Tracking metal flow network using hybrid Ghoshian framework

Topic:
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Material Flow Analysis (MFA) concerns how natural resources are extracted, how they are transformed and used by economy, how they are discarded or recycled, and where they accumulate or diminish. Clearly Input-Output Analysis (IOA) is closely related with MFA, as it deals with the interactions between industries by means of producing and consuming goods and services. Typical imputation analysis that Leontief IO framework deals with, however, concerns the quantity of factor inputs necessary to meet certain final demand, which is a slightly different class of question than those posed by MFA.
MFA generally starts from the source: extraction of materials from nature. Once extracted from nature, industrial materials are passed on to various processes along the supply-chain, and the number of processes involved quickly become significant after a few tiers of downstream supply-chain. Collecting material flow data by visiting each and every individual facility involved is therefore impractical under finite time and resources. On the other hand, product classification in an input-output table, even with over 400 categories distinguished, is often not adequate for characterizing the flows of particular material.
In this study, we employed mixed-unit Ghoshian framework and combined input-output and process-specific data from a survey of individual facilities. The approach is used to analyze the flows of 5 metals that are lead, zinc, manganese, aluminum, and molybdenum using data from South Korea.
The official South Korean input-output table, which distinguishes 404 products, is disaggregated to better identify unique allocation structures for selected metals using physical, bottom-up data. The table is further augmented to include waste, household, and export, for which physical, bottom-up data have been collected. For each metal, products containing the metal within the product and those not are distinguished using a Boolean vector. The basic allocative structure is then converted into a metal flow map in physical quantity using bottom-up data on import and domestic supply of each metal. The result is used to identify major flows of each metal between industries, household, and the natural environment. Detailed on-site data are collected only for the major flows identified, and relevant estimates are replaced by more accurate on-site data.
The results are also used to draw material flow maps and to estimate end-recipients of each metal. Different metals exhibited different pathways in intermediate supply-chain, while their end-recipients were remarkably similar. Except for lead, where motor vehicle is the dominant end-recipient, significant portion of other metals were ended up in building construction, infrastructure and civil engineering projects, and machineries and equipments. The analysis informs material resources policy and urban mining strategy. The analysis is currently being extended to analyze the changes in material flow structures and accumulation of materials in the economy over time using time-series data. The approach demonstrates the wisdom of hybrid approach, where top-down data is combined with bottom-up data maximizing the potentials of the two.