Achieving Emission Reduction Targets by Changing Eating Habits in Norway

Luis María Abadie and Ibon Galarraga,
Basque Centre for Climate Change

Geir Wæhler Gustavsen and Anna Birgitte Milford, NILF

NILF
Norwegian Agricultural
Economics Research Institute

Reducing GHG emissions from food production

- A tax on emissions from agricultural production is difficult to implement

- disfavour domestic producers
- “carbon leakage”
- monitoring difficult and costly
- technological possibilities for reducing emissions limited

Reducing GHG emissions from food consumption

- The variations in emission levels between individual producers within a food category are in general much smaller than the differences between food categories. Since there are good possibilities for consumers to substitute between different food items, setting a tax on output is a better option than setting it on emission sources (Wirsenius et a 2011).
- Halving the consumption of meat, dairy products and eggs in the European Union would achieve a 25-40% reduction in GHG emissions (Westhoek et al. 2014)
- Demand side measures are seen as more efficient in reducing GHG emissions than supply side measures, and also better at meeting both the requirement for climate change mitigation and food security (Smith et al. 2013, Popp et al. 2010)
- A lower consumption of animal products may also prevent adverse health impacts, such as obesity and chronic disease (Reynolds et al. 2014, Gonzalez et al 2011, Ripple et al. 2014).

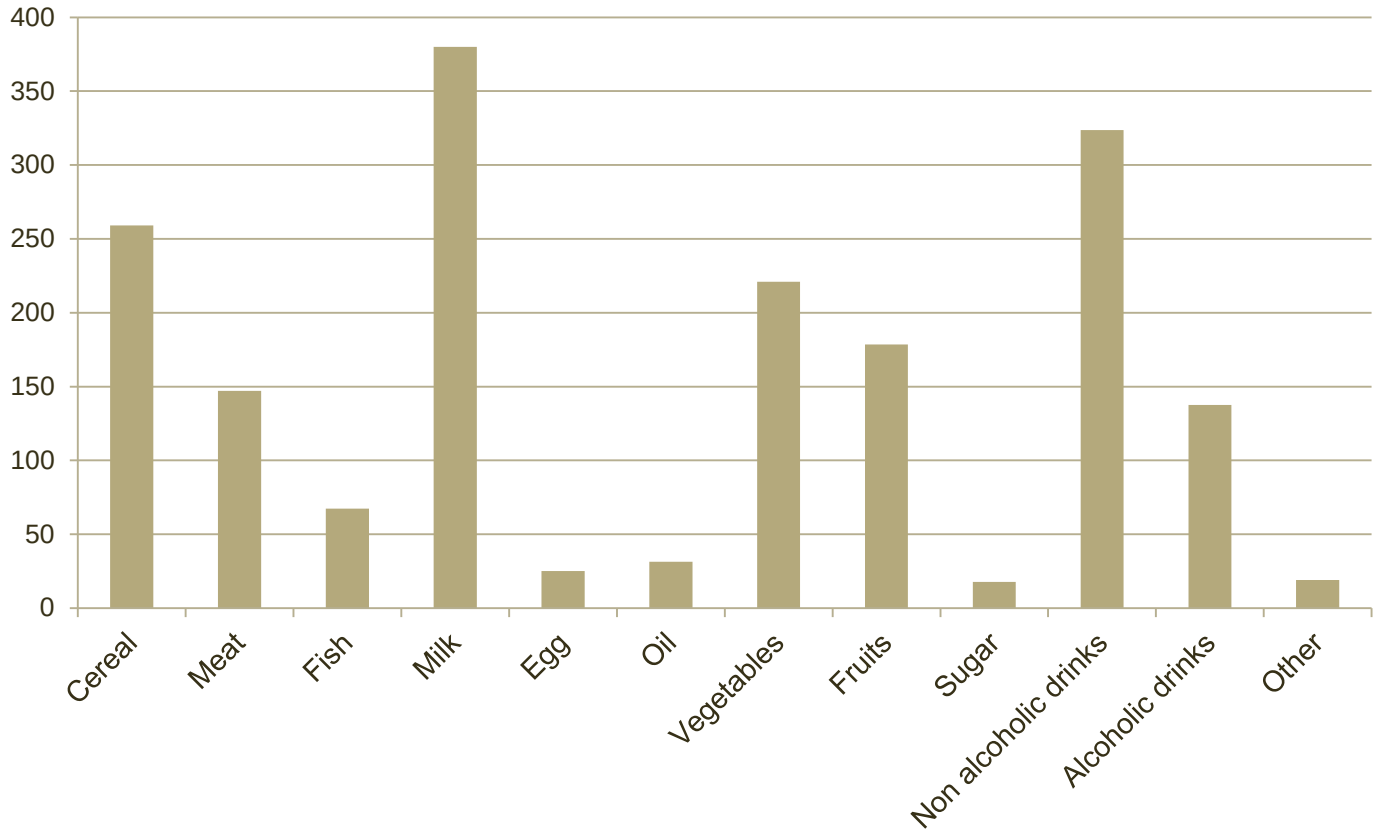
Food taxes to reduce GHG emissions

- Imposing a tax on animal products corresponding to 60 euro per ton CO2-equivalents would reduce CO2-emissions from agriculture in the EU27 by 7% (Wirsenius et a 2011)
- A taxation scheme in Denmark could, in the most effective scenario, lead to a decrease in the carbon footprint from food of 10.4-19.4% (Edjabou and Smed 2013)

Overview presentation

- The Norwegian diet: Macronutrients and CO2 emissions
- Optimization model: Taxes and subsidies to reduce emissions and still have optimal level of macronutrients in the average diet

Daily gram intake different food products, Norway

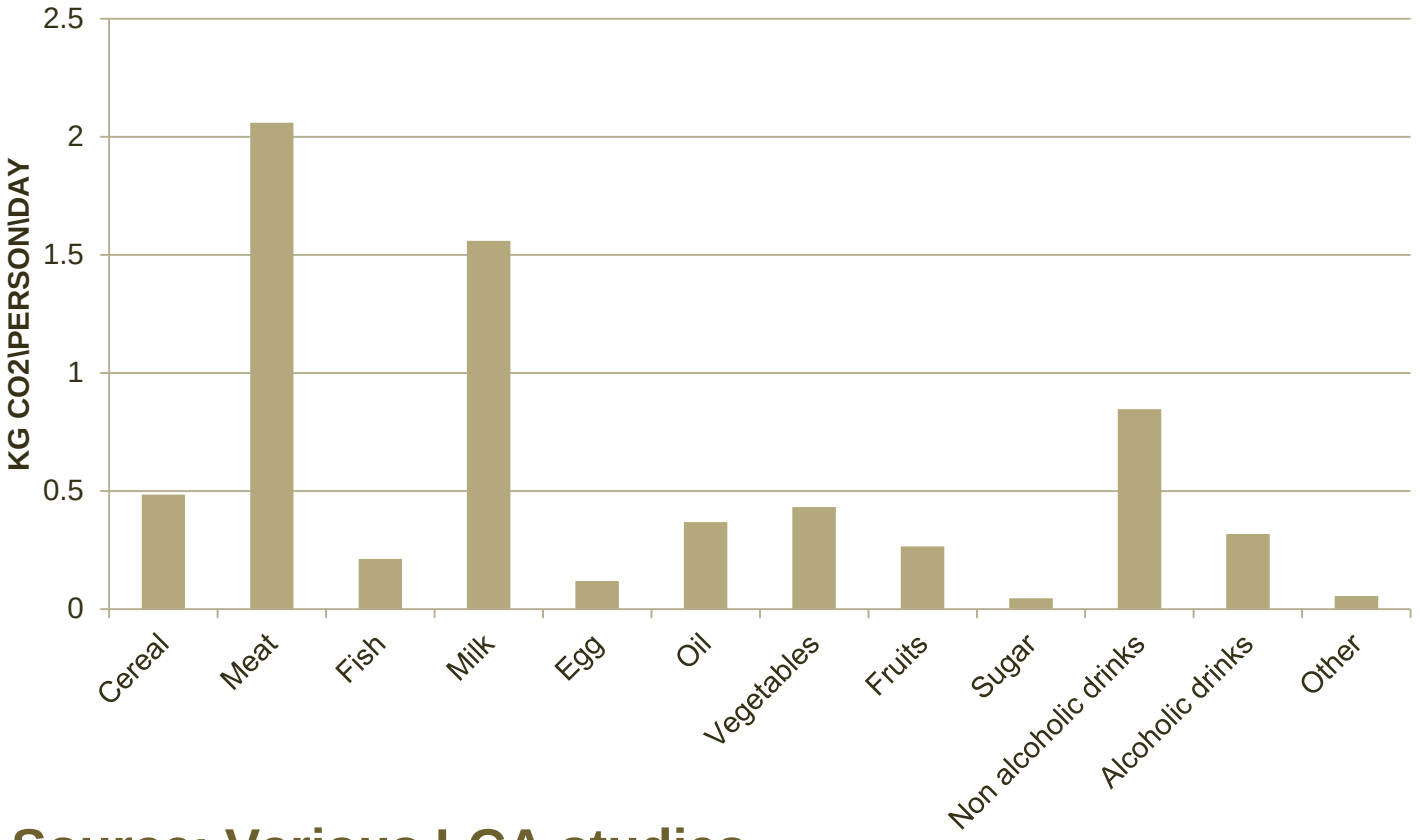


- Source: Norkost3 survey 2010-11

Comparison actual compared to diet recommended by Norwegian Directorate of Health

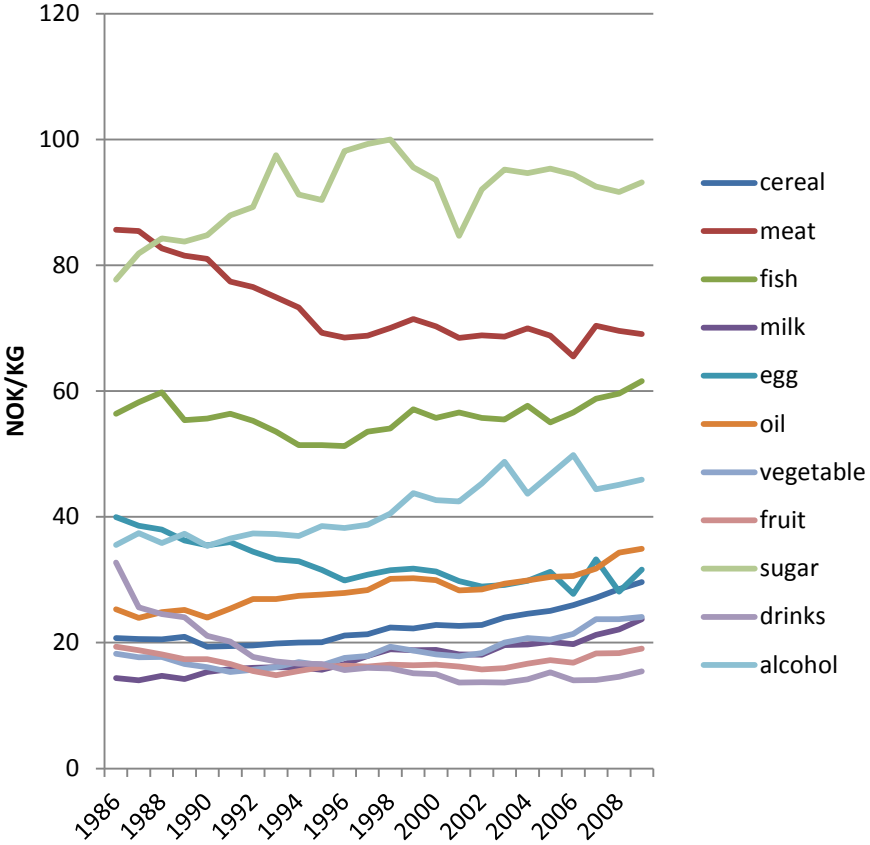
Dietary Factor	Norwegian health authority guidelines	Actual diet
Total Fat:	25-35%	34%
of which Saturated Fats	<10%	13%
Total Carbohydrates	50-60%	44%
Protein	10-20%	18%
Free Sugars/ added sugar	<10%	7.4%
Cholesterol	No recommendations	356
Salt	<2,4 g	7.5 g
Total Dietary Fibre	3 g/MJ	2.5 g
Total Calorie Intake	2200 for females and 2500 for males	2271
Fruits and Vegetables	≥ 500 g	328 g
Fish	≥ 54 g	54 g
Fat fish	≥ 36 g	26 g
Red meat	<107 g	118 g

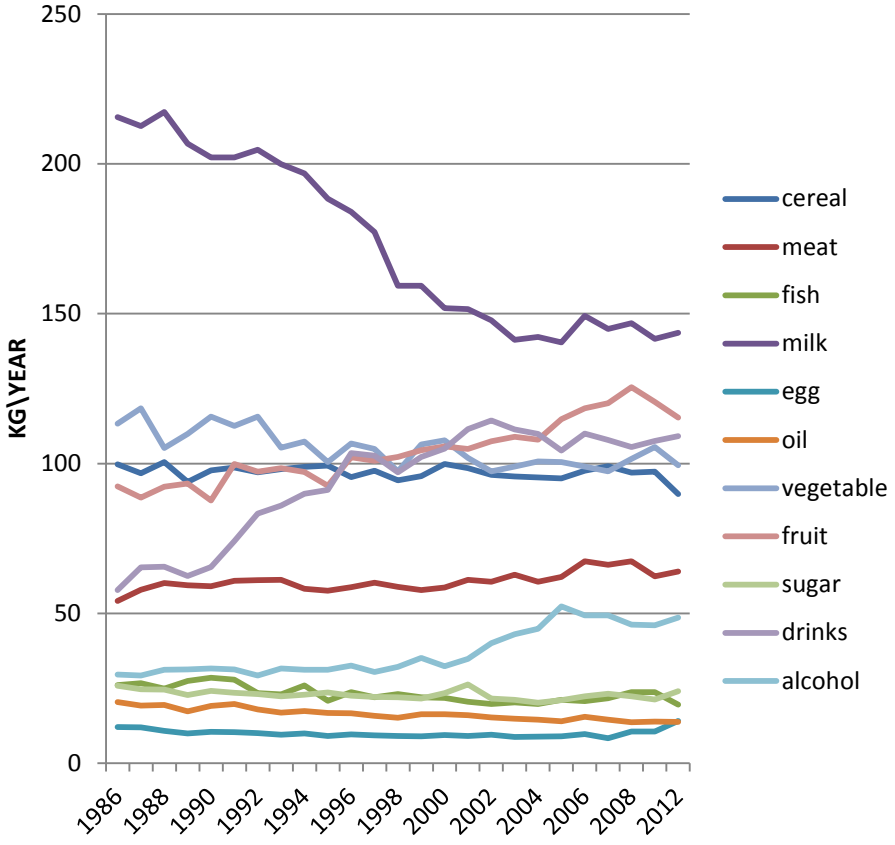
CO2 emissions per person per day from Norwegian diet



- **Source: Various LCA studies**

Price and consumption development





Optimization

- Find estimates for the taxes and subsidies necessary in order to reduce CO2-emissions by a certain percentage, while keeping the average Norwegian diet within the recommendations of the Health Authorities.
- Find the combination of taxes and subsidies that minimise the DWL for certain GHG reduction targets, while complying with recommendations for a healthy diet.

Minimize dead weight loss

$$DWL = 0.5 \sum_{i=1}^{i=n} \sum_{j=1}^{j=n} t_i t_j P_i P_j S_{ij}$$

t_i: taxes

P_i: initial prices

Sij: marginal compensated changes in the demand for good “i” when there is a change in the price of good “j”

$$\mathbf{S} \equiv \begin{bmatrix} \mu_{1,1}\frac{q_1}{P_1} & \mu_{1,2}\frac{q_1}{P_2} & \cdots & \mu_{1,12}\frac{q_1}{P_{12}} \\ \mu_{2,1}\frac{q_2}{P_1} & \mu_{2,2}\frac{q_2}{P_2} & \cdots & \mu_{2,12}\frac{q_2}{P_{12}} \\ \mu_{3,1}\frac{q_3}{P_1} & \mu_{3,2}\frac{q_3}{P_2} & \cdots & \mu_{3,12}\frac{q_3}{P_{12}} \\ \cdots & \cdots & \cdots & \cdots \\ \mu_{12,1}\frac{q_{12}}{P_1} & \mu_{12,2}\frac{q_{12}}{P_2} & \cdots & \mu_{12,12}\frac{q_{12}}{P_{12}} \end{bmatrix}$$

Optimization model

$$\min_{\mathbf{x}} DWL(\mathbf{x}) = -\frac{1}{2}\mathbf{x}^T\mathbf{S}\mathbf{x}$$

subject to

$$(\mathbf{q} + \Delta\mathbf{q}) \geq \mathbf{0}$$

When CO2 emissions are to be restricted to a certain level, an additional restriction is added:

$$\mathbf{e}^T \times (\mathbf{q} + \Delta\mathbf{q}) = emi$$

Where the vector contains the values of unit emissions for each product category and is a scalar.

More restrictions

- Restriction to assure that number of calories does not change from Norkost3 average

$$\mathbf{B(q + \Delta q) = } Kcal$$

- Restriction to ensure that sugar intake does not increase

$\Delta q_9 = 0$

Elasticities: Linear Almost Ideal Demand System (LA/AIDS)

- Use the Norwegian consumer expenditure survey (CES) performed by Statistics Norway
- Yearly results are available from 1986 to 2012

Elasticity	
Uncompensated own price for good i	$\mu^{M}{}_{ii} = \frac{\gamma_{ii}}{w_i} - \beta_i - 1$
Uncompensated cross price between good i and j.	$\mu^{M}{}_{ij} = \frac{\gamma_{ij}}{w_i} - \beta_i \frac{w_j}{w_i}$
Income for good i	$\eta_i = 1 + \frac{\beta_i}{w_i}$

Entities used for the optimization

Product	Own price elasticity	Average daily intake (grammes)	Emissions Kg CO2/g
Cereal	0.9940	259	0.001872
Meat	1.0715	147	0.014012
Fish	1.0578	67	0.003162
Milk	0.9639	380	0.004105
Egg	1.0411	25	0.004727
Oil	0.9573	31	0.011761
vegetable	0.9700	221	0.001953
Fruit	0.9784	179	0.001487
Sugar	0.9891	18	0.002565
Drinks	0.9705	324	0.002617
Alcohol	1.2915	138	0.002317
Other	0.7787	19	0.002931

Final food quantities for emissions reduction targets (g per day)

	Emission Reduction Target					
Food Categories	Actual	5%	10%	15%	20%	25%
Cereal	259	278	304	333	364	395
Meat	147	132	120	108	97	87
Fish	67	67	66	64	61	58
Milk	380	360	338	317	295	273
Egg	25	24	22	20	18	17
Oil	31	32	31	28	25	22
Vegetable	221	211	200	187	174	160
Fruit	179	181	182	182	181	180
Sugar	18	18	18	18	18	18
Drinks	324	297	274	253	233	213
Alcohol	138	134	129	123	116	109
Other	19	19	20	19	19	18

Changes in quantity for % emission reductions.

	Percentage change in quantities for % emission reduction target				
	5%	10%	15%	20%	25%
Cereal	7.4%	17.2%	28.6%	40.5%	52.6%
Meat	-10.0%	-18.7%	-26.5%	-33.9%	-41.1%
Fish	0.0%	-1.4%	-4.4%	-8.7%	-14.0%
Milk	-5.4%	-11.0%	-16.6%	-22.3%	-28.2%
Egg	-4.1%	-10.7%	-18.4%	-26.3%	-33.9%
Oil	4.3%	-0.3%	-10.5%	-20.8%	-29.9%
Vegetable	-4.4%	-9.6%	-15.2%	-21.3%	-27.7%
Fruit	1.0%	1.7%	1.8%	1.3%	0.4%
Sugar	0.0%	0.0%	0.0%	0.0%	-0.8%
Drinks	-8.4%	-15.5%	-21.9%	-28.2%	-34.4%
Alcohol	-2.8%	-6.4%	-10.6%	-15.6%	-21.3%
Other	2.1%	3.0%	2.1%	-0.5%	-4.5%

Taxes and subsidies needed for each emissions reduction target

	Emission Reduction Target				
Food Categories	5%	10%	15%	20%	25%
Cereal	-9.4%	-19.8%	-29.7%	-38.3%	-45.5%
Meat	7.7%	15.3%	23.1%	31.7%	41.5%
Fish	0.5%	2.0%	4.7%	8.6%	13.9%
Milk	5.6%	12.8%	21.3%	31.4%	43.3%
Egg	4.0%	10.1%	17.7%	26.7%	37.3%
Oil	-2.0%	3.1%	14.1%	27.8%	43.0%
Vegetable	2.6%	6.3%	11.0%	17.0%	24.3%
Fruit	2.4%	7.7%	16.7%	28.9%	43.8%
Sugar	-2.3%	-5.6%	-10.0%	-14.9%	-19.5%
Drinks	6.6%	13.5%	20.8%	29.3%	39.3%
Alcohol	2.2%	5.1%	9.0%	13.9%	20.1%
Other	-2.1%	-3.3%	-3.1%	-1.3%	1.7%

Results macronutrients

	For % emission reduction target					
Macronutrients (g)	Actual	5%	10%	15%	20%	25%
Proteins	17.29	16.85	16.52	16.24	15.96	15.66
Fat	34.42	33.99	32.98	31.60	30.20	28.86
Saturated fat	13.26	12.96	12.46	11.86	11.25	10.66
Carbohydrates	43.57	44.44	45.80	47.47	49.18	50.85
Sugar	7.61	7.50	7.44	7.40	7.37	7.31
Fibre	2.06	2.13	2.22	2.33	2.43	2.53
Alcohol	2.51	2.44	2.35	2.24	2.12	1.98

Note:

- This is just the presentation of a tool that may be refined by using more food categories (for instance distingushing between different types of meat and different types of vegetables) and more restrictions