Carbon-taxation of food consumption: A global perspective

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Introduction

Reducing food consumption emissions is an important step to achieve net-zero emissions in the food system by 2050 (Costa et al., 2022). Thus, countries with net-zero commitments and relatively high per capita food consumption emissions should factor in food consumption in their decarbonization strategies (Springmann, Clark, et al., 2018). In the next decade, middle-income countries are expected to rapidly transition from staple-rich diets towards diets richer in animal food products (OECD & FAO, 2023). Therefore, if only selected high-income countries apply a food carbon tax, there could be unintended consequences for total emissions and health outcomes if the price in the rest of the world (ROW) of some food products becomes low enough.

In this paper, we investigate how food consumption decarbonization strategies affect greenhouse-gas (GHG) emissions and health outcomes. The strategies are designed to consider different ways of sharing the abatement burden across countries.

Methodology

We use a three-stage procedure (see Fig. 1). First, we calculate the demand changes using a demand system (Robinson et al., 2015) for the countries that apply the carbon tax. Then, to obtain the general equilibrium effects, we target these demand changes in GTAP (Corong et al., 2017) through a tax instrument. Third, we input the demand changes in a comparative risk assessment (CRA) of dietary and weight-related risks (Springmann et al., 2020; Springmann, Wiebe, et al., 2018) to estimate the health implications of carbon pricing.

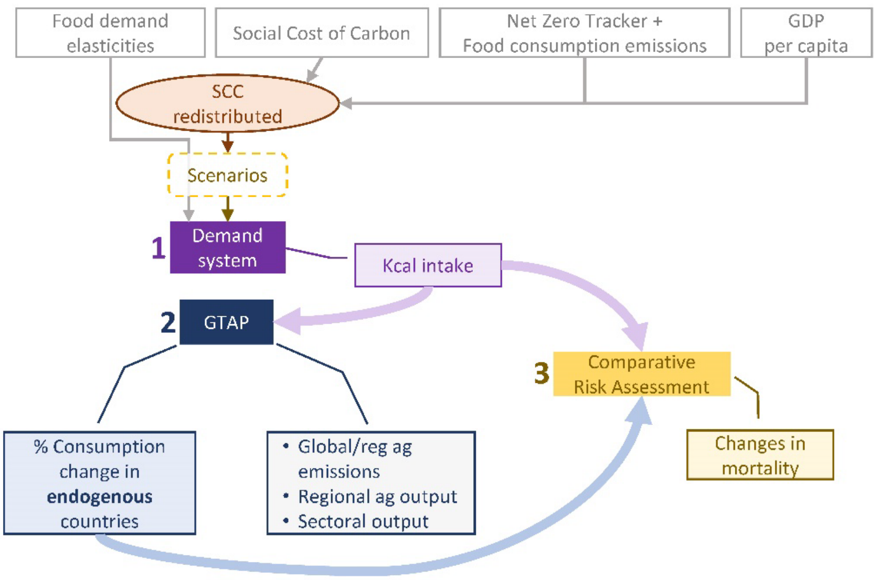

Figure 1. Summary of the methodology.

The reason we decided to circumvent the CDE demand system in GTAP is because it has serious limitations to capture cross-price effects (Boysen, 2019; Hanoch, 1975). These are key to estimate the effects of a GHG tax on food consumption, since GHG intensities significantly vary across specific food groups (Poore & Nemecek, 2018) and substitution across food groups is expected.

We define the carbon tax level using Social Cost of Carbon (SCC) estimates. Even if the SCC is a global measure, inequalities across countries/world regions should be taken into account (Anthoff & Emmerling, 2019). Similar to previous scenarios(e.g., the GLOBTAXPROP scenario of Jansson et al. (2023)), we redistribute the burden of the tax using the GDP per capita in PPP as a weight, so that the weighted average is the same as the SCC.

To explore the leakage effects of a partial (i.e., non-global) GHG tax of food consumption we design seven scenarios (see Table 1). The group of countries applying the tax depends on their level of ambition in terms of net-zero targets and on their per capita emissions from food consumption. The reason is that countries with more stringent climate targets and high per capita emissions from food consumption have strong incentives to apply a carbon tax to transition away from GHG-intensive diets as part of their decarbonization strategies. In scenarios 1-3 the countries not applying the carbon tax are set to keep their demand constant. These scenarios will not reflect the leakage effect but the full GHG reduction potential of the tax. In scenarios 4-6 the demand in the countries not applying the carbon tax will be calculated endogenously in GTAP, in order to capture the leakage effects. Finally, in scenario 7 there is a global tax on food consumption.

Table 1. Scenarios design.

Sce.	Countries net-zero plan + high per capita emissions from food consumption	Countries net-zero goal + high per capita emissions from food consumption	High-medium per capita emissions from food consumption	ROW
1	Tax	Constant demand	Constant demand	Constant demand
2	Tax	Tax	Constant demand	Constant demand
3	Tax	Tax	Tax	Constant demand
4	Tax	Endogenous demand	Endogenous demand	Endogenous demand
5	Tax	Tax	Endogenous demand	Endogenous demand
6	Tax	Tax	Tax	Endogenous demand
7	Tax	Tax	Tax	Tax

To obtain the health outcomes we apply the changes in consumption from the countries applying the tax and from the endogenized regions back into a global health model based on risk-disease relationships (Springmann, Wiebe, et al., 2018). Our CRA model includes eight diet and weight-related risk factors and five disease endpoints. The risk factors are high consumption of red meat, low consumption of fruits, vegetables, nuts, and legumes, as well as being underweight, overweight, and obese, the latter of which are related to changes in energy intake from all foods. The disease endpoints are coronary heart disease (CHD), stroke, type-2 diabetes mellitus (T2DM), cancer (in aggregate and as colon and rectum cancers), and respiratory disease.

Data

The demand system (Robinson et al., 2015) is parameterized with meta-estimates of food demand elasticities obtained using a large database with food demand elasticities collected from the literature (Bouyssou et al., 2024) and a machine learning model (Chen & Guestrin, 2016). For the general equilibrium simulations, we use the GTAP database v.11 (Aguiar et al., 2022).

We use publicly available data sources To parameterize the comparative risk analysis, we use publicly available data sources (Springmann et al., 2020; Springmann, Wiebe, et al., 2018). We adopt relative risk estimates that relate change in risk factors to changes in disease mortality from meta-analysis of prospective cohort studies to minimise bias from individual studies. Age-specific mortality and population data by country are adopted from the Global Burden of Disease project. Baseline data on weight distributions are adopted from a pooled analysis of population-based measurements undertaken by the NCD Risk Factor Collaboration. We estimated changes in body weight based on the statistical relationship between calorie availability from all foods and body weight (Springmann et al., 2016).

For the scenarios, we determine the country groups using the data from the Net Zero Tracker (Lang et al., 2023) and the food consumption emissions (Poore & Nemecek, 2018). For the tax level, we use the recent SCC estimate of US$185 per tonne of CO2eq for a 2% discount rate (Rennert et al., 2022) and perform a sensitivity analysis considering other discount rates and estimates (Drupp et al., 2018; Rennert et al., 2022; Ricke et al., 2018; Tol, 2019, 2023). To redistribute the SCC we use the GDP per capita from the World Bank (2024).

Expected results

From this study we expect to have a range of GHG emissions and health effects stemming from the different scenarios and taxation levels. Our setup is designed to identify the economic feedbacks and leakage effects across a comprehensive set of carbon-tax scenarios. These results should shed light on the trade-offs and synergies of diverse approaches for distributing net-zero efforts in food demand across countries.

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