# Supplementary Material

Supplementary Material for *Assessing the Potential of Tax Policies in Reducing Environmental Impacts from European Food Consumption*

**Table S1**: Reduced meat and standard VAT rates by country

| | **Meat VAT (2023)** | **Standard VAT (2023)** |
|---|---|---|
| Austria | 10.0 | 20.0 |
| Belgium | 6.0 | 21.0 |
| Bulgaria | 20.0 | 20.0 |
| Croatia | 5.0 | 25.0 |
| Cyprus | 5.0 | 19.0 |
| Czechia | 15.0 | 21.0 |
| Denmark | 25.0 | 25.0 |
| Estonia | 20.0 | 20.0 |
| Finland | 14.0 | 24.0 |
| France | 5.5 | 20.0 |
| Germany | 7.0 | 19.0 |
| Greece | 13.0 | 24.0 |
| Hungary | 5.0 | 27.0 |
| Ireland | 0.0 | 23.0 |
| Italy | 10.0 | 22.0 |
| Latvia | 21.0 | 21.0 |
| Lithuania | 21.0 | 21.0 |
| Luxembourg | 3.0 | 16.0 |
| Malta | 0.0 | 18.0 |
| Netherlands | 9.0 | 21.0 |
| Poland | 5.0 | 23.0 |
| Portugal | 6.0 | 23.0 |
| Romania | 9.0 | 19.0 |
| Slovakia | 10.0 | 20.0 |
| Slovenia | 9.5 | 22.0 |
| Spain | 10.0 | 21.0 |
| Sweden | 12.0 | 25.0 |

**Table S2**: Correspondence table of food categories to COICOP and EXIOBASE products

| Category | COICOP | EXIOBASE |
|---|---|---|
| Bread and cereals | 01111, 01112, 01113, 01114, 01115, 01116, 01117, 01118 | 'Paddy rice', 'Wheat', 'Cereal grains nec', 'Crops nec', 'Processed rice' |
| Fruits and vegetables | 01161, 01162, 01163, 01164, 01165, 01166, 01167, 01168, 01169, 01171, 01172, 01173, 01174, 01175, 01176, 01177, 01178 | 'Vegetables, fruit, nuts' |
| Veg. oils and fats | 01152, 01153, 01154 | 'Oil seeds', 'products of Vegetable oils and fats' |
| Milk and dairy | 01141, 01142, 01143, 01144, 01145, 01146, 01151 | 'Raw milk', 'Dairy products' |
| Fish and seafood | 01131, 01132, 01133, 01134, 01135, 01136 | 'Fish and other fishing products; services incidental of fishing (05)', 'Fish products' |
| Beef | 01121 | 'Cattle', 'Products of meat cattle' |
| Pork | 01122 | 'Pigs', 'Products of meat pigs' |
| Poultry | 01124 | 'Poultry', 'Products of meat poultry' |
| Other meat/animal products | 01123, 01125, 01126, 01127, 01128, 01147, 01155 | 'Meat animals nec', 'Animal products nec', 'Meat products nec' |
| NEC incl. sugar | 01181, 01182, 01183, 01184, 01185, 01186, 01191, 01192, 01193, 01194, 01199 | 'Sugar cane, sugar beet', 'Sugar', 'Food products nec' |

*Note:*
The table shows the mapping of COICOP (structure level 4/ subclasses (five-digit)) as well as EXIOBASE agricultural and food processing sectors included in the analysis (24 out of 200) and their assignment to the corresponding food category. NEC denotes not elsewhere classified food items.

**Table S3**: Stressors/Impacts from EXIOBASE (v3.8.2)

| Stressor | Type | Subtype | Row |
|---|---|---|---|
| Water Consumption Blue - Total | | | 33 (imp) |
| Phosphorous | | | 105 (imp) |
| CH4 - combustion - air | GHG emissions | CH4 | 25 (str) |
| CH4 - non combustion - Extraction/production of (natural) gas - air | GHG emissions | CH4 | 68 (str) |
| CH4 - non combustion - Extraction/production of crude oil - air | GHG emissions | CH4 | 69 (str) |
| CH4 - non combustion - Mining of antracite - air | GHG emissions | CH4 | 70 (str) |
| CH4 - non combustion - Mining of bituminous coal - air | GHG emissions | CH4 | 71 (str) |
| CH4 - non combustion - Mining of coking coal - air | GHG emissions | CH4 | 72 (str) |
| CH4 - non combustion - Mining of lignite (brown coal) - air | GHG emissions | CH4 | 73 (str) |
| CH4 - non combustion - Mining of sub-bituminous coal - air | GHG emissions | CH4 | 74 (str) |
| CH4 - non combustion - Oil refinery - air | GHG emissions | CH4 | 75 (str) |
| CH4 - agriculture - air | GHG emissions | CH4 | 427 (str) |
| CH4 - waste - air | GHG emissions | CH4 | 436 (str) |
| CO2 - combustion - air | GHG emissions | CO2 | 24 (str) |
| CO2 - non combustion - Cement production - air | GHG emissions | CO2 | 93 (str) |
| CO2 - non combustion - Lime production - air | GHG emissions | CO2 | 94 (str) |
| CO2 - agriculture - peat decay - air | GHG emissions | CO2 | 428 (str) |
| CO2 - waste - biogenic - air | GHG emissions | CO2 | 438 (str) |
| CO2 - waste - fossil - air | GHG emissions | CO2 | 439 (str) |
| HFC - air | GHG emissions | HFC | 425 (str) |
| N2O - combustion - air | GHG emissions | N2O | 26 (str) |
| N2O - agriculture - air | GHG emissions | N2O | 430 (str) |
| PFC - air | GHG emissions | PFC | 426 (str) |
| SF6 - air | GHG emissions | SF6 | 424 (str) |
| Cropland - Cereal grains nec | Land use | annual crops | 447 (str) |
| Cropland - Crops nec | Land use | annual crops | 448 (str) |
| Cropland - Fodder crops-Cattle | Land use | annual crops | 449 (str) |
| Cropland - Fodder crops-Meat animals nec | Land use | annual crops | 450 (str) |
| Cropland - Fodder crops-Pigs | Land use | annual crops | 451 (str) |
| Cropland - Fodder crops-Poultry | Land use | annual crops | 452 (str) |
| Cropland - Fodder crops-Raw milk | Land use | annual crops | 453 (str) |
| Cropland - Oil seeds | Land use | annual crops | 454 (str) |
| Cropland - Paddy rice | Land use | annual crops | 455 (str) |
| Cropland - Plant-based fibers | Land use | annual crops | 456 (str) |

**Table S3**: Stressors/Impacts from EXIOBASE (v3.8.2) *(continued)*

| **Stressor** | **Type** | **Subtype** | **Row** |
|---|---|---|---|
| Cropland - Sugar cane, sugar beet | Land use | annual crops | 457 (str) |
| Cropland - Wheat | Land use | annual crops | 459 (str) |
| Other land Use: Total | Land use | extensive forestry | 461 (str) |
| Forest area - Marginal use | Land use | extensive forestry | 466 (str) |
| Forest area - Forestry | Land use | intensive forestry | 460 (str) |
| Permanent pastures - Grazing-Cattle | Land use | pasture | 462 (str) |
| Permanent pastures - Grazing-Meat animals nec | Land use | pasture | 463 (str) |
| Permanent pastures - Grazing-Raw milk | Land use | pasture | 464 (str) |
| Cropland - Vegetables, fruit, nuts | Land use | permanent crops | 458 (str) |
| Infrastructure land | Land use | urban | 465 (str) |
| N - agriculture - water | Nitrogen | N | 429 (str) |
| N - waste - water | Nitrogen | N | 441 (str) |
| NH3 - combustion - air | Nitrogen | NH3 | 29 (str) |
| NH3 - agriculture - air | Nitrogen | NH3 | 431 (str) |
| NH3 - waste - air | Nitrogen | NH3 | 442 (str) |
| NOx - combustion - air | Nitrogen | NOx | 28 (str) |
| NOX - agriculture - air | Nitrogen | NOx | 432 (str) |
| NOX - waste - air | Nitrogen | NOx | 443 (str) |

*Note:*
The table shows EXIOBASE environmental extensions included in the analysis, as well as their corresponding rows in the stressor (str) and impact (imp) matrices. Stressors are characterized according to their attributed subtype and aggregated for final output according to their type.

**Table S4**: Sample characteristics by country

| Country | Data source | Household size (mod. OECD) | Households with children (share) | Urban households (share) | Household head is female (share) | Household head aged 45 or older (share) | Median household income | Sample size (final) | Share of imputed items |
|---|---|---|---|---|---|---|---|---|---|
| **Austria** | KE14 | 1.55 | 21.4% | 32.6% | 35.2% | 66.2% | 34563 | 7155 | 100 % |
| **Belgium** | HBS2015 | 1.58 | 27.1% | 60.7% | 41.1% | 64% | 37802 | 6135 | 0 % |
| **Bulgaria** | HBS2010 | 1.69 | 19.4% | 43.4% | 36.8% | 83.8% | 4650 | 2976 | 2 % |
| **Croatia** | HBS2015 | 1.86 | 28.2% | 30% | 37% | 75.9% | 12353 | 2028 | 0 % |
| **Cyprus** | HBS2015 | 1.77 | 29.2% | 53% | 38.1% | 61.8% | 27924 | 2861 | 100 % |
| **Czechia** | HBS2015 | 1.54 | 24.1% | 33.6% | 49.6% | 68.5% | 12098 | 2929 | 35 % |
| **Denmark** | HBS2015 | 1.48 | 23.3% | 31.8% | 43.1% | 63.2% | 48306 | 2203 | 100 % |
| **Estonia** | HBS2015 | 1.55 | 25.5% | 47.4% | 52.2% | 62.7% | 12143 | 3369 | 0 % |
| **Finland** | HBS2015 | 1.45 | 19.1% | 38.3% | 41.6% | 64.8% | 38000 | 3642 | 4 % |
| **France** | HBS2010 | 1.55 | 27.1% | 48.1% | 39% | 62.7% | 32851 | 14884 | 4 % |
| **Germany** | EVS | 1.44 | 18.1% | 48.1% | 42.3% | 65.3% | 35454 | 10345 | 0 % |
| **Greece** | HBS2015 | 1.72 | 24.8% | 42.7% | 30.1% | 71.7% | 16675 | 6150 | 0 % |
| **Hungary** | HBS2015 | 1.60 | 21.9% | 34.7% | 45.9% | 67.5% | 9108 | 7051 | 16 % |
| **Ireland** | HBS2010 | 1.80 | 35.8% | 37.1% | 46.4% | 52.4% | 39441 | 4863 | 0 % |
| **Italy** | HBS2015 | 1.61 | 23.1% | 34.7% | 33.7% | 73.5% | NA | 14916 | 100 % |
| **Latvia** | HBS2015 | 1.62 | 25.7% | 51.7% | 51.2% | 65.5% | 8242 | 3843 | 2 % |
| **Lithuania** | HBS2010 | 1.74 | 29.7% | 46.5% | 43.9% | 59.7% | 9576 | 6090 | 0 % |
| **Luxembourg** | HBS2015 | 1.63 | 26.7% | 40.2% | 30.5% | 59.5% | 65904 | 3161 | 0 % |
| **Malta** | HBS2015 | 1.72 | 28% | 92.6% | 35.6% | 71.1% | 24764 | 3685 | 100 % |
| **Netherlands** | HBS2015 | 1.53 | 22.4% | 58.4% | 34.6% | 64.8% | 32500 | 14276 | 100 % |
| **Poland** | HBS2015 | 1.80 | 34% | 39.7% | 39.6% | 62.7% | 10790 | 37145 | 4 % |
| **Portugal** | HBS2015 | 1.70 | 30% | 45.4% | 41.4% | 69.1% | 19610 | 11238 | 0 % |
| **Romania** | HBS2015 | 1.76 | 28.6% | 34% | 31.8% | 62.7% | 6468 | 29865 | 13 % |
| **Slovakia** | HBS2015 | 1.88 | 30.8% | 38.1% | 34.8% | 56.9% | 15376 | 4785 | 0 % |
| **Slovenia** | HBS2015 | 1.72 | 26.4% | 20.5% | 51.7% | 65.9% | 22375 | 3749 | 16 % |
| **Spain** | HBS2015 | 1.69 | 25.4% | 51.5% | 33.7% | 67.5% | 24882 | 21989 | 24 % |
| **Sweden** | HBS2015 | 1.50 | 23.2% | 26% | 38.7% | 59.5% | 35633 | 2802 | 100 % |

*Note:*

Sample characteristics based on Eurostat Household Budget Survey (HBS) 2010 and 2015, Konsumerhebung (KE) 2014/2015, and Einkommens- und Verbrauchsstichprobe (EVS) 2018. All values are rounded means weighted using sampling weights. Household size is computed according to the modified OECD scale, which assigns a value of 1 to the household head, of 0.5 to each additional adult member and of 0.3 to each child. Items imputed displays the share of imputed quantities for all food items that have not been recorded in a given country (Case I).

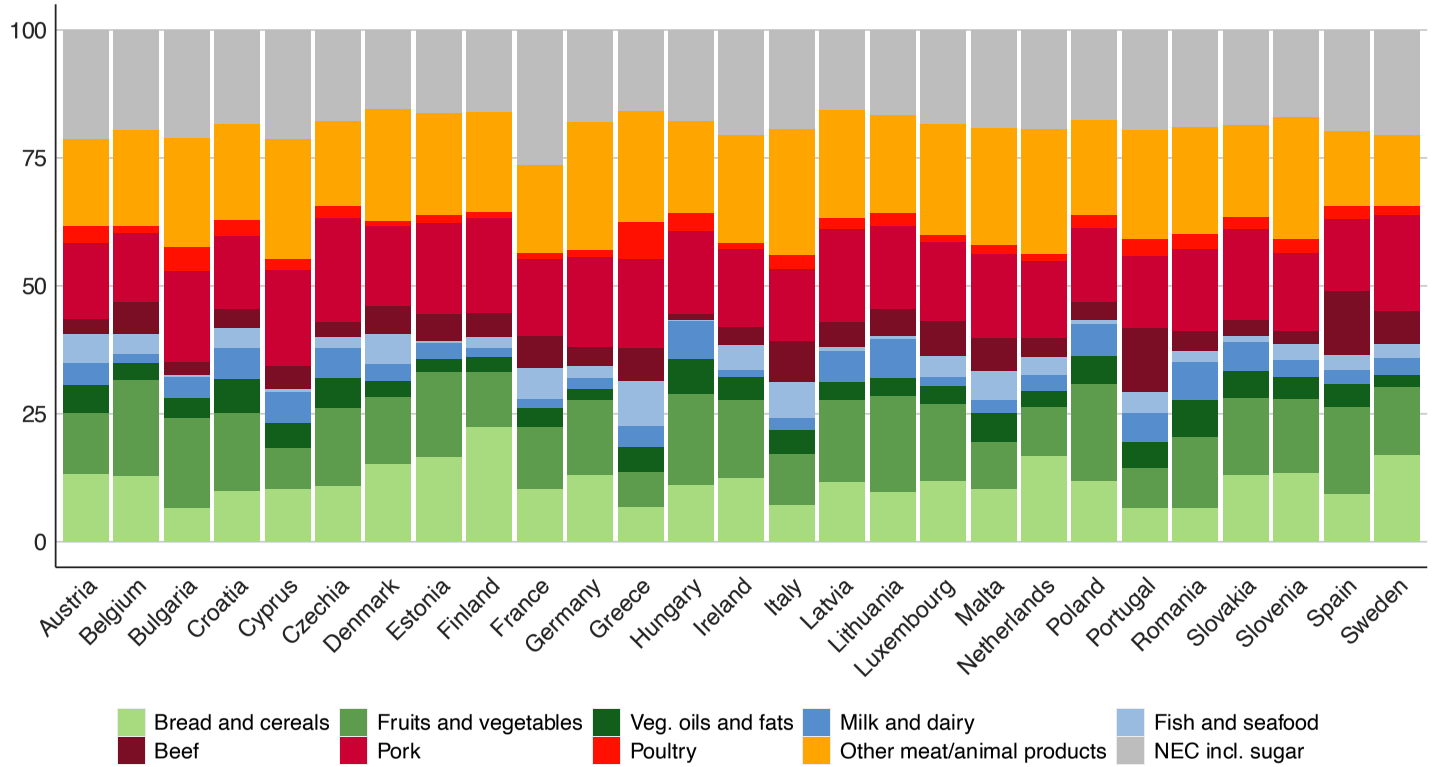


**Fig. S1**: Budget shares of different food categories by country based on representative household expenditure surveys. Data sources for each country are listed in Supplementary Table 4. Values are weighted by sample weights to ensure representativeness. NEC denotes not elsewhere classified food items.

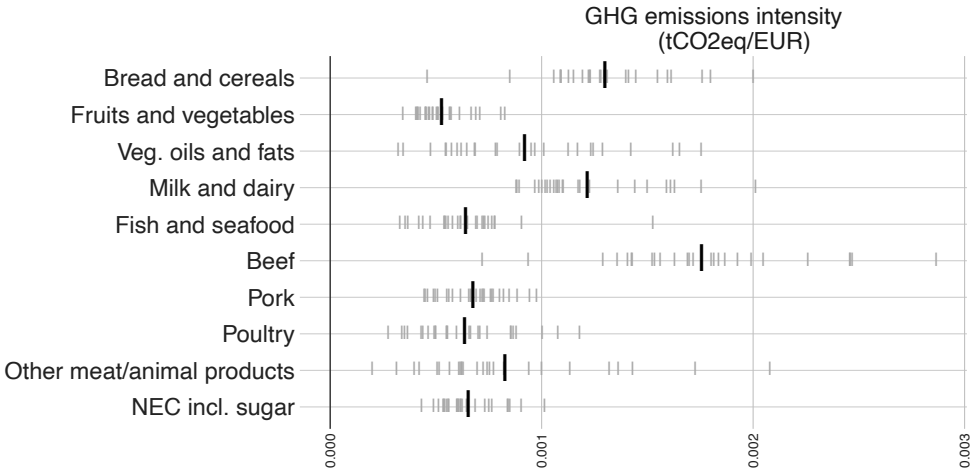


**Fig. S2**: Greenhouse gas emission intensities of demand by food category based on EXIOBASE for the year 2019 (own computation). Grey bars indicate country-specific demand intensities; black bars indicate the category-specific (unweighted) mean demand intensity across all EU27 countries.

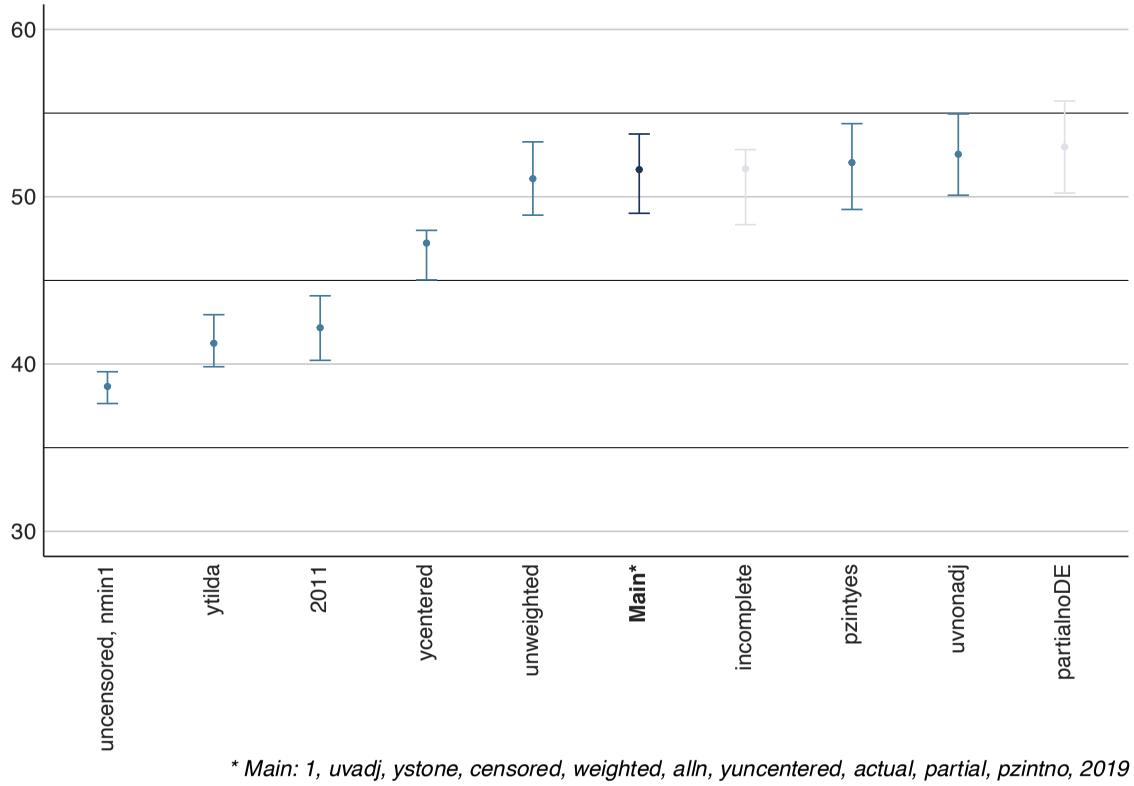


**Fig. S3**: Robustness of GHG emission price estimates in EUR across different demand system and EXIOBASE base year specifications. The main specification is compared with specification (1) *uncensored, nmin1* (ignores censored distribution of the dependent variable of the demand system and uses only $n-1$ equations recovering the residual food category through the adding up-restriction), specification (2) *ytilda* (uses mean budget share $\bar{w}$ to construct the Stone index $\tilde{y}$ as opposed to the household-specific budget share $w$ used to construct $y$), specification (3) *2011* (based on EXIOBASE year 2011 using real data points only), specification (4) *ycentered* (uses a median-centered $y$ instead of the absolute value), specification (5) *unweighted* (uses no household weights in the SUR estimation), specification (6) *incomplete* (uses numéraire good to avoid the weak separability assumption, results for 26 countries excl. Germany), specification (7) *pzintyes* (accounting for interactions between household characteristics and prices), specification (8) *uvnonadj* (uses unit values not adjusted for quality choices of the household), and specification (9) *partialnoDE* (main specification excl. Germany, only for comparison with specification *incomplete*). Uncertainty bars represent the range between the minimum and maximum values of the $b = 100$ computed GHG emission price levels based on the $b = 100$ bootstrapped elasticity estimates for each specification.

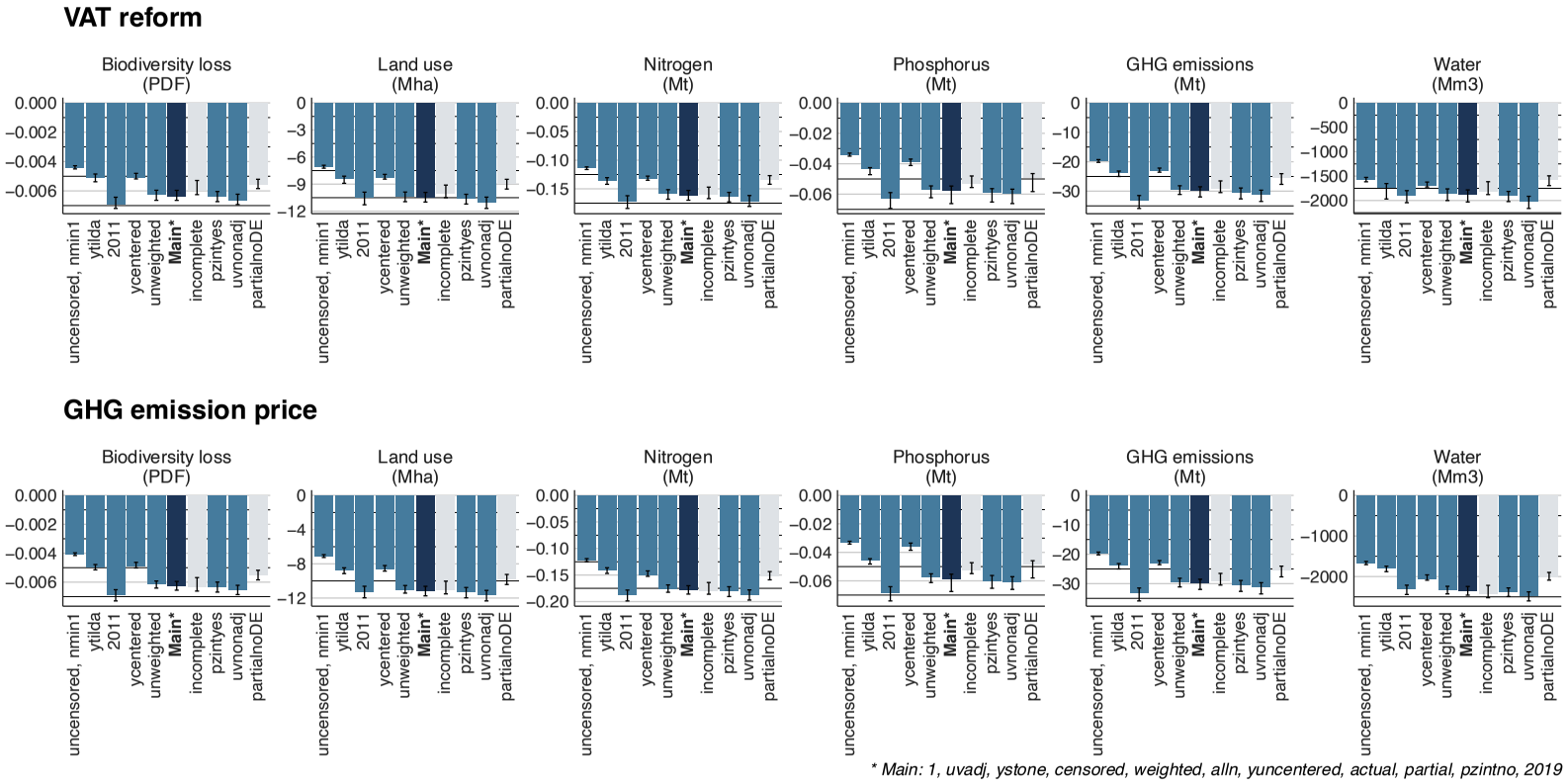


**Fig. S4**: Robustness of environmental footprint reduction estimates across different demand system and EXIOBASE base year specifications. The main specification is compared with specification (1) *uncensored, nmin1* (ignores censored distribution of the dependent variable of the demand system and uses only $n-1$ equations recovering the residual food category through the adding up-restriction), specification (2) *ytilda* (uses mean budget share $\bar{w}$ to construct the Stone index $\tilde{y}$ as opposed to the household-specific budget share $w$ used to construct $y$), specification (3) *2011* (based on EXIOBASE year 2011 using real data points only), specification (4) *ycentered* (uses a median-centered $y$ instead of the absolute value), specification (5) *unweighted* (uses no household weights in the SUR estimation), specification (6) *incomplete* (uses numéraire good to avoid weak separability assumption, results for 26 countries excl. Germany), specification (7) *pzintyes* (accounting for interactions between household characteristics and prices), specification (8) *uvnonadj* (uses unit values not adjusted for quality choices of the household), and specification (9) *partialnoDE* (main specification excl. Germany, only for comparison with specification *incomplete*). The underlying GHG emission price varies by specification (see Fig. S3). Uncertainty bars represent the range between the minimum and maximum values of the $b = 100$ computed footprint reductions based on the $b = 100$ bootstrapped elasticity estimates for each specification.