Consumer heterogeneity in emission and diet impacts of meat taxes

Catharina Latka* Klaus Mittenzwei† Thomas Heckelei‡

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Abstract

Many consumers in high-income countries do not adhere to dietary guidelines. This imposes a threat to their health and to the environment as some of the excessively consumed foods also have high emission footprints. Food price changes (e.g. enforced through taxes) are a promising lever to steer consumers toward a recommended diet. However, a country-level pricing policy fails to only target those consumers that do not follow dietary recommendations but affect all consumers. Here, we estimate individual household-specific demand systems using a locally-weighted approach to capture differences in the preference structure and price sensitivity of consumers. We compare these to a pooled estimation and assess elasticity differences and implications for meat tax simulations. Tax-induced meat consumption reductions, embedded greenhouse gas emission savings and the level of adherence to dietary recommendations are compared at the national level and for consumer groups defined based on their baseline meat intake. Our findings stress that without considering heterogeneity in price responsiveness, we tend to over-estimate benefits from pricing policies. Consumers eating more meat than

*University of Bonn, Germany & EuroCARE Bonn GmbH, Germany, clatka@uni-bonn.de
†Ruralis, Norway
‡University of Bonn, Germany

recommended are less responsive to price changes, but would still contribute most to emission savings and show the largest absolute dietary improvements.

Keywords: Demand elasticities, demand system, food consumption, nutrition, policies

1 Introduction

Food consumption is related to environmental and health concerns, especially in high-income countries (Steenson and Buttriss, 2021; Tilman and Clark, 2014). In particular, meat is consumed above recommended levels on average and is among the food products with the highest greenhouse gas emission footprints (Röös et al., 2014). Since the price remains one of the most important attributes for consumption choices, market incentives such as taxes and subsidies are a promising policy intervention to steer food consumption toward less polluting and healthier choices (Funke et al., 2022; Springmann et al., 2025). However, such policies affect every consumer, even those that already consume in line with dietary recommendations.

Various studies model and assess meat taxes at national levels for the average diet in a region (e.g. Abadie et al., 2016; Latka et al., 2021; Springmann et al., 2018). However, in particular to assess health impacts, it is of interest to understand how the group of consumers that does not adhere to dietary recommendations responds to such a policy intervention. Especially considering that these might be particularly reluctant to the requested behavioral changes (García-Muros et al., 2017).

Here, we disentangle impacts of a meat tax by consumer groups based on their adherence to dietary recommendations. Thereby, we consider that there are differences in baseline consumption levels between these groups and that they may also differ regarding their preferences and price sensitivity for food products. Therefore, we estimate individual household-specific food price elasticities of demand and explore their differences at consumer group level. Such food price elasticities of demand are a measure to quantify and compare food preferences and demand reactions to price changes (Andreyeva et al.,

2010). Furthermore, we use these estimates to showcase the effect of a meat tax accounting for heterogeneity in consumer reactions. When comparing the implications of a meat tax based on the individually estimated demand systems to a pooled estimation across all households, we find that without considering such heterogeneous price reactions, we tend to over-estimate benefits from pricing policies. Lastly, our results show that the consumer group exceeding meat intake recommendations in the baseline contributes 74% to the resulting meat demand reductions.

We choose Norway as study location for this research. The link of food consumption patterns in Norway to environmental impacts has been investigated in previous research, e.g., regarding greenhouse gas emissions (Abadie et al., 2016; Blandford et al., 2019). Price and income changes in Norway have shown heterogeneous reactions in consumption patterns across consumer cohorts (Gustavsen and Rickertsen, 2014, 2011). For several high-income countries, demand elasticities have been estimated under consideration of subnational differences such as age, sex or income (e.g. for France by Allais et al. (2010), for Germany by Roosen et al. (2022), for Sweden by Säll (2018), or for Norway by Gustavsen and Rickertsen (2014)). A recent study by Zhen et al. (2024) shows preference heterogeneity of US consumers by obesity status. Gustavsen and Rickertsen (2011) differentiate consumers by their expenditures for sugar-sweetened beverages. We contribute to this field of research by investigating consumer groups defined based on their baseline meat intake relative to recommended intake levels.

2 Theoretical background

Elasticities measure the relative change in one variable due to a relative change in another variable (Verbeek, 2008). The effect is proportional, unit-free and related to a specific point on a function (Nicholson and Snyder, 2012). Demand elasticities represent the change in the quantity demanded resulting from a change in the (i) own good's price, (ii) the income, or (iii) prices of other goods. Demand elasticities derived from Marshallian demand functions are uncompensated, they comprise substitution and income effects.

In contrast, compensated (Hicksian) demand elasticities depict demand quantities as a function of prices and utility, the income effect gets compensated (Nicholson and Snyder, 2012). If the absolute value of an elasticity $|e_{x,D}| > 1$, demand is considered to be elastic, whereas if $0 < |e_{x,D}| < 1$, demand is considered inelastic (with $D = \{p_x, I, p_y\}$). Consumers react more elastic to price changes, if they have no strong preference for a product or if they are very price sensitive. However, this depends on the product and how easily substitutable it is. Food price elasticities are a question of affordability. Cornelsen et al. (2015) show that across income levels, cereals and oils have the lowest own-price elasticities, which indicates their important role in diets. Demand elasticities also reflect preferences, which can change over time e.g., throughout the life time of a person (Gustavsen and Rickertsen, 2014) as well as due to consumption trends among population subgroups such as vegetarianism (Tonsor et al., 2023). Diets and dietary preferences are very diverse and hence demand elasticities are heterogeneous across consumer groups (Lusk, 2017). Policy recommendations based on anaylses using average elasticities can still provide valid guidance for maximizing aggregate outcomes (e.g. welfare, greenhouse gas emission reductions). However, when subgroup-specific responses matter, reliance on such average parameters may lead to biased conclusions. Therefore, to accommodate preference heterogeneity, we estimate demand systems at the individual level instead of imposing a representative-agent structure.

3 Methods

3.1 Data

We use cross-sectional food consumption and expenditure data from the Norwegian Consumer Expenditure Surveys (CES) for 2006-2009, and 2012 (Statistics Norway, 2023a, 2023b, 2023c, 2023d, 2022). The more recently available survey round collected in 2022 differs in terms of product resolution and only provides data on expenditures, but not on quantities and is therefore unsuitable for our analysis (Statistics Norway et al., 2024).

In addition, we retrieve socio-economic information from the surveys. While earlier survey years were conducted annually, no surveys have been conducted between 2009 and 2012, nor between 2012 and 2022. The sample size in the 2012 surveys is larger than in preceeding survey rounds.

Table 1: Food categories and food products

Food category	Food products
Cereals	Wheat
	Other Cereals
Meat	Beef
	Pork
	Poultry
	Sheep
	Processed meat
Fish	Fish
Dairy & eggs	Milk
	Yoghurt
	White cheese
	Skimmed milk powder
	Butter
	Eggs
Fruits & vegetables	Apples
	Tropical fruit
	Other fruit
	Field vegetables
	Greenhouse vegetables
	Potatoes
	Plant-based oils

We aggregate the detailed food item data to 21 food products grouped within 5 food categories (Table 1). Therefore, consumed quantities and expenditures of all CES items matched to a food product are aggregated for each household and year. For the presented analysis, we focus on demand system estimations at the food category level. Note that all averages reported are accounting for household weights to ensure national representativeness.

To define consumer groups based on meat intake levels, we refer to dietary recommenda-

tions from the "planetary health EAT Lancet diet" (Willett et al., 2019). Therefore, the food consumption quantities at household level are divided by the adult male equivalent for each household to retrieve per person consumption quantities. Since dietary recommendations are specified on the basis of intake, we use food waste shares from Vanham et al. (2015) to approximate intake levels. Intake values are then derived for the average consumer in a household due to missing information for individual household members. We remove outliers, i.e., the upper 0.5% regarding meat intakes that appear to eat more than 800 grams/ day of meat per person on average. The households that "adhere" have an aggregated daily intake of poultry, pork, beef and sheep meat of less than 43 grams/ day on average. The group that consumes more than the recommendation but remains still below the "upper recommended level" of the intake range has an intake between 43 and 86 grams/day. All consumers with a larger intake than 86 grams/ day of meat per person are classified in the "overintake" group. Figure 1a shows that there is a wide range in how much more people in the overintake group eat compared to the recommendation. Across survey years, we see a slight decline with respect to the adherence to meat recommendations, whereas the fraction consuming too much meat continuously represents more than half of the households (Figure 1b).

Figure 2 summarizes intake levels by food categories for the national average and the mean of the consumer groups over time. Grey lines indicate the recommended intake levels (i.e., the solid line shows the average recommendation, the dotted line shows the lower level of the recommended range, and the dashed line represents the upper level of recommended range). Interestingly, the consumers adhering to recommended meat intake levels consume less than the other groups across all food categories. The consumer group exceeding meat intake levels does not appear to exceed recommended intake ranges of other food categories as well. None of the consumer groups reaches recommended intake levels for fruits and vegetables. Fish intake is in line with recommendations on average in Norway.

Unit prices of the original products are retrieved by dividing respective expenditures by

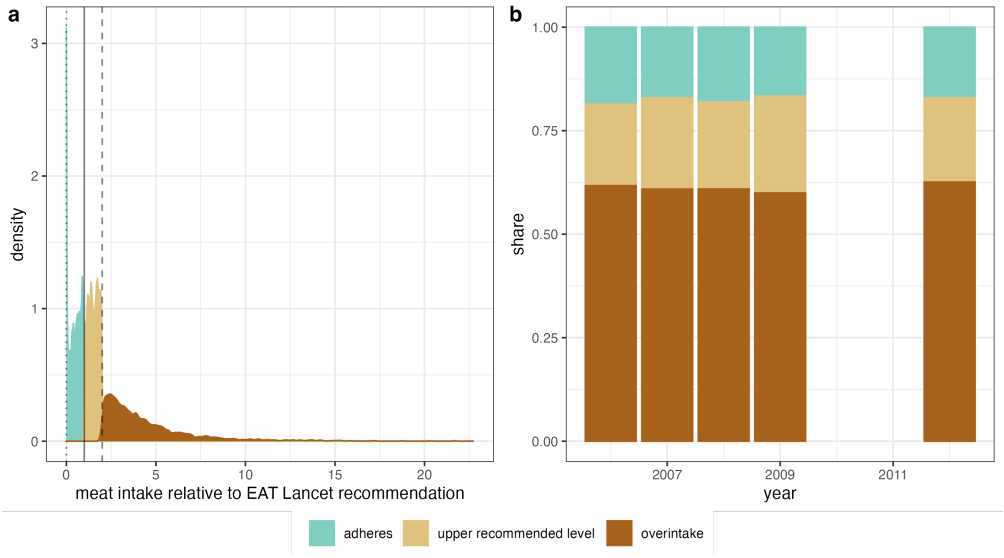

Figure 1: Consumer groups based on meat intake.

consumed quantities. Not all food products are consumed by every household. To create a price exposure for households with zero consumption of a food product, we fill the missing prices with the annual and regional average price of that product. Constructed food prices are quality adjusted following Cox and Wohlgenant (1986) controlling for the age and gender of the household head, and income and household size as polynomial terms up to the second degree as household characteristics. The resulting product prices are aggregated to food category level by creating mean prices weighted with consumed quantity shares. For households that do not consume a food product the simple mean is used. We use the consumer price index to express all prices and expenditures in 2022 NOK. Prices appear stable or slightly increasing over time (Figure 3).

We find no substantial difference between the average food prices that the consumer groups experience, with the exception of meat prices. It appears that the group with the largest intake of meat pays on average the lowest price. In comparison, consumers adhering to meat intake recommendations pay around 40 NOK/kg more. In addition, within this group there is also the largest variability regarding the meat price.

This difference is driven by two reasons. First, the meat demand of the consumer

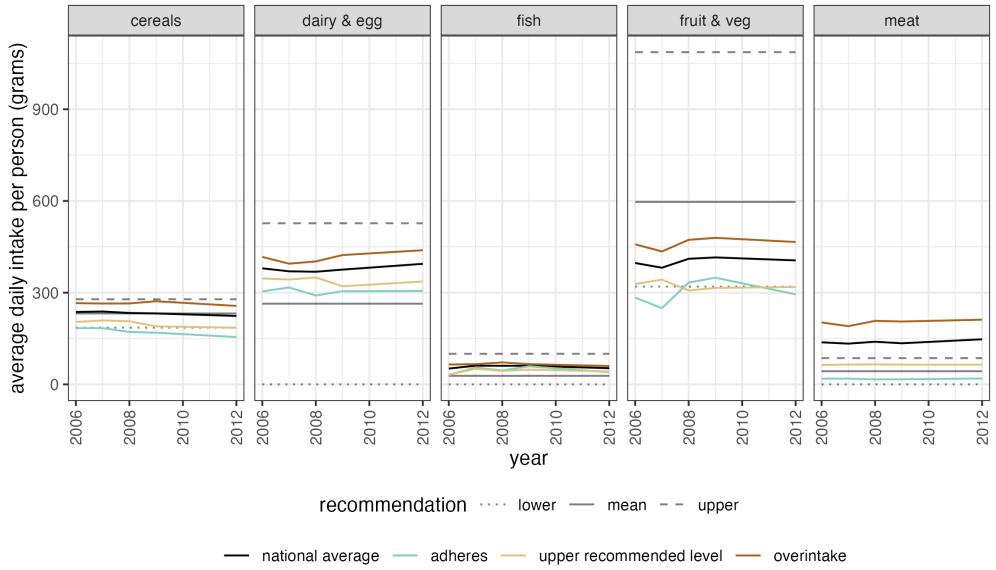

Figure 2: Food intake by consumer group.

groups is composed to different shares of the underlying meat products (Table 2). For example, consumers that adhere to recommendations demand to a larger extent beef and processed meat products than the other consumers and these products have higher prices than other meat products. Second, across meat products, the adhering group often chooses more expensive items (Table 3).

Table 2: Meat demand shares by consumer groups in 2012

indicator	product	adheres	upper rec.	overintake	national
average demand share	beef	0.12	0.07	0.09	0.09
	other processed meat	0.60	0.66	0.53	0.57
	pork	0.13	0.12	0.18	0.16
	poultry	0.13	0.14	0.16	0.15
	sheep	0.02	0.01	0.04	0.03

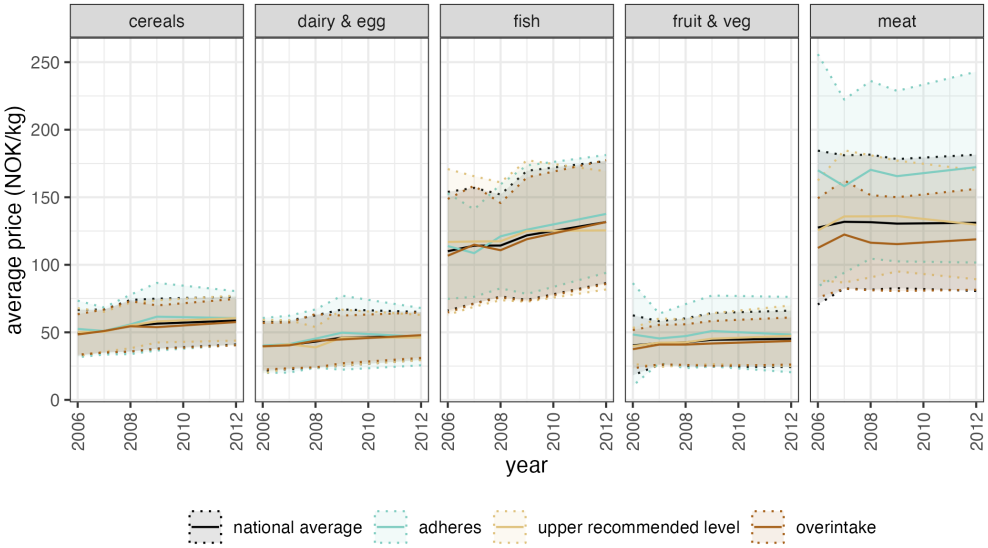

Figure 3: Food prices by consumer group

Note: Shares are calculated at household level and then aggregated.

These price differences could potentially arise from choosing products of higher quality, from certain brands, with quality labels or purchased from more expensive providers than the other consumer groups do. Despite the higher prices that this group pays, the overall household expenditures for meat are still lowest in the group that adheres to meat intake recommendations as shown in Figure 4. This is to some extend driven by on average smaller household sizes in this consumer group. By comparing expenditure shares relative to total household food expenditures we see that the overintake group spends about three times more of their food budget on meat compared to the group in line with meat intake guidelines. Altogether, this indicates different preference structures between the groups.

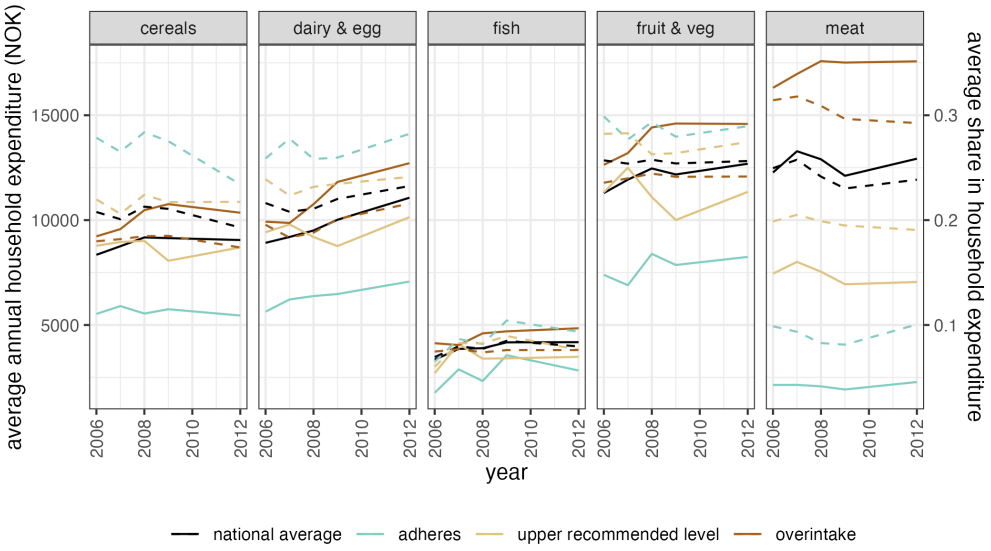

Figure 4: Food expenditure by consumer group. Note: Expenditure shares are shown as dashed lines.

Table 3: Meat prices by consumer groups in 2012

indicator	product	adheres	upper rec.	overintake	national
average price	beef	209	210	203	205
	other processed meat	164	130	126	134
	pork	162	158	137	146
	poultry	121	123	117	119
	sheep	183	176	174	176
	meat	172	130	119	131

3.2 Modeling preferences heterogeneity using individual demand systems

We aim to capture heterogeneity in preferences and price sensitivity between individual households and across consumer groups. However, subsetting the survey data to the

observations in each of the groups based on how well their average meat intake aligns with dietary guidelines to estimate these demand systems is problematic for the following reasons.

To estimate the elasticities we exploit variation in prices and expenditure shares in our cross-sectional data. Subsetting consumers based on their observed meat consumption mutes this variation for meat expenditures and is also correlated to the prices they face. In addition, meat consumption is an endogenous outcome of the demand system, so that defining consumer groups on this basis poses a risk of selection bias or reverse causality.

To address this concern, we instead estimate an individual demand system for each households using a locally weighted estimation framework. Specifically, we implement a k-nearest-neighbor kernel estimator in which distances in standardized peer characteristics define local neighborhoods, and tri-cube weights are applied to obtain smoothly varying, household-specific demand parameters. Distances are computed based on household socioeconomic and demographic characteristics, including log income, household size, the number of children under age 20, the age and educational attainment of the household head. This approach allows parameters to vary flexibly across the population without imposing discrete segmentation. To retrieve consumer group specific average estimates, we aggregate the estimated parameters for all households in the respective groups.

3.3 Demand system estimation

The Almost Ideal Demand System fulfills desired properties and restrictions implied by economic theory (i.e., utility maximization, the axioms of choice, adding up of expenditure shares, homogeneity, symmetry) (Deaton and Muellbauer, 1980; Henningsen, 2023).

The Quadratic Almost Ideal Demand System (QUAIDS) extends the Almost Ideal Demand System by allowing for nonlinear Engel curves through the inclusion of a quadratic term in log expenditure. This added flexibility enables the model to capture richer consumption patterns across the income distribution. This flexibility is especially important

in applications where preference heterogeneity and distributional effects are central. We compared the fit of both specifications for pooled models based on all household data by summing the squared residuals from each product equation and computing a Wald-type statistic. The QUAIDS model significantly improves fit over AIDS (W = 18.30, p = 0.0011), so we adopt it for all subsequent analyses.

We estimate the QUAIDS in its reduced form, linking expenditure shares w_{ih} for each product i and household h to the logarithm of the price p_{jh} of product j and total household expenditure M_h over price index P_h. Unlike the standard Almost Ideal Demand System, QUAIDS includes a quadratic term in log expenditure to capture nonlinear Engel curves.

To account for censoring, i.e., zero observations where households do not consume a certain product at all, we apply a two-step estimation following Roosen et al. (2022). First, we estimate the probability of demanding a product by a household based on probit models, controlling for Z_h, i.e. the age, gender and education level of the household head, number of children and the region.

Second, we integrate the values of the probability density function ϕ_{ih} and the cumulative distribution function Φ_{ih} into the demand system estimation and also control for Z_h:

$$w_{ih} = \Phi_{ih} \times [\alpha_i + \sum_j \gamma_{ij} \ln p_{jh} + \beta_i \ln(M_h/P_h) + \lambda_i [\ln(M_h/P_h)]^2 + Z_h] + \theta \phi_{ih} + \epsilon_{ih}$$

where $P_h = \sum_i w_{ih} \times p_{jh}$ is the Stone's price index.

The demand system is estimated as seemingly unrelated regressions. The estimation is carried out in R using the *systemfit* package (Henningsen and Hamann, 2023) building on the code example in Piipponen (2017). One product equation is dropped to avoid singularity. To ensure representativeness, budget shares and ϕ_{ih} are adjusted using the square root of household weights.

We then compute expenditure elasticities, compensated and uncompensated elasticities.

Expenditure elasticities:

$$\eta_i = \bar{\Phi}_i \times \frac{\hat{\beta}_i + 2\hat{\lambda}_i \overline{\ln(M_h/P_h)}}{\bar{w_i}} + 1$$

Uncompensated price elasticities:

$$\epsilon_{ii} = \bar{\Phi}_i \times \frac{\hat{\gamma}_{ii}}{\bar{w_i}} - 1$$

$$\epsilon_{ij} = \bar{\Phi}_i \times \frac{\hat{\gamma}_{ij} - (\hat{\beta}_i + 2\hat{\lambda}_i \overline{\ln(M_h/P_h)})\, \bar{w_j}}{\bar{w_i}}$$

Compensated price elasticities:

$$\epsilon^*_{ij} = \epsilon_{ij} + \bar{w_j} \times \eta_i$$

We retrieve individual household-specific elasticites by using household-specific budget shares in the expressions above and by using a locally-weighted estimations procedure for each household as outlined in the previous section. These elasticities are winsorized at 5% to limit the effect of outliers. In addition, we compute standard pooled estimates for all the data and consumer group subsets based on the average budget shares in the underlying sample used for the estimation. We use the delta method to calculate standard errors of these elasticities.

3.4 Scenario simulation

Elasticities capture preferences and consumer reactions to price changes. Therefore, they are used to ex-ante assess implications of market-based policies. Here, we use the example of a meat tax to illustrate the implications of accounting for consumer heterogeneity in the underlying elasticity estimation. Meat consumption levels for 2012 are used as a baseline We analyze the change in the meat demand in response to different meat tax levels. In the first scenario, we use the elasticities estimated for individual

households using the locally weighted estimation approach. In the second scenario, we use parameter estimates from standard pooled models as comparison. The estimated model parameters are simulation inputs from the respective models. Meat prices are adjusted relative to the respective tax level. For each household, we adjust household food expenditures and the price index to predict expenditure shares for each household. Cross-price and expenditure effects are taken into account implicitly. Predicted demand quantities are retrieved for each household. We compare resulting demand reductions, embedded greenhouse gas emission changes, and adherence to meat intake guidelines. Greenhouse gas emission coefficients are taken from Møller and Samsonstuen (2023) for underlying meat products and aggregated to a weighted emission coefficient for every household. National and consumer group averages are shown in the appendix, where the averaged emission coefficient is highest for the adhering group, due to their larger demand share of emission-intensive beef products. Demand and emission results are scaled up to the population size of Norway in 2012. This simulation assessment should be interpreted as an illustrative example, as it does not account for i) differences in food waste levels between consumers or scenarios, ii) substitution possibilities between the underlying meat products and items, iii) emissions from non-meat products, iv) market and trade feedback.

4 Results

4.1 Elasticities

Marshallian own-price elasticities of food categories based on locally weighted estimations for individual households are presented in Figure 5. Violin plots show the distributions and boxplots represent the median and interquartile range for the full sample (national) and the three different meat intake groups. All own-price elasticities are negative, in line with standard assumptions for normal goods. Across intake groups, the median own-price elasticity of meat is largest and the one of cereals is smallest in abso-

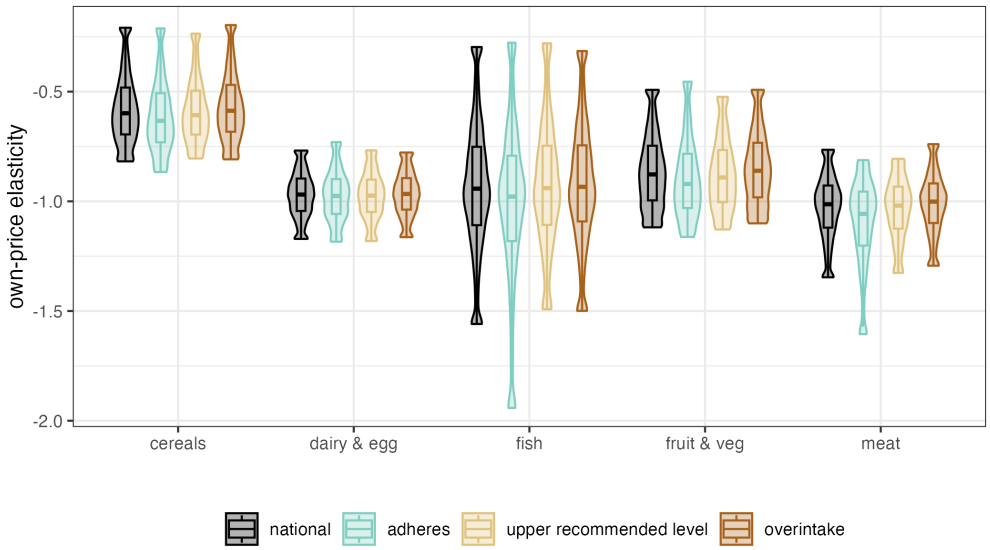

Figure 5: Own-price elasticities for the national average and by consumer group based on individual household-specific estimations

lute terms. In general, the consumer group adhering to meat intake recommendations tends to be most elastistic, whereas overconsuming consumers react least elastic toward price changes.

Figure 6 compares the average own-price elasticities between individual household-specific estimations and pooled estimations. For the individual estimations, the average is calculated based on the weighted mean of the elasticity distribution. The standard error of the weighted mean elasticity accounts for both the estimation uncertainty of each individual elasticity and the heterogeneity across households. In contrast, for the pooled estimation these elasticities and their standard errors for the respective subsets result directly from the QUAIDS estimation.

The locally weighted estimation uncovers substantial household-level heterogeneity in own-price elasticities that is concealed by the pooled specification. While the pooled model estimates a single pooled elasticity, the local approach reveals a distribution of responses across households and provides a precisely estimated population mean. While national average estimates of both approaches are very close for cereals, dairy

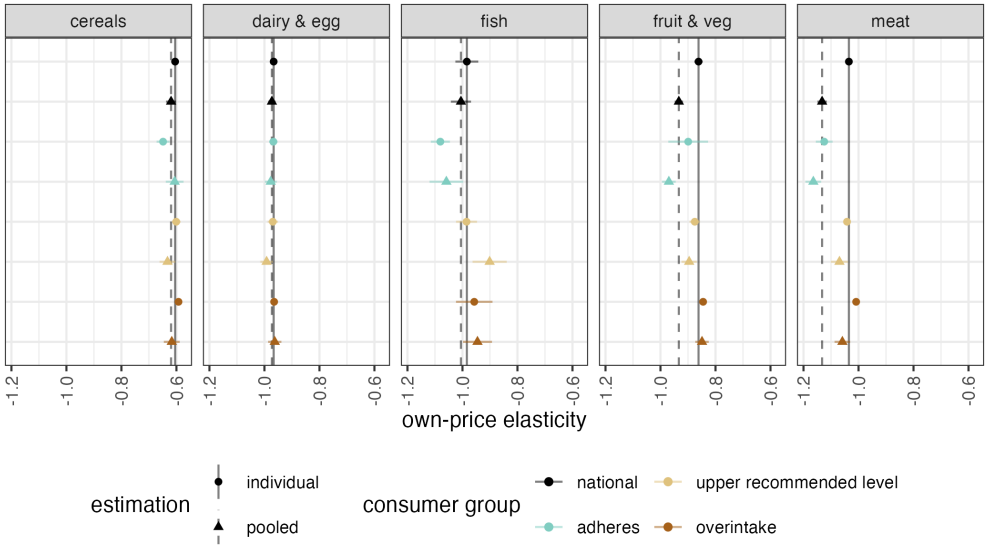

Figure 6: Average own-price elasticities for the national average and by consumer group based on individual household-specific versus pooled estimations

and egg and fish, the locally weighted estimation approach suggest lower elasticities for fruits and vegetables, and for meat. However, the relation between subgroup elasticities is supported by both approaches: Consumers adhering to meat recommendations are more elastic than those that consume up to the upper recommended level, and these are more elastic than the consumers that overconsume. Still, we need to interpret the subgroup elasticities of the pooled model with caution, given that these subgroups were created based on an endogenous characteristic.

4.2 Meat tax scenario

The demand sytem estimates are used for the illustrative simulation of a meat tax implemented in the Norway of 2012. In Table 5, the results of a tax of 40% on meat are compared based on estimates from the locally weighted individual estimation and the pooled estimation. The results are presented as absolute changes compared to a baseline simulation with a zero tax rate. Results for various indicators are shown for the national and consumer group aggregates. For meat-related greenhouse gas emissions, a

reduction of 0.95 million tonnes CO_2eq at national scale is found with the individual estimations, while the pooled model suggests larger emission reductions of 1.1 million tonnes CO_2eq. Even though the tax is addressing all consumers, the high meat intake group is contributing the largest share to this reduction in absolute terms. This is driven by the fact that this group contains most observations and the baseline consumption is much larger than in other groups making even a smaller relative change weigh more. Meat intake is reduced due to the tax for all consumers. Similar as for the greenhouse gas emission change, using the demand system for the average national consumer suggests larger dietary changes than the consumer group-specific models. In both cases, the weighted national average as well as the weighted average of the overintake group remains well above the recommended range. However, the share of overall consumers below the upper recommended meat intake range increases by about 21%. In terms of meat reductions and related emission savings, almost 80% are contributed by consumers originally exceeding meat intake recommendations. Also, in terms of average meat intake, this group achieves the largest absolute improvement. Still, the 40% tax would not be enough to move this group to within recommended intake levels on average, even though this price increase is considerably larger than the discussed red meat taxes in Norway (Grimsrud et al., 2020). Theoretically, a meat tax targeted to the consumers in the overintake group would achieve most of the changes that a tax to all consumers does. Still, even a 100% tax rate would not push every household in our simulation to a meat intake below the upper recommended level (Figure 7).

Table 4: Group-specific changes due to 40% meat tax simulated for 2012 based on individual and pooled estimation

Indicator	Group	Individual estimation	Pooled estimation
Δ Total meat demand	national	-71.90	-82.98
	adheres	-5.73	-5.85
	upper rec	-12.88	-13.65
	overintake	-53.29	-63.48
Δ Total emissions	national	-0.95	-1.10
	adheres	-0.08	-0.08
	upper rec	-0.18	-0.19
	overintake	-0.70	-0.83
Δ Individual meat intake	national	-38.83	-45.76
	adheres	-19.54	-20.06
	upper rec	-30.58	-32.86
	overintake	-47.18	-57.34
Δ Pop share no overintake	national	0.21	0.24
Δ Pop share adhering	national	0.08	0.08

Note: Sum of meat demand in 1000 tonnes, greenhouse gas emissions in million tonnes CO2-equ., average meat intake in grams per day and person, shares in total consumers, pop=population, upper rec=upper recommended level

5 Discussion and conclusions

Demand systems for policy assessments often rely on elasticities for the average national consumer. However, for various policy goals it matters who is changing their behavior by how much, considering heterogeneity in preferences and price sensitivity. In this

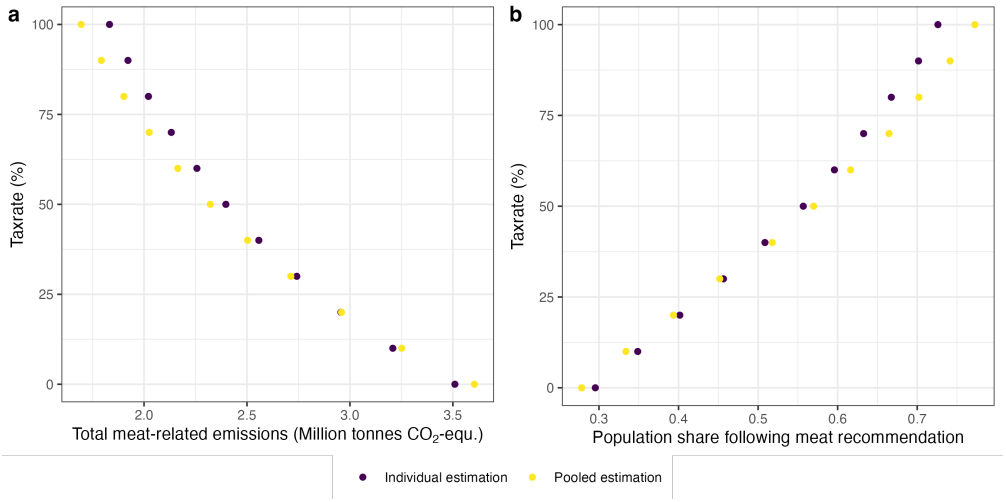

Figure 7: Simulation of various tax rates for (a) meat-related emissions and (b) meat intake below upper recommendation level

study, we therefore estimate elasticities for individual households and aggregate these for our assessment of consumer groups defined according to their adherence to meat intake recommendations. Then, we evaluate the implications of using these demand systems with an illustrative example of a meat tax.

Our results indicate that we overestimate the assumed emission savings and dietary improvements, if we rely on pooled average elasticities and do not disentangle implications by households and consumer groups. Most benefits, environmental and dietary ones, arise in the group that does not adhere to meat intake recommendations in the baseline. For this group, high tax increases of up to 100% seem still insufficient to reduce meat intake to recommended levels for all.

However, this result is based on a stylized example, ignoring any potential awareness effect of a meat tax that might induce additional behavioral change on top of the pure price effect. Also, the estimated parameters are based on relatively small price changes with limited validity for assessing some of the substantial tax rates in our simulation. We also have not considered any macroeconomic implications in terms of trade and production feedbacks. Future research could combine the differentiation of consumer

groups in a simulation exercise that accounts for such market effects.

In absolute terms, consumers already adhering to recommendations in the baseline, do not reduce their demand to a large extent. However, these consumers are paying the tax without any need for a consumption change. Since there is no minimum requirement of meat intake, one can argue that the harm to these consumers is limited. Nonetheless, their intake is already lower than the average recommendation and for some keeping their level of meat intake might be a dietary requirement.

In aggregate, we show that meat taxes are a promising policy tool to reduce greenhouse gas emissions and overconsumption of certain population groups. However, rising overall food price levels might increase the already prevalent unpopularity of food taxes as policy intervention (Ejelöv et al., 2025). Still, product-specific taxes could adjust the relative price differences between products to favor recommended consumption choices. Our findings however emphasize that the consumer group that eats too much meat, is less price responsive than the average and requires a higher price lever to achieve the targeted consumption change.

In the prevalent food shopping environment, it is unrealistic to assume a differentiated food tax scheme could easily be implemented. However, a food policy package can account for the heterogeneity in price responsiveness and try to address the not-adhering consumers explicitly, for example with targeted information-based complementary policies.

Our findings emphasize that food policy design should, to the extent possible, account for heterogeneity in consumer behavior and aim to target those consumers with the largest need for dietary change. Demand system simulations, especially if addressing dietary change, benefit from disentangling consumer groups and their heterogeneity in preferences and price sensitivity.

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9 Appendix

Table 5: Descriptive statistics by consumer groups

Variable	**adheres** N = 3,076	**upper_rec** N = 2,942	**overintake** N = 9,301
survey year			
2006	477 (15%)	365 (12%)	1,290 (14%)
2007	406 (13%)	415 (14%)	1,312 (14%)
2008	452 (15%)	424 (14%)	1,275 (14%)
2009	444 (14%)	480 (16%)	1,208 (13%)
2012	1,296 (42%)	1,258 (43%)	4,217 (45%)
household weight	3.79 (1.87, 5.94)	2.28 (1.28, 4.44)	2.43 (1.46, 4.55)
region			
MIDT	291 (9.5%)	288 (9.8%)	874 (9.4%)
NORD	316 (10%)	356 (12%)	1,043 (11%)
OEST	1,569 (51%)	1,415 (48%)	4,501 (48%)
SOER	410 (13%)	423 (14%)	1,384 (15%)
VEST	489 (16%)	461 (16%)	1,500 (16%)
count household members			
1	1,664 (54%)	1,004 (34%)	3,401 (37%)
2	746 (24%)	824 (28%)	2,977 (32%)
3	267 (8.7%)	414 (14%)	1,275 (14%)
4	251 (8.2%)	441 (15%)	1,103 (12%)
5	103 (3.3%)	196 (6.7%)	456 (4.9%)
6 or more	46 (1.5%)	62 (2.1%)	90 (1.0%)
gender household head			

Variable	**adheres** N = 3,076	**upper_rec** N = 2,942	**overintake** N = 9,301
female	1,388 (45%)	1,211 (41%)	3,530 (38%)
male	1,688 (55%)	1,731 (59%)	5,771 (62%)
age household head			
19 or younger	40 (1.3%)	18 (0.6%)	43 (0.5%)
20-29	572 (19%)	479 (16%)	817 (8.8%)
30-39	572 (19%)	601 (20%)	1,565 (17%)
40-49	502 (16%)	630 (21%)	1,850 (20%)
50-59	599 (19%)	575 (20%)	2,157 (23%)
60-69	463 (15%)	325 (11%)	1,793 (19%)
70 or older	328 (11%)	313 (11%)	1,076 (12%)
education household head			
low	1,781 (58%)	1,728 (59%)	5,590 (60%)
middle	973 (32%)	859 (29%)	2,582 (28%)
high	255 (8.3%)	301 (10%)	972 (10%)
none	66 (2.2%)	54 (1.8%)	157 (1.7%)
count children			
0	2,346 (76%)	1,802 (61%)	6,378 (69%)
1	313 (10%)	411 (14%)	1,248 (13%)
2	278 (9.0%)	468 (16%)	1,166 (13%)
3 or more	139 (4.5%)	261 (8.9%)	510 (5.5%)
food expenditure	19,881 (11,705, 32,239)	34,292 (21,107, 54,983)	51,094 (32,187, 75,377)
household income	340,000 (227,261, 520,000)	440,000 (280,000, 660,000)	440,000 (300,000, 647,620)

Variable	**adheres** N = 3,076	**upper_rec** N = 2,942	**overintake** N = 9,301
adult male equivalent	1.00 (0.82, 1.82)	1.75 (1.00, 2.70)	1.63 (1.00, 2.55)

Table 6: Emission factors by product and aggregated for consumer groups

group	product	ghge	share	average ghge
national	beef	30.0	0.08	13.41
	other processed meat	16.6	0.54	13.41
	pork	3.2	0.18	13.41
	poultry	2.3	0.16	13.41
	sheep	26.1	0.04	13.41
adheres	beef	30.0	0.10	14.81
	other processed meat	16.6	0.62	14.81
	pork	3.2	0.12	14.81
	poultry	2.3	0.13	14.81
	sheep	26.1	0.03	14.81
upper recommended level	beef	30.0	0.07	14.12
	other processed meat	16.6	0.65	14.12
	pork	3.2	0.11	14.12
	poultry	2.3	0.15	14.12
	sheep	26.1	0.02	14.12
overintake	beef	30.0	0.08	13.28
	other processed meat	16.6	0.53	13.28
	pork	3.2	0.19	13.28
	poultry	2.3	0.16	13.28
	sheep	26.1	0.05	13.28

Note: Shares are calculated at group level based on aggregated demand quantities of each group, ghge= greenhouse gas emission factor (kg/ CO_2eq) based on Møller and Samsonstuen (2023)