# Projecting demand elasticities for disaggregated animal food products under alternative Shared Socioeconomic Pathways

## Introduction

Dietary transitions play an important role in the discussions of food and nutrition security, land use, the environment, climate change, and public health (Clark et al., 2020; Crippa et al., 2021; Hawkes, 2006; IPCC, 2022; Springmann et al., 2018; Willett et al., 2019). In particular, the possible convergence of low- and middle-income countries to western diets rich in animal food products would have profound implications on how natural resources are exploited by agricultural activities, and on the climate impacts of the agricultural and food system (Tilman & Clark, 2014).

Parameters such as income and price elasticities are key to shape trajectories of dietary development, which are often necessary in the construction of baseline and alternative future scenarios (Ho et al., 2020; Valin et al., 2014). Focusing on dietary transitions, it is desirable to incorporate a higher level of disaggregation on the food demand elasticities. Particularly, it is relevant to disaggregate the animal food products, given that their resource use intensities and greenhouse gas emission intensities differ (Poore & Nemecek, 2018). This suggests that both the total share of animal food products in dietary choices and the composition within animal agricultural products have important implications (Poore & Nemecek, 2018; Willett et al., 2019).

In this paper, we estimate income and price elasticities for disaggregated animal food products across countries from a meta-analysis. The meta-analysis is based on data collected through a systematic review of the food demand elasticities, with an emphasis on disaggregated animal food elasticities. Recognizing the need from the modeling communities to specify alternative dietary transition scenarios under different socio-economic trajectories, we further generate a complete set of demand elasticities under alternative shared socioeconomic pathways (SSPs), using existing SSP data sets on income and demographic developments at the country level (Riahi et al., 2017). Since the elasticities estimated from the meta-analysis are not necessarily theoretically consistent, we also develop and implement a calibration method to generate a set of food demand elasticities compliant with the Engel and Cournot aggregations, as well as a set of parameters for the CDE demand system to allow for readily replication of these elasticities in the GTAP model (Corong et al., 2017).

## Data

In this study we build a meta-data set collected through a systematic review of the literature. To retrieve enough disaggregation in the animal food sector, we emphasized the search for meat and dairy products.

The meta-data contains elasticity estimates from 444 studies coming from bibliographic and grey literature and published after 1990. The studies were selected using the MAER-NET guidelines (Havránek et al., 2020). We collected information about the bibliographic reference, information related to the elasticity estimate, and information related to the data used for the estimation. Overall, our database contains 51,207 observations where 8,510 correspond to expenditure elasticity estimates, 9,253 to own-price elasticities, and 33,444 to cross-price elasticities. From the World Bank (2022) data, we use the GDP per capita, % urban population, % of population under 15, and % of population over 64 years old. We merge them with our database using the country and year of data collection. To project the elasticities, we use the basic elements of the SSP (Riahi et al., 2017). Particularly we use the GDP (Dellink et al., 2017), population (Kc & Lutz, 2017), and urbanization (Jiang & O'Neill, 2017) data. Finally, we use the market shares derived from the ICP 2011 and 2017 (World Bank, 2020) disaggregated datasets in our calibrations.

## Methodology

In the study we use a 3-step estimation strategy of the demand elasticities. First, we perform meta-regressions based on data from literature and use the SSP data to generate the elasticity projections for the different countries and scenarios. The dependent variable in our regressions is the elasticity estimate. As explanatory variables we include information on the commodity for expenditure and own-price elasticities, and commodity-pairs for cross-price elasticities; information on the type of data and model used; variables assessing the quality of the publication; the country's socio-economic variables from the World Bank; the world region the elasticities' estimates belong to; and interactions between some of the variables. Second, we calibrate the estimated elasticities to ensure compliance with consumer theory. For this calibration we calculate the set of price and income elasticities in an optimization program, where the weighted sum of elasticities' squared deviations from the initial estimates is minimized, subject to constraints given by Engel and Cournot aggregation properties, and where the weights depend on the initial elasticity estimates' standard deviations. As a robustness check, we replicate the optimization procedure where the least-squares criterion is replaced by a minimum cross-entropy criterion. Third, we further calibrate these elasticities to the CDE demand system parameters, using the routines developed in Liu et al. (1998) and in Yu et al. (2004), to facilitate the replication of the theoretically consistent elasticities in the standard GTAP model.

## Expected results

The main outputs from this paper are two datasets. In the first dataset, theoretically consistent elasticities projected under different SSP scenarios are provided. This should be useful for modelers using demand systems other than CDE. The second will be the result of the second calibration and will provide parameters ready to use with GTAP.

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