



# Greenhouse Gas Emissions

## Correlations to Income and Environmental Concern

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# Motivation

To mitigate climate change, it is – among other things – indispensable to know:

- **What factors are related to greenhouse gas (GHG) emissions?**
- Are the correlations the same for **different areas** of consumption?

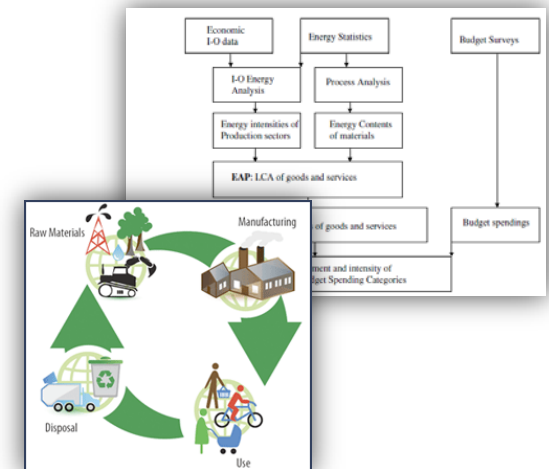
Studies from ...

- **Natural sciences point to structural and socio-demographic factors**  
(e.g. location, income, household size, properties of the building, ...)
- **Social sciences point to psychological and social factors**  
(e.g. environmental attitudes, values, social norms, ...)

# Environmental Impact or Pro-environmental Behavior?

## "Natural Sciences": Environmental Impact

- Data: Statistics of material and energy flows, household budget surveys
- Environmental impact computed in terms of emissions, energy use, ...
- Strength: Estimation of environmental impact
- Weaknesses: Mostly descriptive, categories sometimes far from everyday behavior ("direct"/"indirect", "services"...)



## "Social Sciences": Pro-environmental Behavior (PEB)

- Data: Mostly surveys
- Environmental impact not captured precisely (if intended at all, more often: intent-oriented, cf. Stern, 2000).
- Weaknesses: Selection of behavior, weighting of behavior
- Strengths: Multivariate analyses, psychological/social factors



# Previous Research & Research Questions

## In conclusion...

- There are few **multivariate** studies on GHG emissions (or env. impact in general)
- Few of these studies incorporate **environmental concern** as a predictor (1+4)
- Few multivariate studies distinguish **areas of consumption**
- Few studies **compare** a environmental impact and PEB

## Research Questions

1. **How are income and environmental concern related to GHG emissions** when analyzed by means of multivariate analysis?
2. Are GHG emissions by **housing, mobility and food** equally related to income and environmental concern?
- (3. Comparison to PEB:  
Does PEB related to the same predictor variables in the same way?)

# Method

## Swiss Environmental Survey 2007

- Nationwide survey in 3 languages: German, French, Italian
- Representative random sample of Swiss residents  $\geq 18$  years whose households have a phonebook entry
- Field time: November 2006 – April 2007
- Telephone interview ( $n = 3,369$ , response rate of 52%) followed by a written questionnaire ( $n = 2,798$ , 83% of 3,369)



Meyer & Diekmann

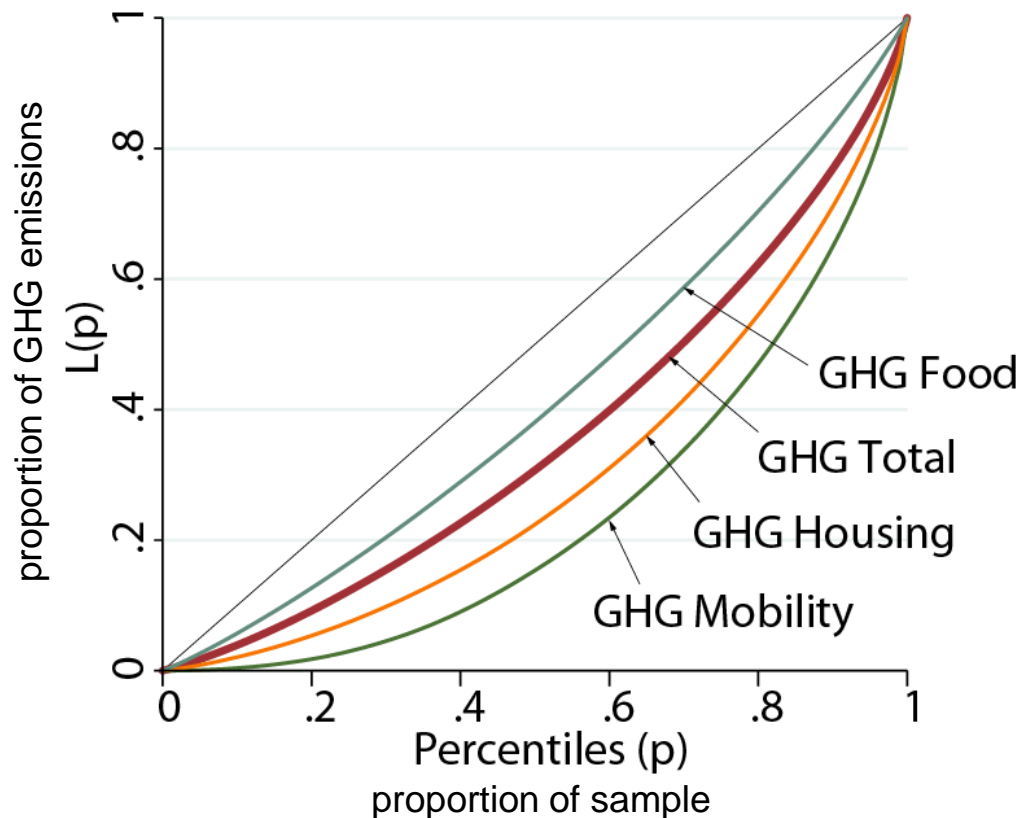
## Multiple Imputation of Missing Values

- Multiple imputation,  $k = 120$ , using Stata's "mi impute chained"  
=>  $n = 3,369$  unless indicated otherwise

## Life Cycle Analysis for Every Survey Respondent

- Calculated with support from the Swiss Federal Laboratories for Materials Science and Technology (see Notter, Meyer & Althaus, 2013, for details)
- Slight modifications

# Unequal Distribution of Emissions: Lorenz Curves



Lowest emission decile:	Mean = 2342 kg	$\hat{=}$ 4% of emissions	} $\approx$ Factor 6
Highest emission decile:	Mean = 13984 kg	$\hat{=}$ 23% of emissions	

## Further Variables

### Equivalence Income

$$\text{Equivalence income} = \frac{\text{disposable household income}}{\sqrt{\text{number of persons in household}}}$$

Median = 4571 per month (95% CI [4468, 4674]; Mean = 5256, 95% CI [5110, 5401])

### Environmental Concern (Scale 1-5)

9 five-point items by Diekmann & Preisendörfer (2001, 2003), e.g.

- *If we continue down the same path, we are heading toward an environmental catastrophe.*
- *In order to protect the environment, we should all be willing to reduce our current standard of living.*

Cronbach's  $\alpha = .760$  (mean across  $k = 120$ ), Mean = 3.68 (95% CI [3.66, 3.70])

### Pro-Environmental Behavior (PEB)

**Sum of 13 binary-coded items, with high values indicating environmentally friendly behavior**

Recycling of (1) organic waste, (2) PET, (3) aluminum and (4) tin, (5) frequent or very frequent consumption of organic produce, (6) use of recycled toilet paper and (7) of recycled paper in general, (8) avoidance of standby on the television set, (9) use of energy-saving light bulbs, (10) switching off lights upon leaving a room, (11) not turning up heating when feeling cold at home in winter, (12) no air travel for private purposes during the past year, (13) no car in household

Mean = 8.23 (95% CI [8.16, 8.30]), Cronbach's  $\alpha = .456$  (mean across  $k = 120$ )

# OLS Regression of GHG Emissions

	GHG Total (log.)	GHG Housing (log.)	GHG Mobility (log.)	GHG Food (log.)	PEB <sup>a</sup>
<b>Equivalence income (log.)</b>	<b>0.17** (9.74)</b>	<b>0.13** (4.59)</b>	<b>0.33** (7.88)</b>	<b>-0.02* (-2.05)</b>	<b>-0.41** (-5.61)</b>
<b>Environmental concern (1-5)</b>	<b>-0.08** (-6.04)</b>	<b>-0.04* (-2.20)</b>	<b>-0.09** (-3.06)</b>	<b>-0.07** (-9.63)</b>	<b>0.54** (10.13)</b>
Number of persons in household	-0.10** (-13.67)	-0.26** (-22.08)	-0.07** (-4.14)	0.02** (3.57)	0.19** (5.81)
Children in household (0/1)	0.04 (1.40)	0.03 (0.85)	0.01 (0.09)	-0.02 (-1.51)	-0.11 (-1.03)
Female	-0.14** (-8.22)	0.07** (2.75)	-0.35** (-8.98)	-0.16** (-16.88)	0.17* (2.38)
Age (divided by 10)	-0.01* (-2.18)	0.07** (6.91)	-0.14** (-9.78)	-0.02** (-6.85)	0.24** (9.58)
Years of education	0.01** (4.40)	0.01 (1.88)	0.05** (6.17)	-0.01** (-5.20)	0.05** (3.67)
Economically active (0/1)	0.03 (1.63)	-0.04 (-1.28)	0.19** (3.98)	0.01 (1.15)	0.11 (1.28)
Car in household (0/1)	0.29** (12.60)		1.64** (26.45)		-0.84** (-8.91)
<i>German-speaking area (ref.)</i>					
French-speaking area	0.05* (2.12)	-0.17** (-4.77)	0.21** (4.05)	0.03* (2.56)	-0.58** (-6.41)
Italian-speaking area	0.04 (1.27)	-0.08 (-1.40)	0.16* (1.98)	-0.11** (-5.87)	-0.50** (-3.75)
<i>City (ref.)</i>					
Small or medium-sized town	0.07** (2.75)	0.19** (4.50)	-0.15* (-2.27)	0.05** (3.15)	0.58** (5.22)
Agglomeration	0.05* (2.09)	0.07* (2.08)	-0.10 (-1.83)	0.05** (3.95)	0.44** (4.85)
Rural community	0.08** (3.13)	0.06 (1.42)	-0.06 (-0.97)	0.10** (7.29)	0.66** (6.13)
Centrality (km, log.) <sup>b</sup>	0.00 (0.29)		0.00 (0.12)		0.08 (1.50)
Environmental knowledge (0-6)	0.01 (1.91)	0.04** (4.49)	0.01 (0.60)	-0.01** (-2.79)	0.08** (3.73)
Conditional cooperation (1-5)	0.02* (2.19)	-0.02 (-1.45)	0.05* (2.25)	0.04** (5.84)	-0.45** (-10.29)
Political right orientation (0-10)	0.01** (3.07)	0.01 (1.34)	0.01 (1.01)	0.02** (6.49)	-0.09** (-4.31)
Postmaterialism (0/1)	-0.00 (-0.18)	0.02 (0.68)	-0.01 (-0.16)	-0.02* (-2.12)	0.25** (3.18)
Constant	-8.34** (86.51)	7.24** (46.53)	6.05** (27.19)	7.27** (131.47)	5.74** (14.52)
Adjusted $R^2$ <sup>c</sup>	0.272	0.322	0.460	0.257	0.224



# Income, Environmental Concern & Behavior

	GHG Total (log.)	GHG Housing (log.)	GHG Mobility (log.)	GHG Food (log.)	PEB (0-13)
+1% equivalence income (log.)	+0.17%	+0.13%	+0.33%	-0.02%	-0.004 units
+1 unit of environmental concern (1-5)	-7.7%	-3.9%	-8.6%	-6.8%	+0.54 units

## + Income ⇔ "worse" behavior (+ emissions, - PEB)

- Exception Food: More of a qualitative than a quantitative shift (Girod & de Haan, 2010)
- **Food < Housing < Mobility**  
Hypothesis: The more essential the consumption, the weaker the link (cf. Gough et al., 2011).

## + Environmental concern ⇔ "better" behavior (- emissions, + PEB)

- **Housing < Food, Mobility**  
Hypothesis Housing: (1) Lack of awareness that living area is extremely relevant, (2) Swiss households typically do not own their home (only 37% do) => Limited choice
- **PEB: Tighter link to environmental concern than to income (also true for Food)**  
Low-Cost-Hypothesis: Higher effect of environmental concern for low-cost than for high-cost behavior (here: food, PEB vs. housing, mobility)

# Concluding Remarks

## Money or morals?

⇒ **Both!**

## Predictors of the different outcome variables (emission categories, PEB) are not necessarily the same

- ⇒ Studies both distinguishing between categories of consumption and using a broad set of predictors needed
- ⇒ To allow for such analyses, comprehensive data sets are needed  
Need to be tailored to this purpose, collaboration social & natural sciences

**Thank you very much for your attention!**

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Andreas Diekmann and I are currently writing up a paper on this very topic  
as well as on air travel for private purposes in particular.

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# Environmental Impact in the Present Study

Total: Mean = 6028 kg CO<sub>2</sub> eq. (95% CI [5904, 6151])

## Emissions by area of consumption

- Housing 33%  
(space heating, building infrastructure, electricity)
  - Mobility 46%  
(travel by air, public transport, car and motorbike)
  - Food 16%
  - Non-durable consumer goods 5%
- ✓ Shelter, mobility & food = most important
- ✗ Absolute numbers are too low. Consumption perspective: ≈ 9-13 tons
- ↔ Not covered: most services (health services, education, telecommunication...) and long-lived goods (furniture, electronic equipment, clothing...)
- ↔ Survey study, hence self-reported behavior; correlational, cross-sectional study; individual vs. household level

# Bivariate Correlations

Table 1. Bivariate correlations (estimated using Stata's "mibeta" with the option "fisherz")

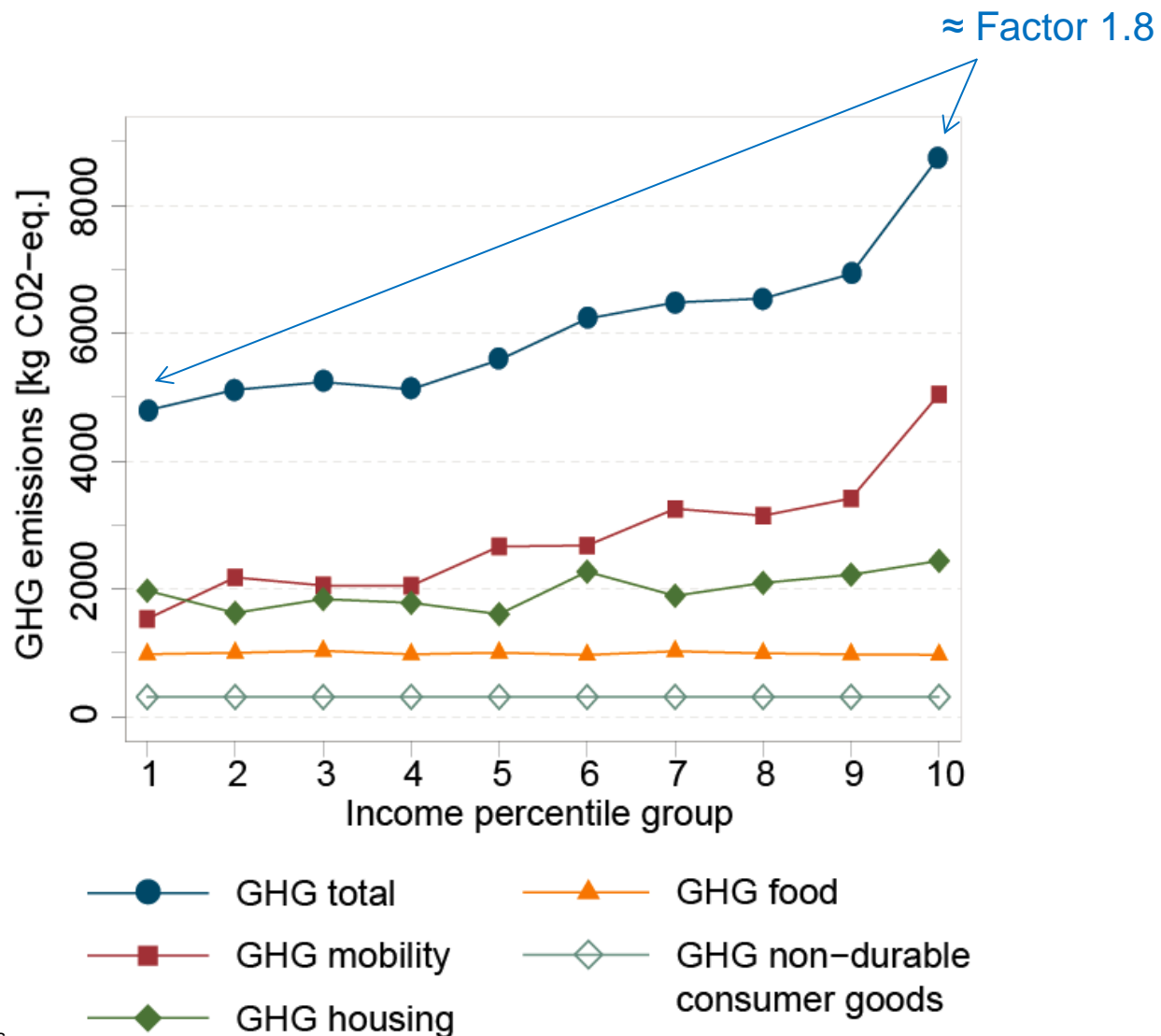
	1	2	3	4	5	6
1 GHG total (log.)	-					
2 GHG housing (log.)	.474***	-				
3 GHG mobility (log.)	.687***	-.076***	-			
4 GHG food (log.)	.200***	-.125***	.173***	-		
5 PEB <sup>a</sup>	-.264***	.042*	-.290***	-.353***	-	
<b>6 Equivalence income (log.)</b>	<b>.328***</b>	<b>.135***</b>	<b>.325***</b>	<b>-.004</b>	<b>-.159***</b>	-
<b>7 Environmental concern</b>	<b>-.211***</b>	<b>-.029</b>	<b>-.178***</b>	<b>-.269***</b>	<b>.266***</b>	-.104***
8 Household size	-.147***	-.521***	.168***	.165***	-.011	-.065***

Notes:

\*\*\*  $p < .001$ , \*\*  $p < .01$ , \*  $p < .05$ .

<sup>a</sup> "PEB" = pro-environmental behavior. High values = environmentally friendly behavior.

# Emissions by Category and Income Decile (Bivariate)





# OLS Regression: Standardized Coefficients

	GHG Total (log.)	GHG Housing (log.)	GHG Mobility (log.)	GHG Food (log.)	PEB <sup>a</sup>
<b>Equivalence income (log.)</b>	<b>0.19**</b>	<b>0.09**</b>	<b>0.13**</b>	<b>-0.04*</b>	<b>-0.11**</b>
<b>Environmental concern (1-5)</b>	<b>-0.10**</b>	<b>-0.04*</b>	<b>-0.05**</b>	<b>-0.16**</b>	<b>0.17**</b>
<b>Number of persons in household</b>	<b>-0.28**</b>	<b>-0.46**</b>	<b>-0.07**</b>	<b>0.07**</b>	<b>0.12**</b>
Children in household (0/1)	0.03	0.02	0.00	-0.03	-0.02
<b>Female</b>	<b>-0.14**</b>	<b>0.05**</b>	<b>-0.13**</b>	<b>-0.27**</b>	<b>0.04*</b>
<b>Age (divided by 10)</b>	<b>-0.05*</b>	<b>0.16**</b>	<b>-0.18**</b>	<b>-0.14**</b>	<b>0.20**</b>
Years of education	0.08**	0.04	0.10**	-0.09**	0.07**
Economically active (0/1)	0.03	-0.03	0.07**	0.02	0.03
<b>Car in household (0/1)</b>	<b>0.24**</b>		<b>0.49**</b>		<b>-0.17**</b>
<i>German-speaking area (ref.)</i>					
French-speaking area	0.03*	-0.08**	0.06**	0.04*	-0.10**
Italian-speaking area	0.02	-0.03	0.03*	-0.09**	-0.06**
<i>City (ref.)</i>					
Small or medium-sized town	0.05**	0.09**	-0.04*	0.06**	0.10**
Agglomeration	0.05*	0.04*	-0.04	0.08**	0.11**
Rural community	0.07**	0.03	-0.02	0.14**	0.13**
Centrality (km, log.) <sup>b</sup>	0.00		0.00		0.03
Environmental knowledge (0-6)	0.04	0.09**	0.01	-0.05**	0.07**
Conditional cooperation (1-5)	0.04*	-0.03	0.03*	0.11**	-0.19**
Political right orientation (0-10)	0.06**	0.03	0.02	0.13**	-0.09**
Postmaterialism (0/1)	0.00	0.01	0.00	-0.04*	0.06**
Adjusted $R^2$ <sup>c</sup>	0.272	0.322	0.460	0.257	0.224

<sup>a</sup> PEB = pro-environmental behavior. High values indicate environmentally friendly behavior.

<sup>b</sup> Adjusted  $R^2$  and standardized regression coefficients were estimated using Stata's "mibeta" with the option "fisherz".