incorporating corresponding data into the CGE models and needs for future research in this area.