

GTAP-LVS: A Disaggregated Livestock Extension for Multi-Regional Input–Output and Environmental Footprint Analysis

Topic: Input-Output Analysis: Sustainable Production and Consumption policies (2)

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Livestock systems differ substantially in animal species, production practices and technologies, feed structures, and environmental impacts, yet most global multi-region input-output (MRIO) frameworks have a rather aggregate representation of this sector. For instance, the Global Trade Analysis Project (GTAP) database, widely used for socio-economic analysis and modeling, represents all live animal livestock with only three aggregate sectors. Other widely used MRIOs, including EXIOBASE, WIOD, and EORA, also have a relatively coarse representation of the primary livestock activities. This aggregation constrains the ability to properly evaluate climate mitigation, dietary transitions, trade reforms, and structural transformation in livestock supply chains.

This study addresses the following research question: how can the GTAP database be systematically restructured to reflect species-level, production-system, and feed heterogeneity in global livestock systems while maintaining consistency within a multi-region input–output framework?

We develop the GTAP-LVS database, an enhanced disaggregation of the GTAP-Power 11 database. The GTAP-Power 11 database contains data for 160 regions, 76 activities, including 3 primary livestock sectors (cattle, other animal products, and raw milk). To develop GTAP-LVS, these 3 sectors were disaggregated by animal species (beef cattle, dairy cattle, dairy sheep and goats, meat sheep and goats, pigs, and poultry) and production system. Ruminant production (cattle, sheep, and goats) can be produced in 3 production systems (extensive/grazing, mixed crop-livestock, and landless/industrial), whereas monogastric production (pigs and poultry) can be produced in 2 production systems (backyard or industrial). This expanded the livestock activities from 3 in GTAP-Power to 25 distinct livestock activities in GTAP-LVS. Each livestock activity produces one of 3 commodities (meat, milk, and eggs). To facilitate a better representation of the various livestock production systems, the other grains and oilseed sectors were disaggregated, with 6 new grain sectors (corn, sorghum, barley, other cereal grains, soy, and other oil seeds).

The construction of GTAP-LVS reconciles physical livestock output, feed use, and emissions data with the economic structure and emissions recorded in the GTAP database. Quantity data on animal numbers, outputs (meat, milk, eggs), and 12 feed categories (including grazing biomass and major feed crops) are mapped to GTAP sectors. Bilateral trade flows are constructed from FAOSTAT quantities and prices and reconciled to GTAP aggregate trade totals. Feed quantities are used as weights to disaggregate intermediate input flows, while cost structures of new activities are derived from parent sectors and adjusted to reflect feed and land use intensity. Grazing feed is explicitly linked to land input; land payments are removed for systems without grazing. Livestock greenhouse gas emissions (CH₄, and N₂O) are incorporated using process-based estimates that account for animal diets and production systems. Emissions are allocated across activities using system-level data. The resulting database provides internally consistent production, trade, cost, and emissions accounts at detailed activity level.

We develop the MRIO-based assessment framework and present environmental footprint indicators across livestock activities, including emission intensities by species and production system at global and country levels. The results reveal substantial heterogeneity in emission intensities across specialized ruminant meat herd, dairy, pigs, and poultry, and across different production systems. Differences in feed composition and land use explain a significant share of cross-system variation. The database also enables comparison of cost structures, showing systematic differences in feed, land, and intermediate input shares across production systems. In addition, the developed

assessment framework allows to trace the economic impacts of various livestock activities, including labor multipliers and employment, differentiated across skill types.

The primary contribution of this study is the creation of a globally consistent livestock extension of the GTAP database that integrates species-level detail, production-system heterogeneity, refined crop–feed linkages, and emissions accounting within a unified multi-region input–output framework. By expanding livestock into 31 activities and aligning physical, economic, trade, and environmental data, GTAP-LVS substantially enhances the capacity of IO and CGE models to assess climate mitigation strategies, dietary shifts, trade policies, and structural transformation in the livestock sector.