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Greenhouse Gas Emissions, Environmental Concern and Income

Analysis of Survey-Based Life Cycle Data

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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 ...

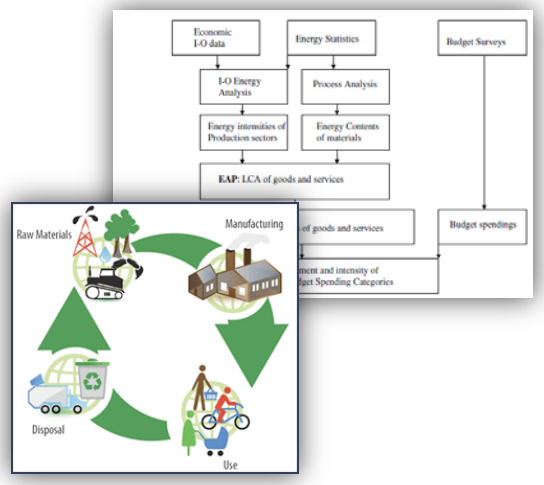
- **Natural sciences point to structural and socio-demographic factors**
  (e.g. location, income, household size, properties of the building, ...)

- **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

Figures: Moll et al. 2005:263 / EPA (21.10.2014)

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
- Few multivariate studies distinguish **areas of consumption**
- Few studies **compare** 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 ≥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

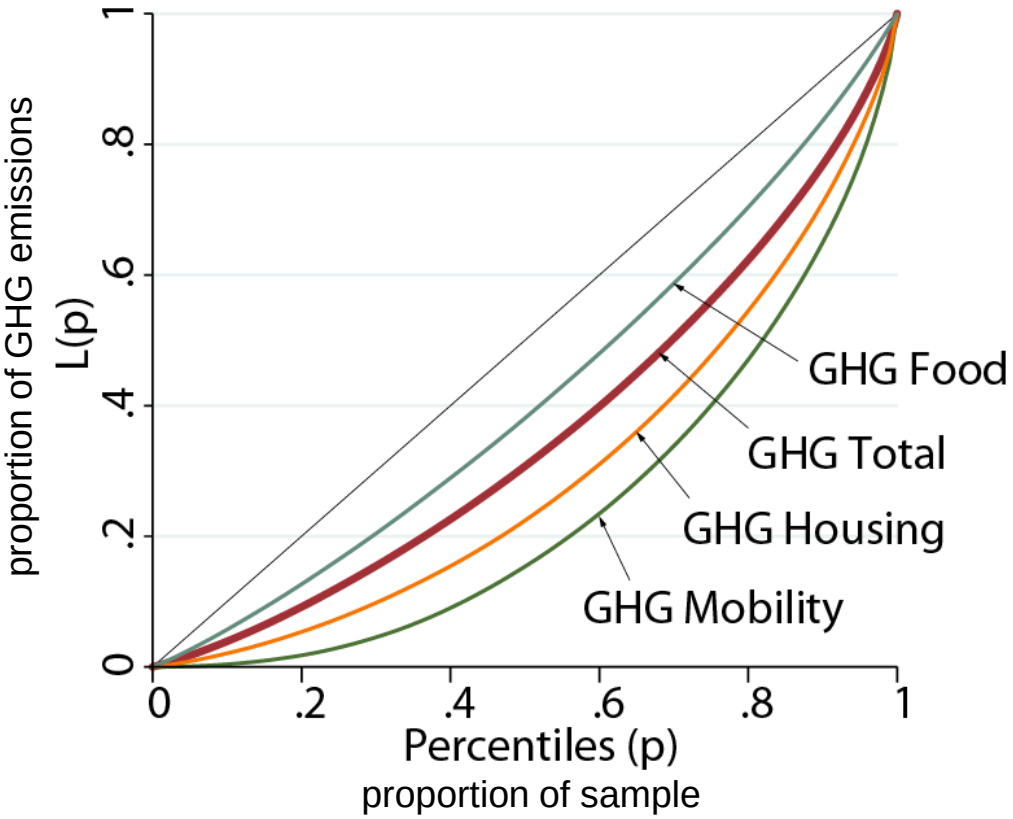
- Multiple imputation, *k* = 120, using Stata's "mi impute chained" => *n* = 3,369 unless indicated otherwise

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

Further details: www.socio.ethz.ch/forschung (German)

Unequal Distribution of Emissions: Lorenz Curves



Lowest emission decile: Mean = 2342 kg ≙ 4% of emissions
Highest emission decile: Mean = 13984 kg ≙ 23% of emissions
} ≈ Factor 6

GHG = Greenhouse gas emissions

Further Variables

Equivalence Income

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

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 α = .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 α = .456 (mean across *k* = 120)

OLS Regression of GHG Emissions

** $p < .01$, * $p < .05$, $n = 3369$

	GHG Total (log.)		GHG Housing (log.)[a]		GHG Mobility (log.)[a]		GHG Food (log.)[a]		PEB[b]	
Equivalence income (log.)	**0.18****	**(10.20)**	**0.14****	**(5.10)**	**0.34****	**(8.14)**	**-0.02**	**(-1.57)**	**-0.42****	**(-5.62)**
Environmental concern (1-5)	**-0.09****	**(-7.85)**	**-0.05***	**(-2.55)**	**-0.11****	**(-3.97)**	**-0.10****	**(-13.45)**	**0.71****	**(13.74)**
Number of persons in household	-0.11**	(-13.78)	-0.26**	(-21.95)	-0.08**	(-4.24)	0.02**	(3.53)	0.20**	(6.02)
Children in household (0/1)	0.04	(1.50)	0.04	(0.88)	0.01	(0.15)	-0.02	(-1.33)	-0.13	(-1.19)
Female	-0.15**	(-9.39)	0.05	(1.90)	-0.36**	(-9.68)	-0.17**	(-18.12)	0.21**	(3.02)
Age (divided by 10)	-0.02**	(-2.64)	0.07**	(6.78)	-0.15**	(-10.47)	-0.02**	(-7.09)	0.27**	(10.89)
Years of education	0.01**	(4.82)	0.02**	(3.45)	0.05**	(6.61)	-0.01**	(-7.79)	0.08**	(6.23)
Economically active (0/1)	0.03	(1.47)	-0.05	(-1.38)	0.19**	(3.98)	0.01	(0.86)	0.12	(1.38)
Car in household (0/1)	0.31**	(13.17)			1.65**	(26.90)			-0.96**	(-10.13)
German-speaking area (ref.)										
French-speaking area	0.04	(1.79)	-0.18**	(-4.90)	0.20**	(3.87)	0.03*	(2.18)	-0.52**	(-5.76)
Italian-speaking area	0.04	(1.08)	-0.10	(-1.71)	0.16*	(1.96)	-0.11**	(-5.68)	-0.54**	(-3.94)
City (ref.)										
Small or medium-sized town	0.07**	(2.78)	0.18**	(4.39)	-0.14*	(-2.23)	0.06**	(3.59)	0.54**	(4.72)
Agglomeration	0.05*	(2.20)	0.07*	(2.04)	-0.10	(-1.81)	0.06**	(4.79)	0.41**	(4.44)
Rural community	0.08**	(3.14)	0.05	(1.26)	-0.06	(-0.96)	0.12**	(8.13)	0.62**	(5.63)
Distance to local facilities (km, log)[c]	0.01	(0.55)			0.01	(0.26)			0.06	(1.12)
Constant	8.54**	(107.28)	7.29**	(56.16)	6.33**	(34.30)	7.54**	(164.51)	3.69**	(11.01)
Adjusted R^2	0.267		0.316		0.459		0.229		0.178	

[a] GHG Housing = household level / number of persons. GHG Mobility and Food: solely relate to respondents' personal travel and eating habits, respectively.
[b] "PEB" = "pro-environmental behavior" (intent-oriented measure). High values indicate environmentally friendly behavior.
[c] Lowest overall distance to closest postal office, public transport stop and grocery store

Income, Environmental Concern & Behavior

	GHG Total (log.)	GHG Housing (log.)	GHG Mobility (log.)	GHG Food (log.)	PEB (0-13)
+1% equivalence income (log.)	+0.18%	+0.14%	+0.34%	0%	-0.004 units
+1 unit of environmental concern (1-5)	-8.6%	-4.9%	-10.4%	-9.5%	+0.71 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 social norms?

⇨ **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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Bruderer Enzler, H., & Diekmann, A. (2015). Environmental Impact and Pro-Environmental Behavior: Correlations to Income and Environmental Concern. *ETH Zurich Sociology Working Papers,* No. 9. http://www.socio.ethz.ch/en/research/energyconsumption.html.

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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[a]	-.264***	.042*	-.290***	-.353***	-	
6	**Equivalence income (log.)**	**.328*** **	**.135*** **	**.325*** **	**-.004**	**-.159*** **	-
7	**Environmental concern**	**-.211*** **	**-.029**	**-.178*** **	**-.269*** **	**.266*** **	-.104***
8	Household size	-.147***	-.521***	.168***	.165***	-.011	-.065***

Notes:

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

[a] "PEB" = pro-environmental behavior. High values = environmentally friendly behavior.

** $p < .01$, * $p < .05$, $n = 3369$

OLS Regression: Standardized Coefficients

	GHG Total (log.)	GHG Housing (log.)[a]	GHG Mobility (log.)[a]	GHG Food (log.)[a]	PEB[b]
Equivalence income (log.)	**0.20****	**0.10****	**0.14****	-0.03	-0.11**
Environmental concern (1-5)	-0.13**	-0.04*	-0.06**	**-0.21****	**0.23****
Number of persons in household	**-0.28****	**-0.46****	-0.07**	0.07**	0.13**
Children in household (0/1)	0.03	0.02	0.00	-0.03	-0.02
Female	-0.15**	0.03	**-0.13****	-0.29**	0.05**
Age (divided by 10)	-0.05**	**0.15****	**-0.19****	-0.14**	**0.23****
Years of education	0.09**	0.06**	0.10**	**-0.13****	0.11**
Economically active (0/1)	0.03	-0.03	0.07**	0.02	0.03
Car in household (0/1)	**0.25****		**0.50****		-0.19**
German-speaking area (ref.)					
French-speaking area	0.03	-0.09**	0.05**	0.03*	-0.09**
Italian-speaking area	0.02	-0.03	0.03*	-0.09**	-0.07**
City (ref.)					
Small or medium-sized town	0.05**	0.08**	-0.04*	0.07**	0.09**
Agglomeration	0.05*	0.04*	-0.04	0.10**	0.10**
Rural community	0.07**	0.03	-0.02	0.16**	0.12**
Distance to local facilities (km, log)[c]	0.01		0.00		0.02
Adjusted R^2	0.267	0.316	0.459	0.229	0.178

[a] GHG Housing = household level / number of persons. GHG Mobility and Food: solely relate to respondents' personal travel and eating habits, respectively.
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