Fighting Climate Change with FinTech

Antonio Gargano[1] Alberto Rossi[2]

[1]University of Houston [2]Georgetown University

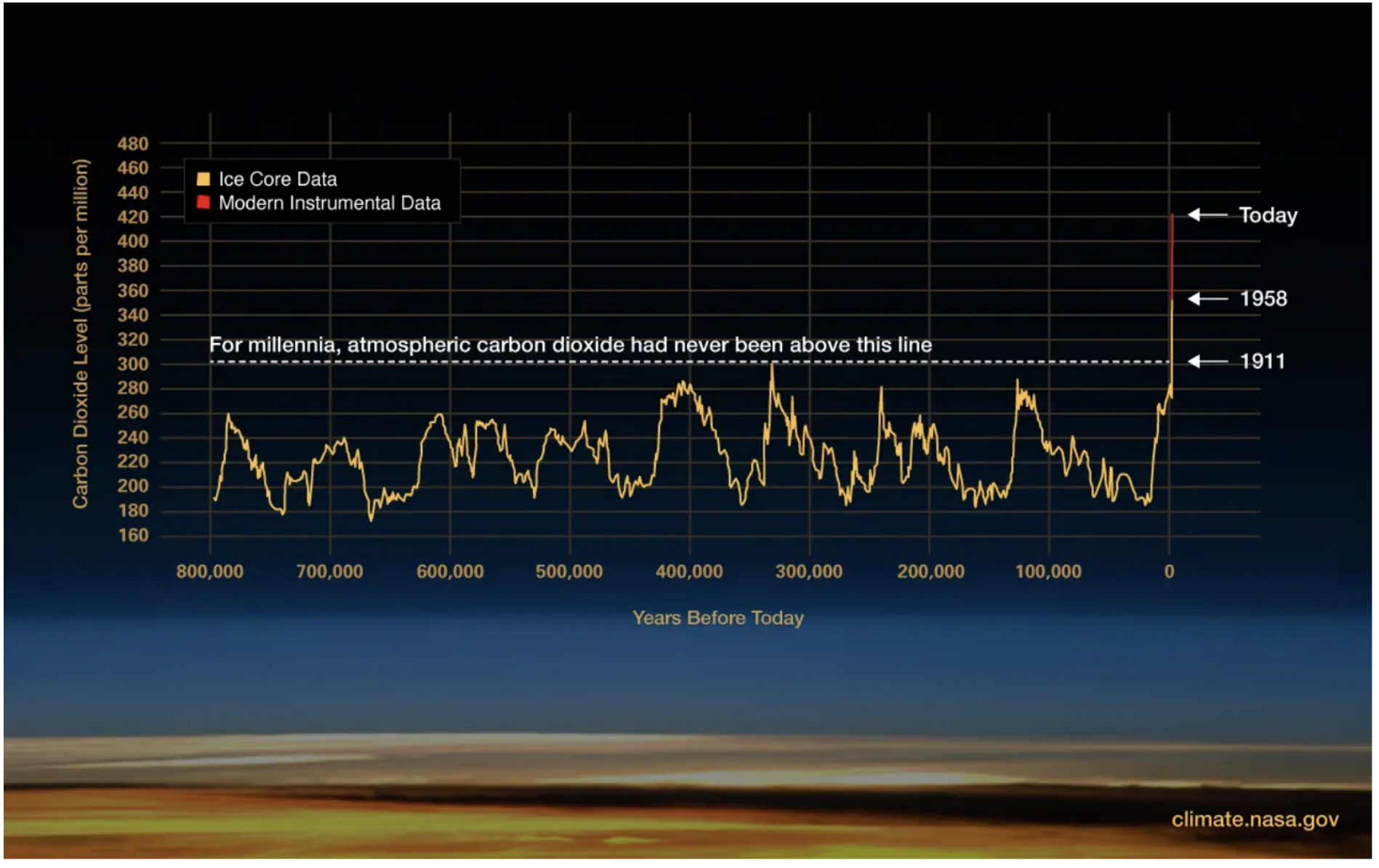
ABFER, May 2024

Motivation: The Science of Climate Change

- **Human activity** *is causing changes to earth's environment and biology*
  - IPCC report: official source of scientific evidence
    - ⋆ The risks they pose, and policy recommendations (e.g. Kyoto Protocol and Paris Agreements)

- The most IMPORTANT: increase in emissions of Greenhouse Gases (GHG). Either trapped in the atmosphere or absorbed by the oceans →
  1. An increase in temperature on earth's and oceans' surfaces (upper 700 m)
  2. A decrease in the p.h. of the oceans

- Chain reaction...
  1. Melting of polar ice with consequent rising sea levels
  2. More frequent and more intense "Extreme (Weather) events"
  3. Loss of biodiversity on land and oceans (with consequences for food chains)


Carbon Dioxide Level (parts per million)
480
460
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
Ice Core Data
Modern Instrumental Data
Today
1958
1911
For millennia, atmospheric carbon dioxide had never been above this line
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Years Before Today
climate.nasa.gov

Motivation: (Some of the) Risks of Climate Change

- Risks
  - Human Health and Labor Output
  - Commercial and Residential Real Estate
  - Infrastructure
    - ⋆ Especially power grids
  - Agriculture and Ecosystem Services
    - ⋆ Reduction in crop yields, degradation in water and soil quality
  - Mass migrations and political instability
  - Damage from extreme weather events

Motivation

- Climate change represents one of humanity's most pressing challenges
- Governments response: tax policies to reduce emissions from **corporations**
- Much less known how to help **individuals** reduce their emissions.

  Important:

  (1) Individuals account for up to 30% (60%) of direct (indirect) global emissions

  (2) 2022 projection from IPCC: target of Paris Agreement will not be met

- **FinTech Apps: promising tool** to promote consumers' sustainable behavior

  1 High penetration of mobile phones worldwide $\rightarrow$ deployed on a large scale

  2 Evidence FinTech apps improve households' financial decisions

What we do

- Partner with a digital bank offering tools to manage consumption's emissions
  1. *Footprint Calculator*
     Displays real-time carbon emissions associated with card transactions
  2. *Carbon offsetting*
     Program pledging to offset individuals' emissions through reforestation

  One of the first banks to introduce these tools

- Many have followed
  - Banco Santander, BNP Paribas, Standard Chartered, Nordea, ...

→ Millions of individuals exposed: no evidence of effectiveness

Benefits of our setting

(1) Rich Data: transaction-level info on CO2 emissions, Merchant Code and €

(2) Identification: Encouragement design based on a marketing campaign

Preview of Findings

1. Individuals are likely to purchase Carbon Calculator services
   - But it does not cause significant changes in consumption and emissions
2. Services that offset emissions by planting trees are less likely to be adopted
   - But prove effective in reducing users' emissions
3. No differences when conditioning on socio-demographic characteristics

- Next steps
  - Survey to understand the frictions at play
    - ⋆ Better benchmarking of information? Lack of trust?
  - RCT to increase adoption rates

Related Literature-I

Financial Technology (FinTech) and household behavior

- Benefits for households'
  - investment (D'Acunto, et al. 2019)
  - borrowing (Di Maggio et al 2022)
  - saving (Gargano and Rossi 2023)
  - spending (Lee 2023)

- Pitfalls and challenges of new technologies
  (e.g. Fuster et al 2018, Di Maggio and Yao 2020)

Our contribution: Benefits and challenges of FinTech for sustainable behavior

Related Literature-II

Climate finance

- Risks posed by climate change to the financial system and pricing of assets (Giglio et al 2020)
- Surveys to capture attitudes toward climate change (Dechezlepretre et al. (2023))
  - To understand support for policies in public opinion
  - Risks are correctly incorporated into prices if investors evaluate them correctly
- Our contribution: Study *actual consumption* choices. Important b/c
  - Consumption decisions are a key driver of carbon emissions
  - Individuals might fail to substantiate their claims through actions

Related Literature-III

Behavioral interventions to promote sustainable behavior

- Purely behavioral interventions (social comparison, nudges)
- Financial interventions offering monetary incentives (subsidies or discounts)
- The evidence is mixed and based on samples < 500
  - Little effect when targeting frequently occurring decisions (home energy)
  - Effective when targeting set-and-forget (install solar panels)
- Our contribution: Focus on
  - overall consumption
  - large-scale intervention

The App-I

- A European FinTech app with deposit and payment features
- Also tools to monitor and manage the emissions resulting from spending
- Sample from January 2022 to May 2023

1 Footprint Calculator

- Cost: €2.50, monthly
- Displays the carbon emissions from card transactions
- Updated once the transaction is approved, resets to zero at the end of month
- Provided by a third party (an industry leader in this space)
- $Footprint_i = €Spending_i \times \underbrace{Carbon\_per\_Euro_{MerchantCode(i)}}_{proprietary\ \ technology}$

The App-II

2 Carbon Offsetting Program

- €7.50 more
- Company pledges to offset up to 1,000kg of emissions per month
- By partnering with external entities that engage in reforestation projects
  - ⋆ One of the most economically efficient ways to perform carbon offsetting (Cornelius 2016)
  - ⋆ Widespread based on Berkeley Carbon Trading Voluntary Registry Offsets Data
- Cost in line with industry
  - ⋆ The price to offset 1,000kg of emissions ranges from a low of $2.55 to a high of $69.2, with the majority of the prices falling between $10 and $25.

The Data

Five tables (information is anonymized to guarantee user privacy)

- **Transactions.** Info on deposits and expenditures
  - Monetary amount, time-stamp, and channel (e.g., card, ATM, . . .)
- **Footprint.** Footprint associated with card expenses
  - The C02 emission (in grams), and the Merchant Category Code
- **Subscription.** Activation of
  - Carbon calculator and/or offsetting features
- **Users**. Information users with a profile on the App since inception
  - Dates of profile opening and closing, age, gender, location of residence, . . .
- **Logins**. Information on the individual logins (with associated time stamps)

Summary Statistics

	Obs	Mean	Std	p50
Panel A. Demographic Characteristics				
Age	29,463	30.04	13.52	24.00
Gender	29,463	0.70	0.46	1.00
Income<€15K (Dummy)	29,589	0.66	0.47	1.00
Panel B. Login Activity				
Days Logins (%)	29,748	31.98	26.93	23.48
N. Logins per day	29,748	2.89	2.02	2.31
Panel C. Spending and Emissions				
Days Transactions (%)	29,615	35.95	30.90	25.15
N. Transactions per day	29,615	1.69	0.92	1.51
Avg. Spending (€)	29,615	58.88	269.52	16.90
Carbon Calculator (Dummy)	29,795	0.26	0.44	0.00
Carbon Offsetting (Dummy)	29,795	0.07	0.26	0.00

Spending and Emissions Patterns

Patterns of users' spending and emissions. Important

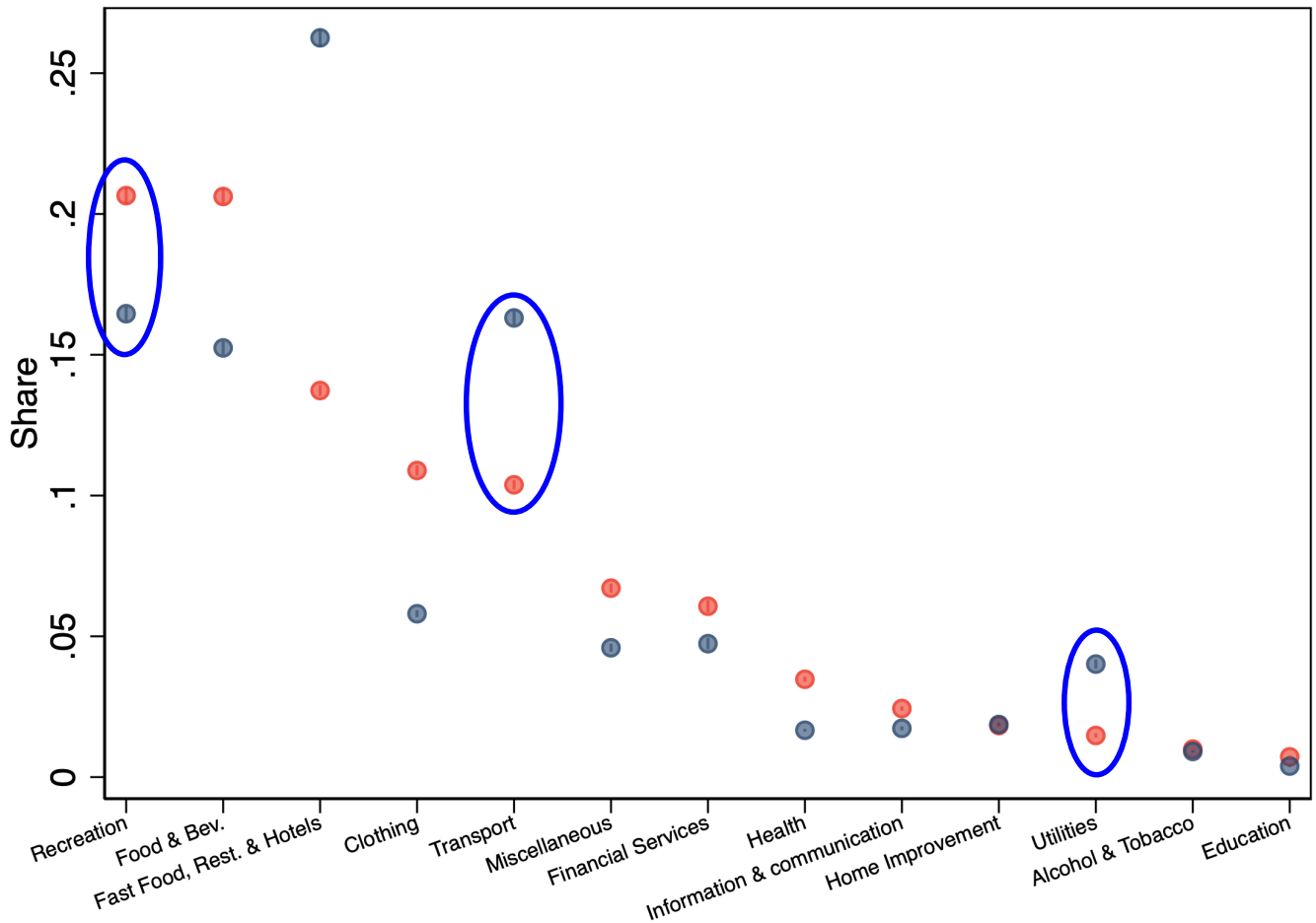
- Emissions are ultimately estimated from spending $\rightarrow$ to validate our data
- Previous studies focused on specific products (example, weatherization)
  - In quasi-experimental settings
  - Less known on how decisions are made
    - ⋆ in the field
    - ⋆ across the full range of consumption categories

Two empirical exercises

1. Allocation of spending and emissions across consumption categories
2. Relation between income and
   - Emissions
   - Emissions per euro

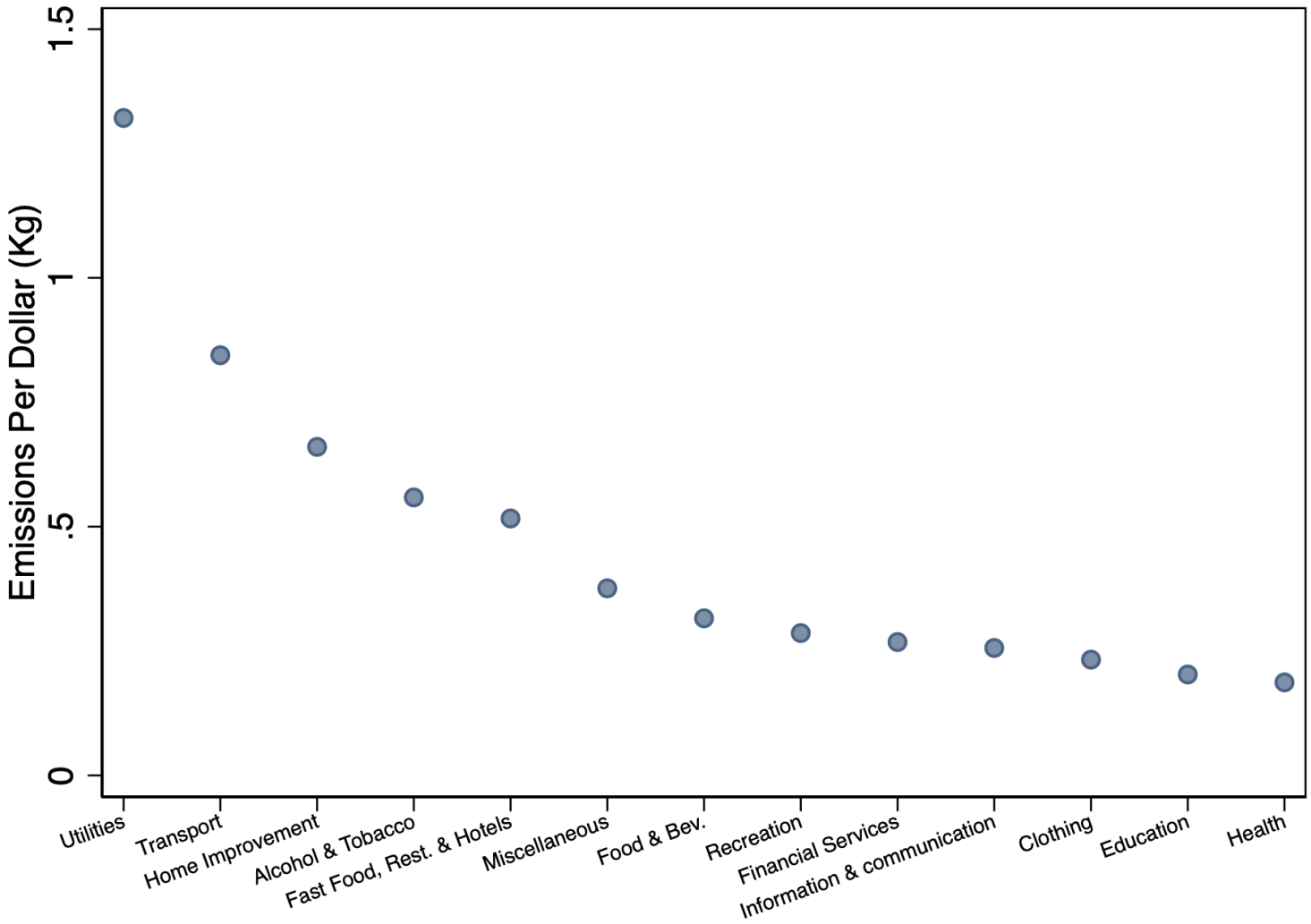
Spending and Emissions

- Map MCCs into two-digit COICOP
  - Developed by the United Nations Statistics Division
- For each user, share of spending and emission in each category
- Report average across users for Spending and Emissions



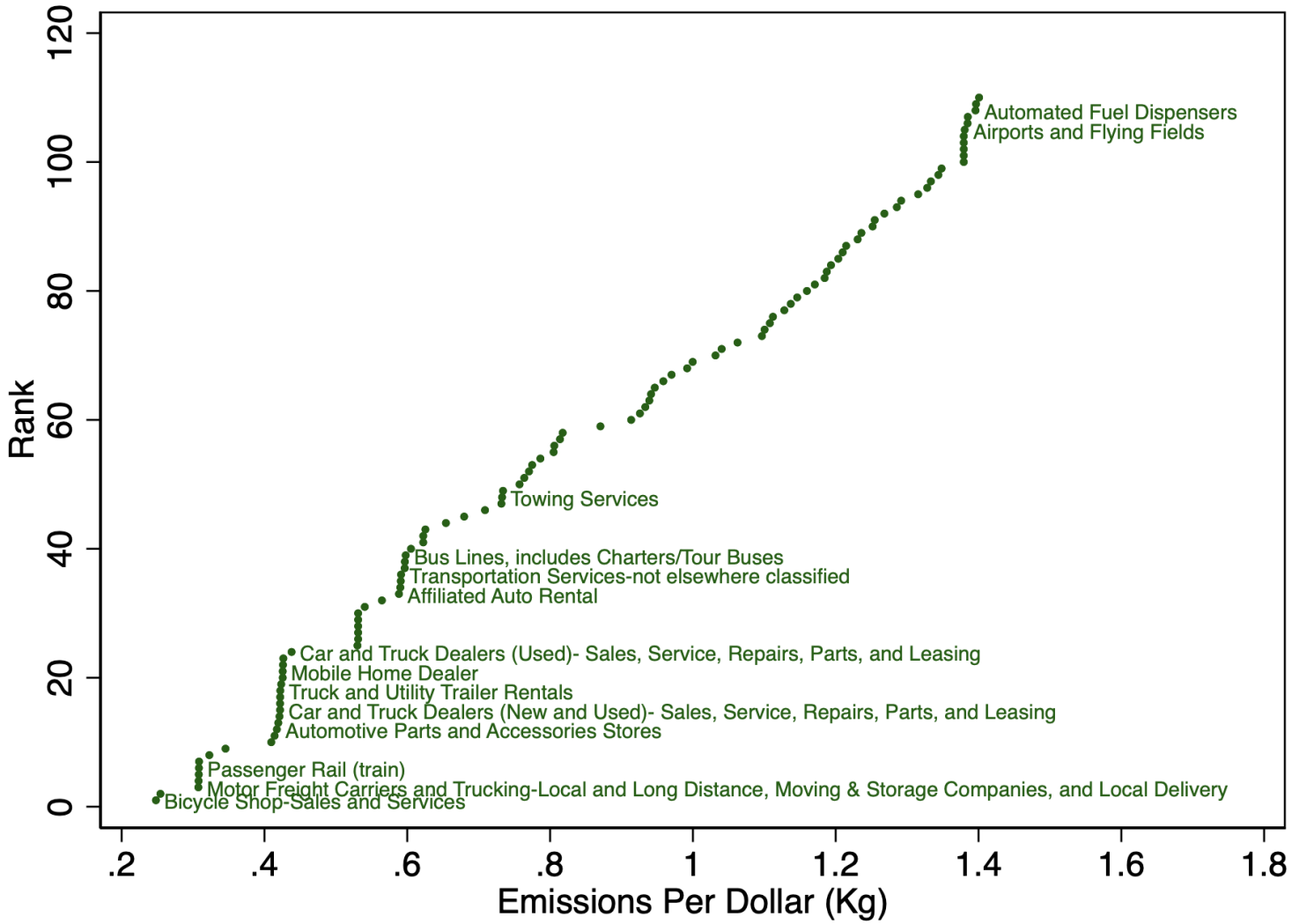
Emissions per Euro

- Average Carbon per Euro across MCCs in the COICOP categories

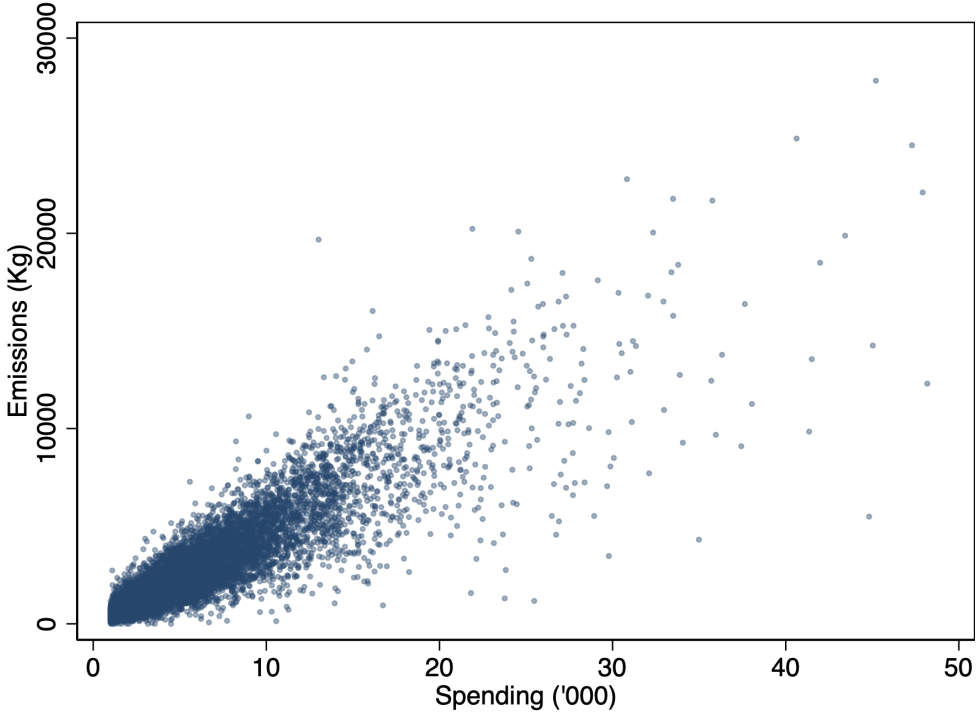


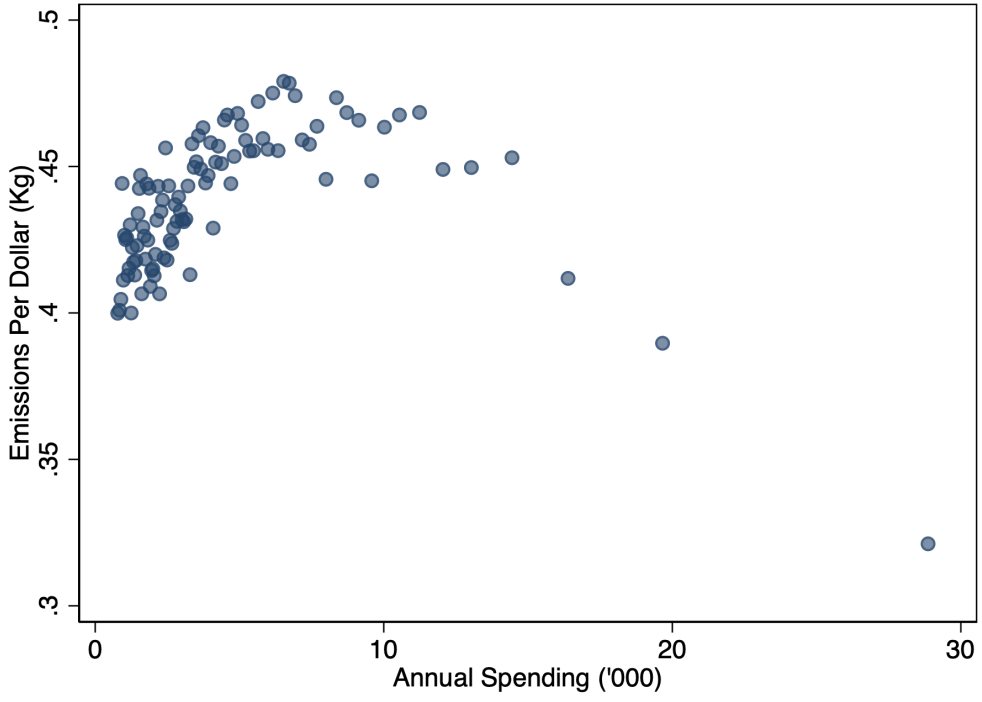
Emissions per Euro: Transportation

- Number of MCCs varies across COICOP categories
- For some, large heterogeneity



Spending and Emissions (1)





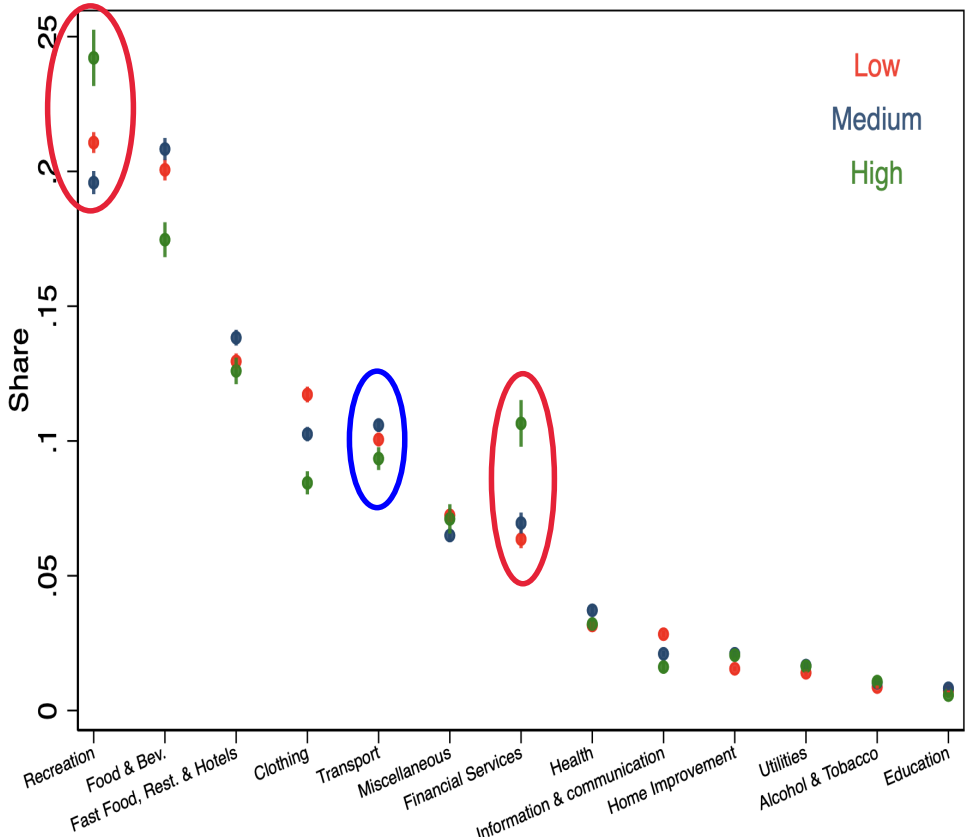
- Strong positive relation (ρ= 0.9)
- Slope: for each additional €10,000 emissions ↑ 4,650kg.
- Heteroscedasticity: dispersion in emissions ↑ with spending

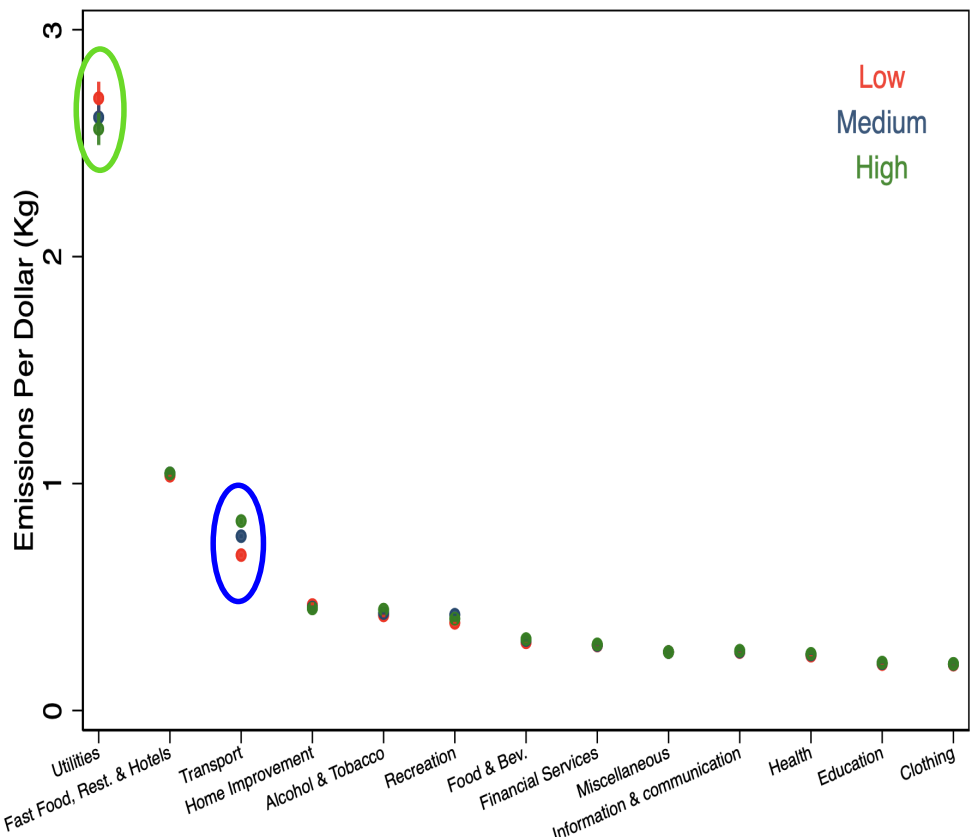
- Inverted U-shaped
- €0K to €3K: emissions per euro ↗
- €3K to €8K: emissions per euro ⟷
- €8K+: emissions per euro ↘

Spending and Emissions (2)

- Two non-mutually exclusive channels. Income differentials could relate to
  - Differences between categories of consumption ✓

    AND/OR
  - Differences within categories of consumption ✗





Challenges of Establishing Causality

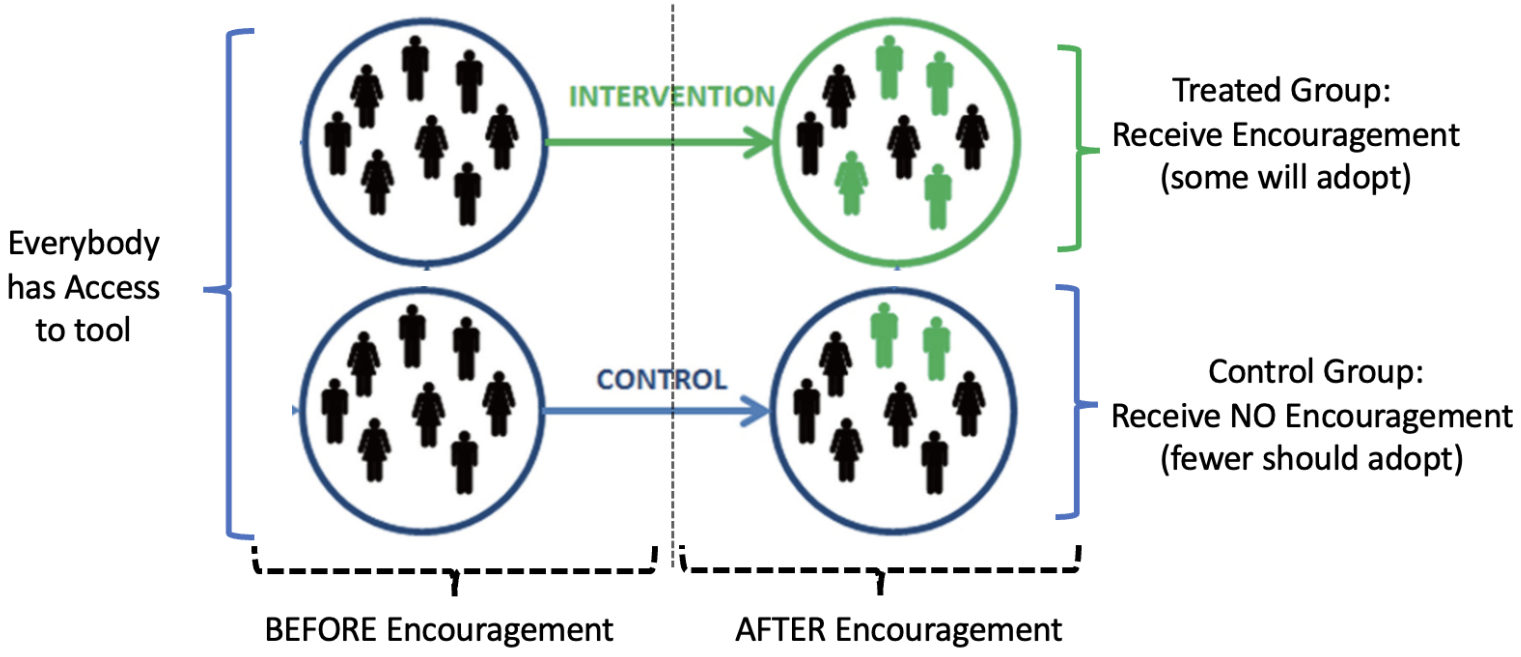
- **Objective: Estimate the causal effect of providing**
  - Information on footprint of transactions (Carbon Calculator)
  - Carbon offsetting services
- **On**
  - € Spending
  - CO2 Emissions
    - ⋆ Because fighting climate change ultimately requires to reduce emissions
  - Emissions per Euro
    - ⋆ Governments want to reduce emissions without depressing economic activity
- **Challenging** because the decision to subscribe is **endogenous**.
  - Cannot compare users who adopt the tools with users who do not

    Unobservables might drive both consumption decisions and adoption of tools $\rightarrow$ selection bias
  - Cannot compare the same user over time

    Users might decide to become more sustainable and *then* adopting the tools $\rightarrow$ reverse causality

Encouragement design

- Tools available to everybody since App inception and cannot be denied
- BUT company ran a marketing campaign on a group of users
- Causal effect is still possible using Instrumental Variable (Imbens and Angrist, 1994)



Encouragement design

- Instrument Adoption with Encouragement. Intuition:
  - Remove endogenous factors of tool adoption
  - Exploit only exogenous variation driven by the campaign

  (Fowlie et al., QJE, 2018)

- Step 1: First Stage

$$\mathbb{1}\{Sus\_Tool\}_{i,t} = \alpha_i + \alpha_t + \theta \ \mathbb{1}\{Encouraged\}_{i,t} + \epsilon_{i,t}$$

  - *Sus_Tool* equal to 1 if user adopted the tool at time t and 0 otherwise
  - *Encouraged* equal to 1 for users targeted by the campaign after the campaign

- Step 2: Second Stage

$$Y_{i,t} = \alpha_i + \alpha_t + \beta \ \widehat{\mathbb{1}\{Sus\_Tool\}}_{i,t} + \epsilon_{i,t}$$

  - β: DIFFERENCE between change in treated AFTER the intervention and change in control AFTER the intervention

Encouragement design

Our Setting:

- Company ran a marketing campaign in July 2022
- The company divided the user population into:
  - control group: not contacted
  - treatment group: emails and App notifications to encourage sign-up
- The email and app notifications ranged in type and content
- Messages highlighted
  - the eco-balance
  - or carbon-offsetting tools

  to combat climate change.

Assumptions

To be interpreted causally, three assumptions must be satisfied

- RELEVANCE
  - Marketing campaign must be effective at increasing tools' adoption
- EXOGENEITY
  - Group in the marketing campaign is **not** chosen based on characteristics that are correlated with sustainable behavior
- EXCLUSION RESTRICTION
  - Encouragement affects users' behavior ONLY through their tools' adoption
  - Inherently untestable, but we provide formal tests that the encouragement does not change the behavior of those who do not adopt treatment

Balancing and Exogeneity of Encouragement

		Panel A: Treated						
		Mean	Std	p5	p25	p50	p75	p95
Age		29.85	13.16	18.00	20.00	24.00	37.00	56.00
Gender		0.68	0.47	0.00	0.00	1.00	1.00	1.00
Frac Days Logins (%)		31.40	22.00	6.02	15.03	25.74	42.42	77.78
N. Logins		3.06	1.81	1.44	2.00	2.57	3.54	6.38
Frac Days Transactions (%)		37.39	29.42	5.38	13.64	27.43	57.58	100.00
N. Transcations		1.68	0.79	1.00	1.22	1.50	2.00	2.86
Avg. Spending		38.37	136.99	0.06	2.59	14.21	37.48	138.97
Emissions		920.08	4,210.73	0.00	8.06	136.87	689.64	3,884.81
		Panel B: Non Treated						
	t-test	Mean	Std	p5	p25	p50	p75	p95
Age	-1.45	30.38	12.87	18.00	20.00	25.00	37.00	57.00
Gender	-1.32	0.70	0.46	0.00	0.00	1.00	1.00	1.00
Frac Days Logins (%)	-1.57	32.36	22.19	6.29	15.56	26.87	43.75	79.01
N. Logins	-1.30	3.11	1.98	1.45	2.00	2.60	3.57	6.50
Frac Days Transactions (%)	-0.72	37.82	28.61	5.38	13.95	29.31	60.00	100.00
N. Transactions	-0.57	1.69	0.72	1.00	1.23	1.54	2.00	3.00
Avg. Spending	-1.31	43.70	217.58	0.03	1.67	13.46	38.52	155.20
Emissions	0.28	894.71	3,032.94	0.00	6.96	112.27	745.86	4,016.23

First Stage

$$\mathbb{1}\{Sus\_Tool\}_{i,t} = \alpha_i + \alpha_t + \theta\ \mathbb{1}\{Encouraged\}_{i,t} + \epsilon_{i,t}$$

	Sustainability Tool	
	Carbon Calculator (1)	*Carbon Offsetting* (2)
Encouragement	0.026***	0.004***
	(8.25)	(3.56)
User FE	✓	✓
Time FE	✓	✓
Adj-R^2	0.616	0.479

- Carbon Calculator: 2.8% of not targeted adopted
  → campaign increased adoption by 2.6/2.8=92.8%
- Carbon Offsetting: 0.38% of not targeted adopted
  → campaign increased adoption by 100%

Second Stage: Carbon Calculator Results

Estimate:

$$Y_{i,t} = \alpha_i + \alpha_t + \beta \; \mathbb{1}\{\widehat{Sus\_Tool}\}_{i,t} + \epsilon_{i,t}$$

(Take logs of the dependent variable to take care of the skewness)

	Instrumental Variable Estimates		
	Consumption	*Emissions*	*Emissions Per Euro*
Carbon Calculator	0.037**	0.014	-0.067
	(1.69)	(0.03)	(-0.37)
F-statistic	68.22	68.22	27.99
User FE	✓	✓	✓
Time FE	✓	✓	✓

Because log-linear regression: marginal effect is $e^{\hat{\beta}}$-1

Second Stage: Carbon Offsetting Results

Focusing on net emissions, estimate:

$$Y_{i,t} = \alpha_i + \alpha_t + \beta \; \mathbb{1}\{\widehat{Sus\_Tool}\}_{i,t} + \epsilon_{i,t}$$

(Take logs of the dependent variable to take care of the skewness)

	Instrumental Variable Estimates		
	Consumption	*Emissions*	*Emissions Per Euro*
Carbon Offsetting	-0.071	-7.437**	-5.531***
	(-0.49)	(-2.05)	(-5.01)
F-statistic	12.69	12.69	8.25
User FE	✓	✓	✓
Time FE	✓	✓	✓

- After-allowance emissions reduced by close to 100%
  - Log-linear regression, marginal effect is $e^{\hat{\beta}}$-1
- Gross emissions are unchanged

Exclusion Restriction

Estimate for those who do not adopt treatment:

$$Y_{i,t} = \alpha_i + \alpha_t + \beta \ \mathbb{1}\{Encouraged\}_{i,t} + \epsilon_{i,t}$$

	Panel A: Carbon Calculator		
	Consumption	*Emissions*	*Emissions Per Euro*
$\mathbb{1}\{Encouraged\}$	0.001	-0.004	-0.002
	(1.08)	(-0.30)	(-0.21)
User FE	✓	✓	✓
Time FE	✓	✓	✓
Adj-R^2	0.35	0.54	0.28
	Panel B: Carbon Offsetting		
	Consumption	*Emissions*	*Emissions Per Euro*
$\mathbb{1}\{Encouraged\}$	-0.000	-0.023*	0.004
	(-0.68)	(-1.90)	(0.40)
User FE	✓	✓	✓
Time FE	✓	✓	✓
Adj-R^2	0.34	0.54	0.28

→ Encouragement doesn't change the behavior

Intention-to-Treat Effects

- Our estimates are Local Average Treatment Effects (LATE)
  - The causal effect of adopting the tools on sustainability
  - Effect on those who adopt
- From a policy perspective, interested in the Intent-To-Treat (ITT) estimate
  - Causal effect of receiving a notification, irrespective of ultimate adoption
  - Effect on entire treated population
- We estimate the following regression:

$$Y_{i,t} = \alpha_i + \alpha_t + \beta \ \mathbb{1}\{Encouraged\}_{i,t} + \epsilon_{i,t}$$

where β provides the ITT estimate of interest.

Intention-to-Treat Effects

	Panel A: Carbon Calculator		
	Consumption	*Emissions*	*Emissions Per Euro*
$\mathbb{1}\{Encouraged\}$	0.001	0.000	-0.004
	(1.47)	(0.03)	(-0.36)
User FE	✓	✓	✓
Time FE	✓	✓	✓
Adj-R^2	0.35	0.54	0.28
	Panel B: Carbon Offsetting		
	Consumption	*Emissions*	*Emissions Per Euro*
$\mathbb{1}\{Encouraged\}$	-0.000	-0.028**	-0.047**
	(-0.49)	(-2.27)	(-2.42)
User FE	✓	✓	✓
Time FE	✓	✓	✓
Adj-R^2	0.34	0.54	0.35

Heterogeneity

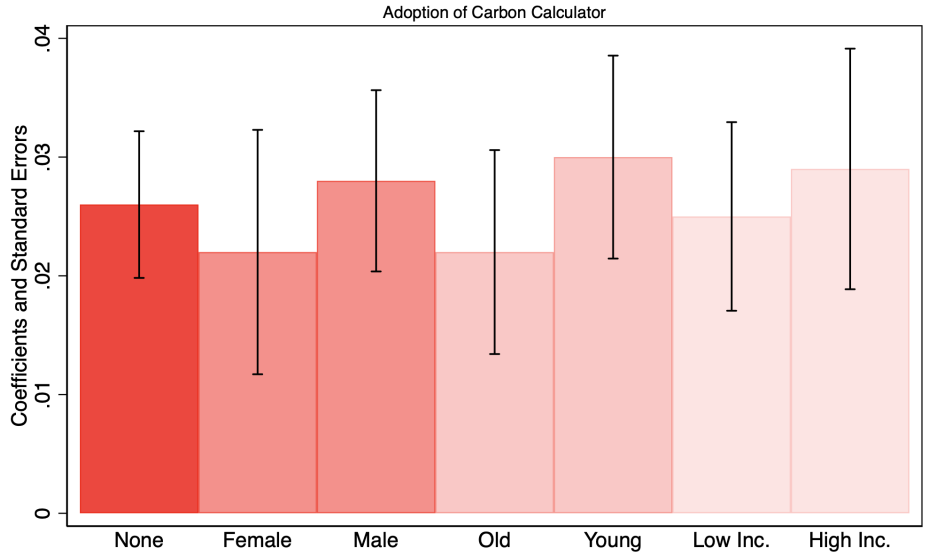
- Individual demographics are correlated with
  - Environmental literacy (Anderson et al., 2022)
  - Preferences & knowledge of socially responsible investments (Bauer et. al., 2021)
  - Support of policies addressing climate change (Stantcheva et. al., 2023)

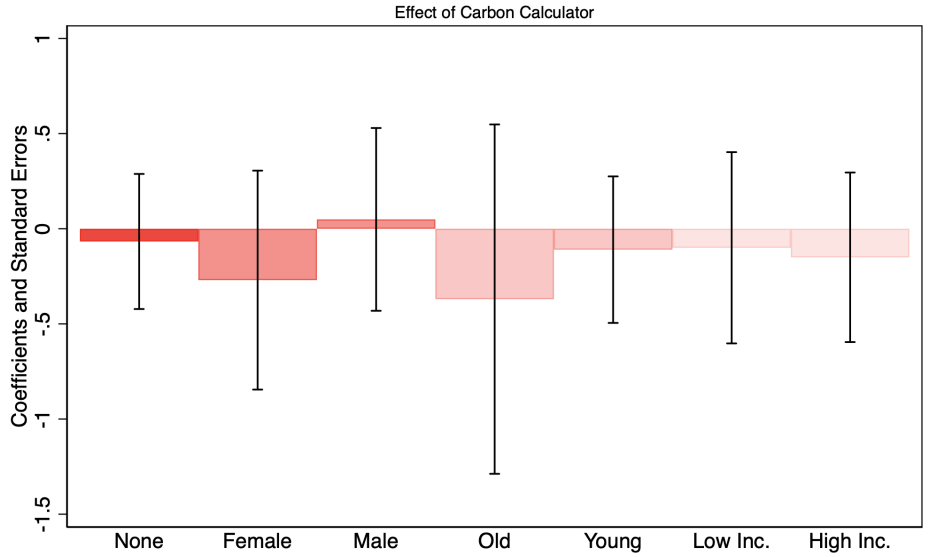
→ Might affect the adoption of the sustainability tools and their effect

→ Null effects may be due to averaging positive and negative effects across users

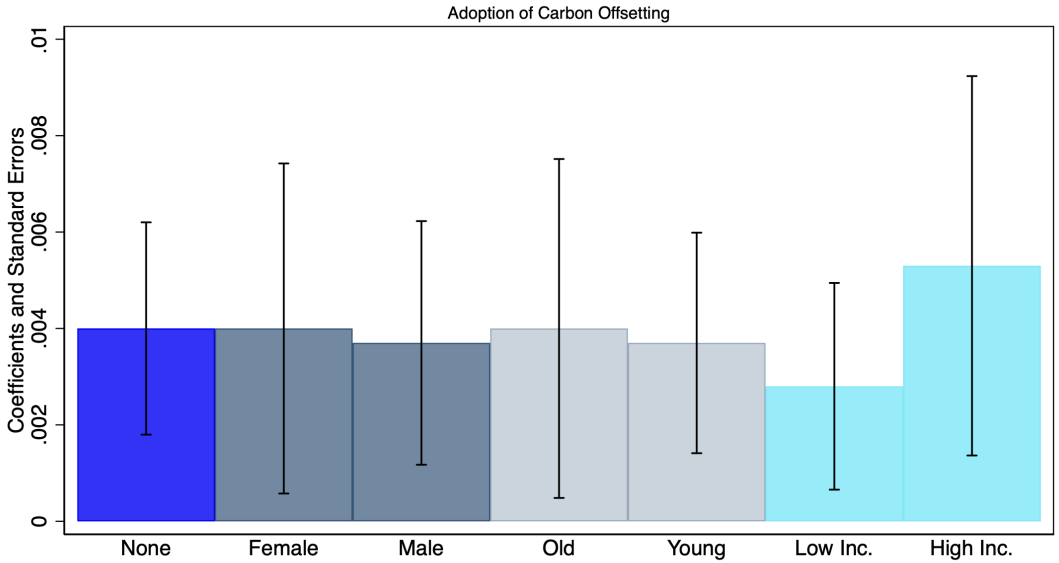
- Estimate main specification (carbon per euro) conditioning on
  - Gender
  - Age
  - Income

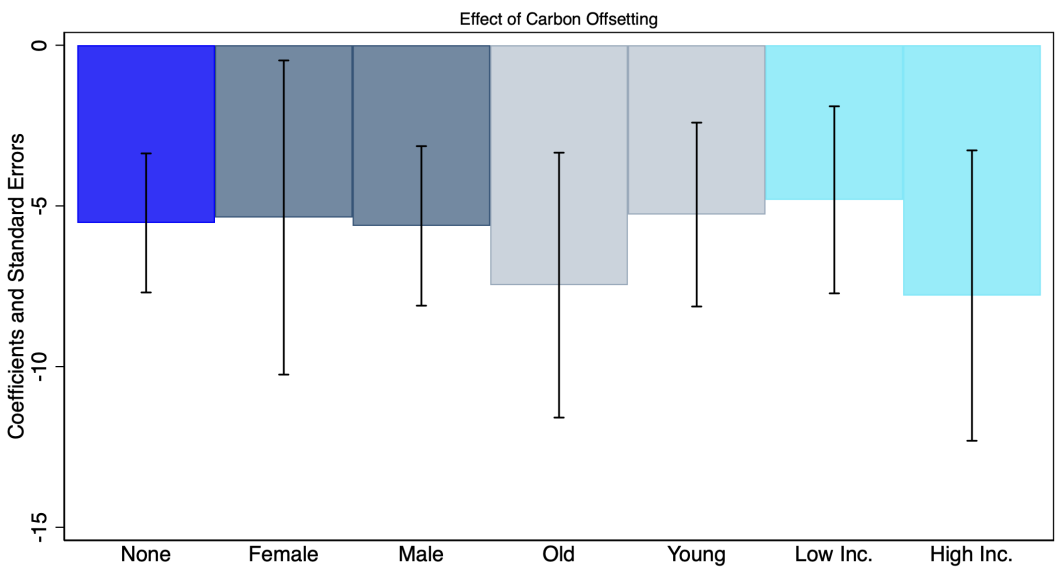
Heterogeneity: Carbon Calculator





Heterogeneity: Carbon Offsetting





Conclusions

- Climate change is one of the most pressing challenges modern society faces
- Individual consumption accounts for 30% of global emissions
  - But little is known regarding how to promote sustainable consumption behavior
- We study the effectiveness of FinTech App tools delivered to help individuals
  - Monitor and reduce the emissions from consumption

MAIN FINDINGS

1. Individuals are likely to purchase Carbon Calculator services
   - But it does not cause significant changes in consumption and emissions
2. Services that offset emissions by planting trees are less likely to be adopted
   - But prove effective in reducing users' net emissions
3. No differences when conditioning on socio-demographic characteristics