Disaggregating Livestock Sector in the GTAP Data Base

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Abstract

Despite the heterogeneity of the livestock sector, the Global Trade Analysis Project (GTAP) Data Base utilized in many global computable general equilibrium models, represents livestock with only three sectors, lacking important technological and agricultural details needed for a comprehensive assessment of the livestock-related policies. The current paper consists in the development of a new dataset (based on GTAP) with a higher level of detail in the livestock sector and related commodity flows, such as feed, food loss and waste. The GTAP Data Base is disaggregated into six livestock sectors: large ruminants for meat production (cows, buffalo), small ruminants for meat production (sheep, goats), pigs, poultry, large ruminants for milk production, and small ruminants for milk production. This study distinguishes three ruminant and two monogastric production systems (with some geographic and climatic variability). The ruminant systems under consideration will include: grazing, mixed, and industrial. The monogastric systems will include: backyard and industrial. The disaggregation of the livestock sector requires refining the representation of the feed sectors, as these not only affect livestock productivity, but also its environmental impacts. There is sufficient data on crop production, already incorporated in the GTAP Data Base with the nutritional extension, but data on grass and crop residues is scarcer. As these are not usually marketed feeds, filling those gaps requires creating either a shadow price or a specific rule system.

This database can be the foundation for assessment of various policies and measures aimed at delivering sustainability solutions in the global livestock sector, including: Climate change mitigation, healthier diets, meat substitutes, circularity, and the analysis of the implications of changing agricultural trade and domestic support policies in the context of promoting sustainability transition in the livestock sector.

Introduction

The contribution of livestock to livelihoods and nutrition cannot be overemphasized. Livestock products provide 16% of global kilo-calorie consumption and 35% of global protein consumption (FAO, 2024). Livestock contributes 40% of total agricultural output in developed countries and 20% in developing countries and supports the livelihoods of almost 1.3 billion people (FAO, 2018). Currently, the value of livestock in assets and products is higher than the total value of crops (Schrobback et al. 2023). On average, over the last 25 years, global demand for animal sourced foods has increased by more than 40kg/person/year (FAO, 2024). However, this number hides substantial variation across regions and by commodity within ASFs, with several different trends operating in opposing directions (Herrero et al 2023). This growth has been driven by population growth and improvement in living standards, and continuing with that process, future demand is expected to continue to increase by more than 70% by 2050 (Alexandratos and Bruinsma, 2012), with very different trajectories in different regions and with different products (Herrero et al. 2023)

Globally, livestock production is responsible for at least 12% of human-induced greenhouse gas (GHG) emissions (FAO 2023) and uses 80% of total agricultural land (Steinfeld et al. 2006). The complexity of the livestock's environmental impacts arises from the inclusion of animals, land, and upstream and downstream sectors, making it difficult to measure. Furthermore, livestock products and production systems vary substantially, each with unique feed efficiency, environmental impacts, and climate change mitigation options (Herrero et al., 2013; Herrero et al. 2023, U.S. EPA, 2019). Given the importance of livestock for human nutrition and livelihoods, climate change mitigation policies involving livestock must be designed with extreme care (Lee et al., 2021).

Despite the heterogeneity of the livestock sector, the Global Trade Analysis Project (GTAP) Data Base (Aguiar et al., 2023), utilized in many global computable general equilibrium models, represents livestock with only three sectors, lacking important technological and agricultural details needed for a comprehensive assessment of the livestock-related policies.

Contribution of the study

The current level of the GTAP Data Base disaggregation is not sufficient for a comprehensive assessment of livestock sustainability transition policies. The main contribution of the current paper is the development of a new livestock dataset (based on GTAP) with a higher level of detail in the livestock sector and related commodity flows, such as feed, food loss and waste, among others.

Sub-dividing ruminants into large and small ruminants would allow, for example, the representation of beef production, which with is the dominant sector amongst ruminants and is the main driver of income and environmental impacts from the livestock sector (65-75% of emissions, Herrero et al. 2016). Nutritional analyses have looked at the impact of red meat consumption on health (Clark et al., 2019). However, nutritionists define red meat as the combination of ruminant meat and pork. Being able to represent pork separately from poultry would facilitate modelling focusing on nutritional and health objectives. We will disaggregate the GTAP Data Base into six livestock sectors: (1) large ruminants for meat production (cows, buffalo), (2) small ruminants for meat production (sheep, goats, lamb), (3) pork, (4) poultry, (5) large ruminants for milk production, and (6) small ruminants for milk production It is important to model meat and milk herds separately as they have very different feed and land use patterns and emission intensities (Herrero et. al 2013, Henderson et al. 2017).

Previous work has tried to categorize production by agro-ecological zones (AEZ) and intensity of production (Thorton et al. 2006, Herrero et al. 2013). This study distinguishes 3 ruminant and 2 monogastric production systems. The ruminant systems under consideration will include: (1) Extensive – almost entirely dependent on grazing, with limited potential of future growth; (2) mixed – some grazing, supplemented with crop residues, and some concentrate feeds made from marketed grains and oil meals; and (3) intensive – more industrialized system with more use of commercial feeds, some grazing/ grass still on input, and faster turnaround in terms of animals being fattened and slaughtered. Within each of these systems, there is heterogeneity in productivity and cost structure across different regions and climates. The monogastric systems under consideration will include: (1) low intensity – more like backyard production with fewer inputs and less efficient; and (2) high intensity – industrial production with high-efficiency use of inputs and rapid processing and reproduction of animals.

Feed is by far the most important input to the livestock sector. Feed inputs are important not only for determining productivity but also the environmental impact of livestock, including GHG emissions (Herrero et al., 2013). Being able to disaggregate livestock sectors, also means having a more refined representation of the feed sectors. Monogastrics, particularly in intensive production systems, predominantly are fed commercially marketed feeds (cereals, and oil meals). These are also important sources of feed for many ruminant systems, but in many other systems, biomass from grazing and crop residues is the dominant input. Thus, an adequate representation of ruminants needs to account for the supply of biomass in rangelands and pastures, as well as crop residues. There is sufficient data on crop production, which can be obtained from FAOSTAT, and is already incorporated in the GTAP Data Base with the nutritional extension (Chepeliev, 2022), but data on grass and crop residue is scarcer. As these are not usually marketed feeds, it also requires creating either a shadow price or a specific rule system to ensure that extensive livestock production is adequately treated. The two global data sets that will provide important information on the relationship between feed use and emissions include Herrero et al. (2013) and FAO (2018).

Other data sources that will provide useful inputs for the disaggregation of the livestock and related sectors in the global input-output framework include the FABIO database, which reports quantity flows of agricultural and food products in the global economy (Bruckner et al., 2019). The EORA database is a global MRIO database with mixed quantity/monetary flows, which covers 190 countries (Lenzen et al., 2013). Feedipedia (www.feedipedia.org) provides inputs for estimating nutritional equivalence (protein and energy) for feed inputs. GTAP-AGROFOOD database (Britz, 2022) introduces 51 additional agro-food products to the GTAP 10 Data Base with 2014 reference year.

It would be important to properly capture several other data inputs and details in the constructed dataset. For the proper representation of preference shifts and dietary changes, it is vital to trace the nutritional accounts within the assessment framework, including food and nutrient supply. To accomplish this, we rely on a study by Chepeliev (2022), which develops an approach toward incorporating nutritional accounts in an economy-wide modeling framework tracing quantities of food, calories, fats, proteins, and carbohydrates along the value chain.

Proper quantification of food loss and waste (FLW) flows generated across global food supply chains is another important dimension for assessing sustainability solutions in the livestock sector (Parfitt et al., 2010). To address this point, in the current study, we will rely on a newly developed methodology toward incorporating FLW flows in an economy-wide modeling framework following Gatto and Chepeliev (2023). One particular challenge is to distinguish which of the FLW flows at different supply chain stages and commodities have the potential to be used as feed.

Potential to generate the discussion

The enhanced global GTAP data base developed in this study is of particular interest to modelers and policy-makers who are involved in the analysis of the livestock sector in particular, as well as broader food and nutritional policies. The current study represents the first step in the broader set of livestock-related modeling, aiming to develop data and methodological framework for a detailed and comprehensive assessment of the various livestock-related policies. The global database developed in this study is a foundation for assessment of various policies and measures aimed at delivering sustainability solutions in the global livestock sector, such as: (a) Climate mitigation policies and measures in the livestock and other agricultural sectors; (b) Policies and measures toward promoting healthier diets, including (red) meat taxation with a potential imposition of subsidies to healthier foods, such as fruits and vegetables; (c) Changing demand patterns and policies focused on promoting meat substitutes; (d) Measures promoting circularity in the livestock sector: using biomass for human consumption first, reducing food loss and food waste, while recycling remaining by-products to the agricultural system; (e) Analysis of the implications of changing agricultural trade and domestic support policies in the context of promoting sustainability transition in the livestock sector.

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