Voluntary Emission Reductions versus CO2 Offsetting: A Theoretical and Empirical Analysis for the U.S. and Germany

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Voluntary provision of public goods

- increasing attention in the literature
- donating money to charities, volunteering, behaving in environmentally friendly ways
- **Fly carbon free!**
  - voluntary CO2 offsetting
  - compensating emissions for which individuals are themselves responsible
  - investing in in renewable energies, energy efficiency, reforestation, etc.
- substantial criticism
  - modern form of buying "indulgences" from the Catholic Church.
  - polluting to a larger extent than would occur without this option

Background literature

- scarce existing academic literature on offsetting
- Kotchen (2009): through possibility of purchasing offsets, free-riding in large economies is reduced due to their presence
  - model based on offsets and polluting good consumption – no other (non-polluting) consumption option
- empirical studies mostly published by non-governmental organizations or consulting firms with aim to support consumers in choosing credible and good-quality CO2 offsetting providers
- WTP studies for offsetting air travel in Amsterdam (Brouwer et al., 2008, Akter et al., 2009)
- WTP for offsetting hypothetical flight between New York and London for adults in the UK (MacKerron et al. (2009)

This paper and presentation

- extends theoretical literature on offsets by studying relationship between CO2 offsetting and alternative individual emission-reducing activities
- provides new and important empirical insights on the link of offset investments and emission-reducing activities
- empirical evidence based on unique surveys in the U.S. and Germany

Preview of results

- theory
  - agents generally invest in offsets if their income exceeds a specific level
  - pollution level (emissions minus offsets) first increases in income before it finally decreases
  - increasing environmental preference affects investments in offsets or emission-reducing activities
  - we compare these offsetting and mitigation channels
- Empirics
  - different options to invest in reducing emissions for the case of vehicle use: CO2 offsetting or purchases of emission-reducing cars
  - representative data of drivers' license holders in the U.S. and Germany
  - country differences in the relative importance of mitigation vs. CO2 offsetting channels

The theory

- motivated by Andreoni (1990) warm-glow

$$u = U(z, x, r) \qquad w = z + x + py = z + x(1 + p/\lambda) + (-r)\underbrace{p/\lambda}_{=\sigma}$$

- z numeraire, x polluting good, r responsibility $r = x - \lambda y$
- z, x, $-r$ normal goods, effective pr
- condition $r \leq x$
- first-order conditions

$$\begin{aligned} \frac{U_x}{U_z}(z, x, r) + \frac{U_r}{U_z}(z, x, r) &= 1 \\ -\frac{U_r}{U_z}(z, x, r) &\leq \sigma \end{aligned}$$

- without offsets: $\frac{U_x}{U_z}(w - x_N, x_N, x_N) + \frac{U_r}{U_z}(w - x_N, x_N, x_N) = 1$

Without offsets

- individuals do not invest in offsets if

$$-\frac{U_r}{U_z}(w - x_N, x_N, x_N) \leq \sigma$$

- when consumer does not invest in offsets, additional income has an ambiguous effect on pollution
- consumption of more of the polluting good must be balanced against the increased feeling for responsibility

$\Rightarrow$ increased income may result in (i) an increase or (ii) an decrease of the polluting activity

Investing in offsets

Proposition 1:

Agents with sufficiently large income will invest in offsets. When investing in offsets, further increases in income lead to an increase in the polluting activity and increasing investments in offsets such that the effective pollution level (responsibility) r will either decline or stay constant.

- normality assumption leads to r decreasing in income, x increasing in income

Investing in offsets – The role of the price

Proposition 2:

Reductions in the price of offsets will make investments in offsets more likely as well as will reduce the effective pollution levels (responsibility).

- decreases in σ make investments in offsets more likely
- decreases in σ make investments in offsets cheaper relative to consuming x and z

Investing in offsets – The effect of increasing environmental preference

- measured by MRS $-U_r/U_x$ and $-U_r/U_z$
- intuition: increases in responsibility feeling *decrease* r
- two different channels ($r = x - \lambda y$):
  - mitigation channel: decreasing x
  - offsetting channel: increasing y
- relative use of these channels depends on preference structure

Illustrating Example I

$$u = U(z, x, r) = (z - hr^{\gamma})^{\alpha} x^{\beta}$$

- below income threshold, no investments in offsets
  - pollution increasing in income, decreasing in h
- above this income threshold, invest in offsets
  - responsibility stays constant in income, i.e. increases in polluting consumption compensated by increasing offsets
  - responsibility r decreasing in h
  - availability of offsets unambiguously increases consumption of polluting goods

Illustrating Example II

$$u = U(z, x, r) = (z + v(x))(K - r)^{\phi}$$

- above income threshold, no further increases in polluting consumption
- below income threshold, no investments in offsets
  - polluting good consumption *decreasing* in income and ϕ
- above this income threshold, agent invests in offsets
  - $v'(x_O) = 1$: consumption of polluting good then stays constant

  $\Rightarrow$ offsets allow keeping consuming the polluting good

  $\Rightarrow$ ϕ affects consumption of polluting good only as long as *no* offsets are bought

  $\Rightarrow$ larger ϕ induces agent to buy more offsets

Theoretical predictions

- relative to a situation without offsets
  - the polluting activity generally increases
  - this is compensated or overcompensated through buying offsets
  - final pollution level decreases
  - investments in offsets only if individual's income and the acceptability of offsets relative to their price are sufficiently high.

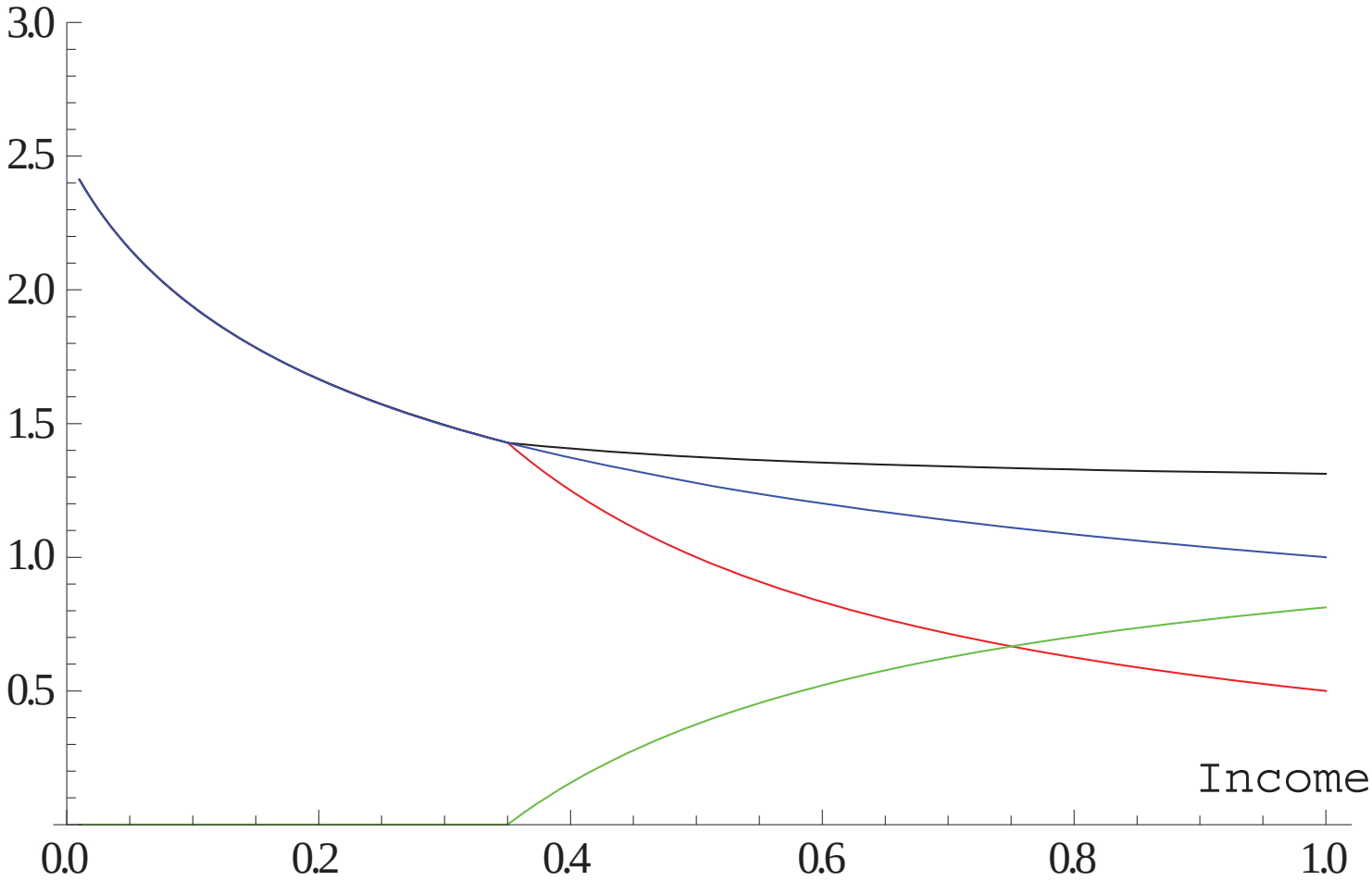
$\Rightarrow$ for low income levels and and high prices for offsets, reduction in pollution levels primarily via the *mitigation channel*

$\Rightarrow$ for large income levels, reduction in pollution levels primarily via *offsetting channel*

Prediction 1:

The offsetting channel is the more important, the higher the acceptability and the smaller the price of offsets is, the larger the income level is, and the larger the environmental preference.

Illustration for Example 1



- offsets (—), effective emissions (—), consumption (—)
- consumption without availability of offsets (—)

The survey

- unique representative data from Computer Assisted Web Interviews in Germany and the U.S. among drivers' license holders (age 18-64)
- conducted between December 2007 and February 2008
- 1000 respondents from Germany and 1231 from the U.S.
- questions involved:
  - likelihood of purchasing CO2 offsetting credits with the purchase of a new vehicle – coded as '1' if "very likely"

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  - change behavior when purchasing a vehicle ("not at all purchase of a smaller vehicle", "purchase of a vehicle with a smaller engine with less hp", "purchase of a vehicle with different fuel or alternative drive systems", "purchase of a vehicle with lower fuel consumption", "purchase of a vehicle with low emissions", "giving up the vehicle entirely in future"

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  - dummy variables "Purchase of smaller vehicle"", "Purchase of vehicle with alternative drive systems", and "Any alternative measure in reducing CO2 emissions" — mitigation channel

The survey

- variables that capture the environmental preference (importance of topic climate change *plus* how convinced that climate change is already taking place today
- dummy variable "Importance of or opinion about climate change" – 1 if at least one of the first alternatives (i.e. "extremely important", "thoroughly convinced") was chosen
- socio-economic variables (educational background, household income, age, etc.
- intensity of use of the underlying good (Log average driven kilometres per year)

Summary statistics

	USA		Germany	
	Mean (std)	n	Mean (std)	n
Purchase of CO_2 offsetting credits	0.23 (0.42)	962	0.24 (0.43)	872
Purchase smaller vehicle	0.52(0.50)	1213	0.63(0.48)	1000
Purchase vehicle with alternative drive systems	0.31(0.46)	1213	0.28(0.45)	1000
Any alternative measure in reducing CO_2	0.76(0.43)	1036	0.79(0.40)	956
Importance of climate change	0.39 (0.49)	1059	0.41 (0.49)	973
Road traffic responsible for CO_2 emissions	0.17 (0.38)	1140	0.11(0.31)	980
Higher education	0.51(0.50)	1213	-0.49(0.50)-	999--
HH income (> $60000 gross, €2500monthly net)	0.50(0.50)	1153	0.46 (0.50)-	776--
Age (in yrs)	42.36 (12.36)	1213	42.07 (10.36)	1000
Gender (male)	0.44(0.50)	1213	0.54(0.50)	1000
Household size	2.60(1.29)	1208	2.56(1.20)	997
Average driven km/yr (in 1000)	18.83 (15.89)	1213	14.93 (9.62)	1000

Empirical approach

- dependent variables:
  - purchase of CO2 offsets
  - purchase of smaller vehicle
  - purchase vehicle with alternative drive system
- joint multivariate binary probit model to capture possible correlations between dependent variables
- Geweke-Hajivassiliou-Keane (GHK) simulator with 50 random draws

Results - Offsetting and mitigation

	USA			Germany		
	CO_2 offsets	Smaller vehicle	Alternative drive systems	CO_2 offsets	Smaller vehicle	Alternative drive systems
Importance of climate change	0.71*** (6.89)	0.50*** (5.17)	0.38*** (4.00)	0.28** (2.51)	0.20* (1.87)	0.21** (1.98)
Road traffic responsible for CO2	0.28** (2.34)	0.12 (1.04)	0.16 (1.39)	0.56*** (3.32)	0.10 (0.55)	0.03 (0.19)
Higher education	-0.10 (-0.95)	0.01 (0.12)	0.30*** (3.13)	0.05 (0.40)	0.04 (0.40)	0.21* (1.88)
Higher household income	-0.03 (-0.30)	0.12 (1.27)	0.14 (1.46)	-0.01 (-0.10)	0.24** (2.13)	-0.04 (-0.33)
Age (in years)	0.00 (0.00)	-0.01** (-2.32)	-0.00 (-0.75)	0.01 (1.64)	0.00 (0.37)	-0.01** (-2.52)
Gender (male)	-0.05 (-0.48)	-0.13 (-1.42)	-0.16 (-1.64)	-0.01 (-0.07)	-0.31*** (-2.96)	0.11 (1.02)
Single	0.22 (1.15)	-0.34** (-2.04)	-0.01 (-0.05)	0.39* (1.71)	-0.17 (-0.83)	-0.17 (-0.78)
Number of observations	843			682		

Results - Offsetting and mitigation

	USA		Germany	
	Purchase of CO_2 offsetting credits	Any alternative measure in reducing CO_2 emissions	Purchase of CO_2 offsetting credits	Any alternative measure in reducing CO_2 emissions
Importance of climate change	0.76*** (7.19)	0.68*** (5.81)	0.26** (2.25)	0.47*** (3.78)
Road traffic responsible for CO_2	0.25** (2.02)	0.42*** (2.64)	0.56*** (3.33)	0.23 (1.05)
Higher education	-0.14 (-1.31)	0.09 (0.80)	0.06 (0.49)	0.14 (1.14)
Higher household income	-0.02 (-0.18)	0.03 (0.23)	-0.04 (-0.34)	0.27** (2.13)
Age(in years)	-0.00 (-0.15)	-0.01*** (-2.58)	0.01 (1.44)	0.00 (0.30)
Gender (male)	-0.04 (-0.38)	-0.48*** (-4.42)	-0.03 (-0.23)	-0.24** (-1.99)
Single	0.18 (0.94)	-0.38* (-1.95)	0.39* (1.68)	-0.48** (-2.00)
Number of observations	794		667	

Results

Result 1:

In the U.S. and in Germany, increased environmental preference has a positive impact on the likelihood that individual plan on using mitigation and offset measures in order to reduce their contribution to climate change.

- but, note that the dependent variables relate to different actions
- e.g., "Purchase of CO2 offsetting credits" (with new vehicle comprises two types: use or not use mitigation options

$\Rightarrow$ better define mutually exclusive alternatives that can be analyzed with multinomial discrete choice models

Offsetting or mitigation or both

- three separate approaches to combine the CO2 offsetting variable with different mitigation dummies
  - purchase of CO2 offsets
  - purchase of smaller vehicle
  - purchase vehicle with alternative drive system
- e.g., exclusive alternatives: "Purchase of CO2 offsetting credits and smaller vehicle", "Only purchase of smaller vehicle", "Only purchase of CO2 offsetting credits", and "No purchase of CO2 offsetting credits or smaller vehicle"
- analyzed using multinomial logit models

Results – Offsetting and mitigation

	USA			Germany		
	Only purchase of CO_2 offsets	Only purchase of smaller vehicle	Purchase of CO_2 offsets and smaller vehicle	Only purchase of CO_2 offsets	Only purchase of smaller vehicle	Purchase of CO_2 offsets and smaller vehicle
Importance of climate change	1.49^{***} (4.61)	0.90^{***} (4.42)	2.08^{***} (7.91)	0.28 (0.80)	0.30 (1.45)	0.78^{***} (2.97)
Road traffic responsible for CO_2	0.96^{**} (2.56)	0.49^{*} (1.81)	0.67^{**} (2.15)	1.20^{**} (2.39)	0.19 (0.50)	0.99^{**} (2.45)
Higher education	0.21 (0.68)	0.07 (0.36)	-0.38 (-1.55)	0.40 (1.12)	0.07 (0.36)	0.03 (0.11)
Higher household income	-0.65^{*} (-1.87)	0.08 (0.42)	0.29 (1.16)	-0.12 (-0.31)	0.40^{*} (1.85)	0.33 (1.14)
Age(in years)	0.01(0.91)	-0.01 (-1.43)	-0.02^{*} (-1.65)	0.05^{***} (2.62)	0.01 (1.14)	0.01 (0.65)
Gender (male)	-0.55^{*} (-1.70)	-0.59^{***} (-3.23)	-0.41 (-1.58)	-0.33 (-0.95)	-0.64^{***} (-3.17)	-0.53^{*} (-2.01)
Number of observations	794			667		

Results – Offsetting and mitigation

	USA			Germany		
	Only purchase of CO_2 offsets	Only purchase of vehicle with alternative drive	Purchase of offsets and vehicle with alternative drive	Only purchase of CO_2 offsets	Only purchase of smaller vehicle	Purchase of CO_2 offsets and smaller vehicle
Importance of climate change	1.42*** (5.39)	0.55*** (2.88)	1.58*** (6.34)	0.54** (2.27)	0.44** (2.18)	0.69** (2.13)
Road traffic responsible for CO_2	0.52* (1.76)	0.36 (1.50)	0.56** (1.99)	1.18*** (3.50)	0.36 (1.05)	0.79 (1.64)
Higher education	-0.35 (-1.38)	0.46** (2.38)	0.21 (0.87)	0.21 (0.88)	0.37* (1.77)	0.26 (0.72)
Higher household income	0.29 (1.06)	0.52*** (2.65)	-0.01 (-0.03)	-0.19 (-0.75)	-0.16 (-0.74)	0.05 (0.14)
Age(in years)	-0.02 (-1.48)	-0.01* (-1.72)	0.00 (0.31)	0.03* (1.85)	-0.02 (-1.60)	-0.03 (-1.45)
Gender (male)	0.23 (0.86)	-0.22 (-1.19)	-0.47* (-1.86)	-0.35 (-1.51)	-0.07 (-0.34)	0.67* (1.68)
Number of observations	794			667		

Results – Offsetting and mitigation

	USA			Germany		
	Only purchase of CO_2 offses	Only alternative measure in reducing CO_2 emissions	Purchase of CO_2 offsets and alternative measure	Only purchase of CO_2 offsets	Only alternative measure in reducing CO_2 emissions	Purchase of CO_2 offsets and alternative measure
Importance of climate change	**2.41*** (4.54)**	**1.42*** (5.18)**	**2.44*** (8.01)**	**-0.25 (-0.45)**	**0.66*** (2.66)**	**1.17*** (4.05)**
Road traffic responsible for CO_2	1.18* (1.85)	1.08*** (2.71)	1.39***(3. 28)	1.81** (2.21)	0.75 (1.32)	1.55*** (2.68)
Higher education	0.14 (0.29)	0.25 (1.18)	-0.07 (-0.27)	0.77 (1.59)	0.40* (1.70)	0.36 (1.23)
Higher household income	0.00 (0.00)	0.08 (0.38)	0.02 (0.06)	-0.50 (-0.98)	0.38 (1.53)	0.37 (1.21)
Age(in years)	0.01 (0.46)	-0.02** (-2.11)	-0.02*(-1.80)	0.06** (2.08)	0.01 (1.18)	0.02 (1.30)
Gender (male)	0.02 (0.04)	-0.83*** (-3.98)	-0.82*** (-3.15)	-0.45 (-1.02)	-0.51** (-2.10)	-0.45 (-1.56)
Number of observations	794			667		

Results

Result 2:

The relative importance of using mitigation or investing in offsets differs between the U.S. and Germany.

In both countries, an increase of importance that is put on climate change makes agents more likely to invest in both mitigation and CO2 offsetting.

When increasing only the use of one channel, the mitigation channel is more prevalent than increasing only the offsetting activities for Germans with a high environmental preference, while in the U.S. the offsetting channel dominates the mitigation channel in this case.

Speculating about the reasons

- increased acceptability of CO2 offsets as a means to reduce once own responsibility feeling

$\Rightarrow$ makes agents more likely to be in the domain where they invest in offsets

$\Rightarrow$ increases in environmental attitudes may well only lead to an extension of this channel

- In Germany, some agents with a high environmental preference may not consider CO2 offsetting as a feasible way to reduce responsibility.

$\Rightarrow$ Such agents would only invest in mitigation and therefore an increase in the importance will lead them to increase their mitigation activities.

Summary and Conclusions

- link between polluting activities and CO2 offsetting
- theoretical insights
  - availability of offsets will reduce the pollution level
  - Kuznets curve effect
  - relative importance of mitigation activities vs. offsetting depends on income level and environmental preference
- empirical findings from unique representative surveys among driver's license holder in the U.S. and Germany.
  - increased personal awareness of climate change increases the likelihood that agents invest in offsets and mitigation
  - important differences between these two countries: offset channel more prominent in the U.S. than in Germany

Outlook

- link to the literature on voluntary provision of public goods
- role of mechanisms to increase offsetting?
- social norms?
- interaction with giving to other charities
- competition between providers (prices, quality differentiation)