

Environmental and Development Economics

Module 2 - How does development affect the environment?

Raahil Madhok
UMN Applied Economics

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Lecture 2

How does development affect the environment?

Housekeeping

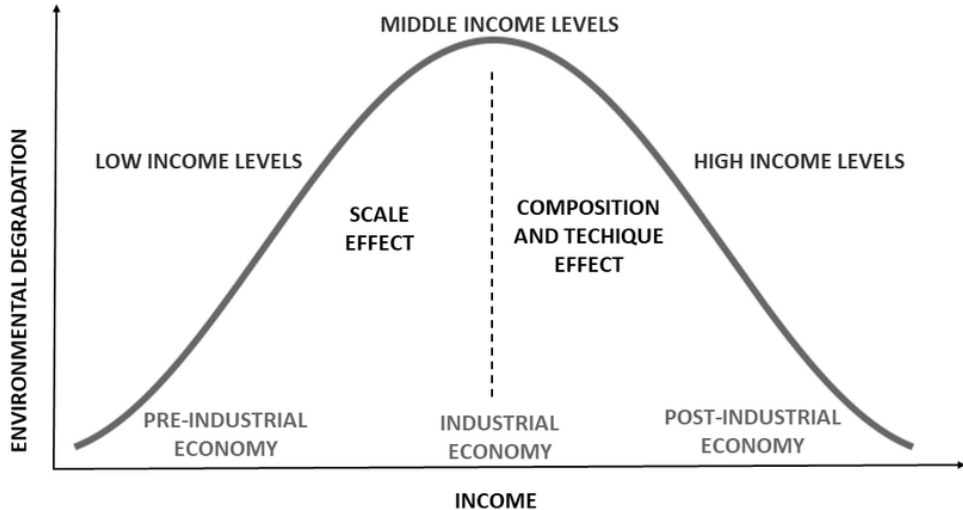
- ▶ Replication project (Ryan announcement)
 - ▶ Due Oct 17th
- ▶ Research proposal
 - ▶ Start thinking about idea + come talk to me
 - ▶ First draft: Oct 3rd (pass/fail)
- ▶ Lecture slides will be posted before each class
- ▶ Reading list is a work in progress
- ▶ 5 min break mid-way through lectures

- ▶ **Guiding question:** how does economic development affect the environment?
- ▶ Descriptive overview
- ▶ Channel I: Income effects (today)
 - ▶ **Changes in consumption**
 - ▶ **Energy**
 - ▶ Diet
- ▶ Channel II: Technology and Infrastructure (next week)
 - ▶ Agricultural productivity
 - ▶ Infrastructure
- ▶ Channel III: Institutions
 - ▶ Later in the course

How does economic development affect the environment?

- ▶ There is no one answer
- ▶ Choices that maximize economic growth often degrade environment
- ▶ But development expands our choice set (e.g. clean energy)
- ▶ Development also lowers $u'(c)$ (model from last week)
- ▶ Hence: the Environmental Kuznets Curve (EKC)

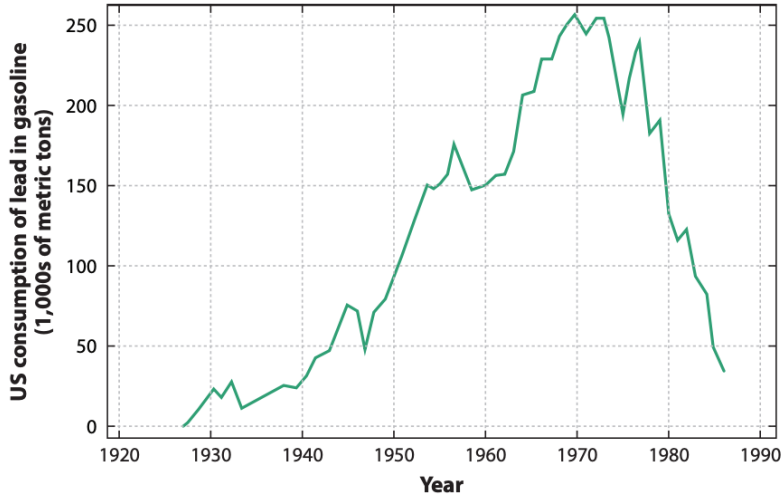
Environmental Kuznets Curve



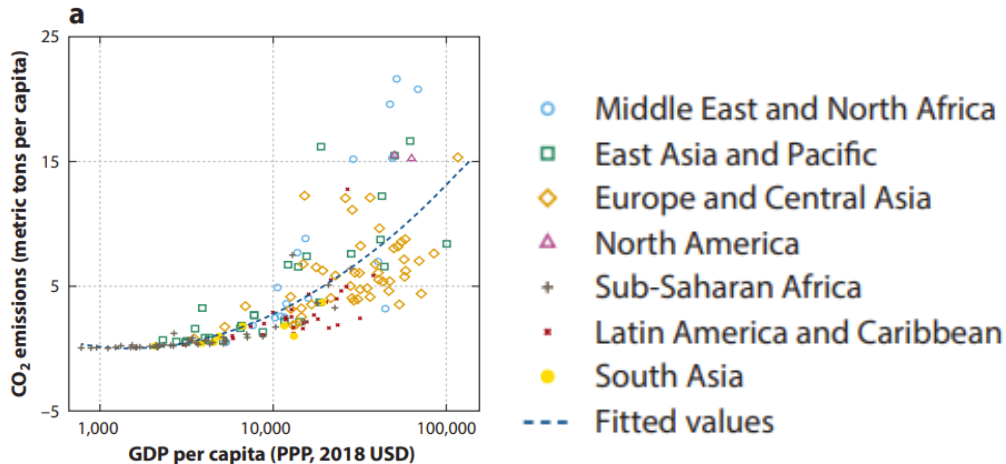
Discussion: Do you believe EKC?

- ▶ Mechanisms?
- ▶ Causality?
- ▶ Robustness?

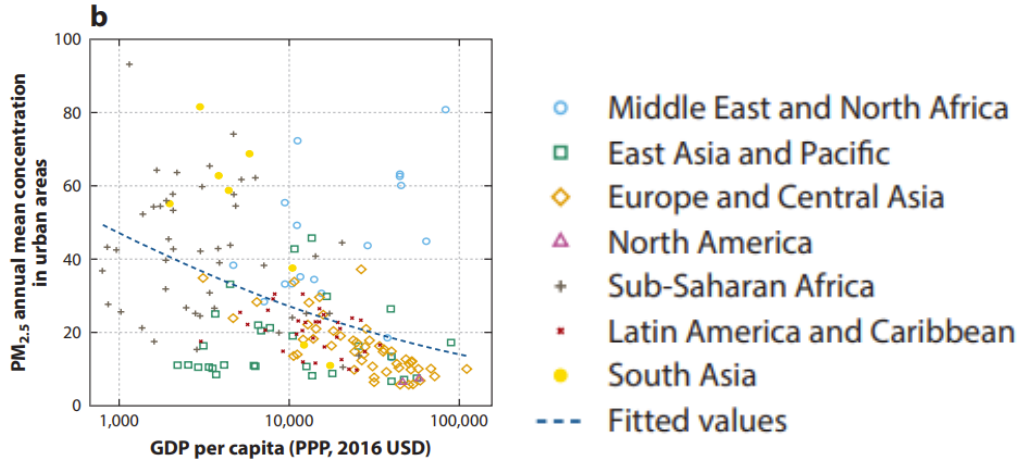
GDP and Lead in Gasoline



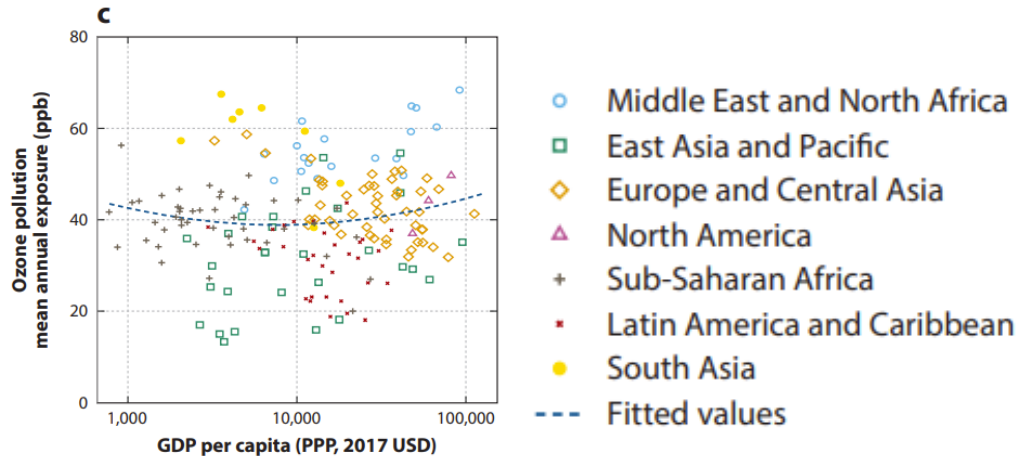
GDP and CO2



GDP and PM2.5



GDP and Ozone



- ▶ Macro correlations give limited answer
- ▶ Not the right question
 - ▶ What do we mean by development?
 - ▶ e.g. manufacturing ↑ pollution, but services may not
- ▶ Narrow, micro/empirical papers more helpful
 - ▶ even if they don't find consensus

Discussion: What is the ideal (quasi-) experiment?

- ▶ Can we randomize GDP?
- ▶ What variation in “development” can approximate the experiment?
 - ▶ what proxies development? (see ookla speed test)
 - ▶ what does the proxy miss?
 - ▶ what (non-random) variation isolates causal relationship?

Discussion: What about mechanisms?

- ▶ **Why and how** does economic development affect the environment?
- ▶ Theory is your friend: especially total derivatives. . .
 - ▶ Sometimes enough to rationalize mechanisms
 - ▶ Otherwise generate testable predictions
- ▶ Heterogeneity is your friend
 - ▶ But have a reason **why** you choose one channel over another

Question: What is the effect of income on environmental quality?

- ▶ Poverty alleviation may \uparrow demand for resource-intensive good
- ▶ Or, it may \uparrow demand for conservation
- ▶ **This paper:** Exploit RDD eligibility to study impact of CCT on forests

Why can't we regress forests on income?

- ▶ Income correlated with other things that affect environment
- ▶ Like what?
- ▶ If we control for OVB, will panel fixed effects work?

Mexico's Oportunidades Program

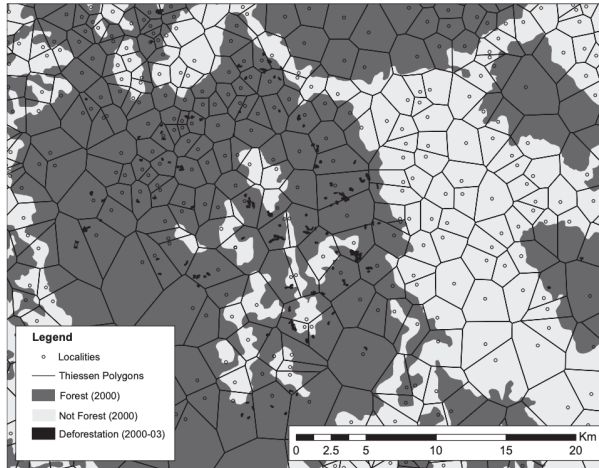
- ▶ **Goal:** Ambitious program to build human capital
- ▶ **Scope:** \$2.6 billion/year (half of anti-poverty budget)
 - ▶ Transfers are 1/3 of total income
 - ▶ Represents shift to new income path
- ▶ **Size:** 4 million households treated
- ▶ **Design:** Randomized rollout from 1998-2000
 - ▶ Afterwards, enrollment is non-random and based on **marginality index**
 - ▶ Two step: 1) village selected on index; 2) households selected in eligible villages

Results Preview: conditional cash transfer increases deforestation

- ▶ **Main variables:** village lat/lon, eligibility index, forest cover (satellite)
 - ▶ Enrollment by village until 2003
- ▶ **Sample size:** 105,749 villages
- ▶ **Unit of analysis:** only village centroids provided?
 - ▶ How do we estimate village-level impacts? Thiessen polygons
 - ▶ Area around a point where every location closer to the point than to all others
 - ▶ Problems?

Thiessen/Voronoi Polygons

FIGURE 2.—ILLUSTRATION OF LOCALITY BOUNDARIES DEFINED USING THIESSEN POLYGONS



Eligibility cutoff: -1.2

FIGURE 3.—ENTIRE SAMPLE MINUS OBSERVATIONS WITH INDEX > 3

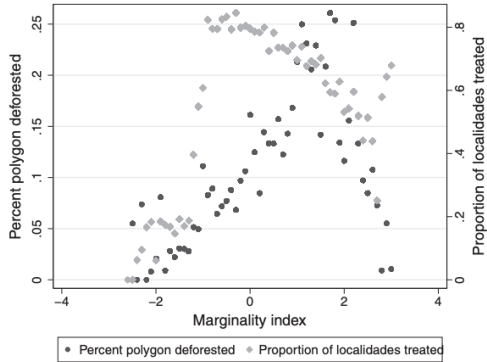
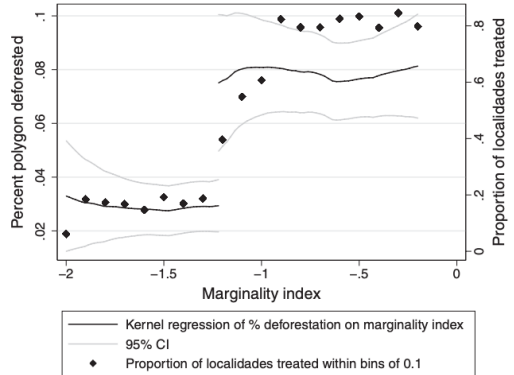


FIGURE 4.—KERNEL ESTIMATION OF DEFORESTATION ON MARGINALITY INDEX—RESTRICTED SAMPLE



Empirical Strategy: OLS Equation

$$\Delta f_i = \alpha + \delta T_i + \beta' X_i + \epsilon_i$$

- ▶ where Δf_i is % deforestation in polygon i over 2000-2003
 - ▶ $T_i = 1$ if the locality enrolled by 2003
 - ▶ X_i includes poverty
 - ▶ But T_i is not random!
-
- ▶ If discontinuity is sharp, replace T_i with $1[E_i > -1.2]$
 - ▶ RDD: Sample window $-2 < I < -0.2$

RDD Equation

- ▶ Discontinuity is fuzzy, not sharp
 - ▶ How do we know? Two reasons
- ▶ Solution: Use cutoff to instrument treatment probability
- ▶ Fuzzy RDD/IV:

$$\Delta f_i = \alpha + \delta T_i + \gamma l_i + \beta' X_i + \epsilon_i$$

$$\Delta T_i = \omega + \tau_1 E_i + \tau_2 E_i l_i + \tau_3 M_i + \tau_4 M_i l_i + \mu l_i + \Gamma' X_i + \epsilon_i$$

where T_i is enrollment dummy, E_i is eligibility cutoff dummy, l_i is index, M_i is dummy for region where enrollment increases rapidly

Identification Assumptions

Results: OLS and Sharp RDD

	Tobit			OLS	
	% Polygon Deforested			Deforestation (0/1)	% Deforested (If 1)
	(1)	(2)	(3)	(4)	(5)
Eligible	.383 (.181)**	.549 (.295)*	.370 (.217)*	.013 (.008)*	.387 (.190)**
Marginality index	.523 (.041)***	.753 (.077)***	.219 (.189)	.031 (.003)***	.069 (.075)
Index ²		.069 (.072)		.002 (.003)	.060 (.075)
Index ³		-.100 (.037)***		-.004 (.001)***	-.022 (.025)
Index ⁴		-.002 (.015)		-.0001 (.0005)	-.012 (.013)
Baseline area in forest, 2000	-.0004 (.001)	-.0005 (.001)	.004 (.002)**	.0006 (.0001)***	.005 (.001)***
Ln(polygon area)	.947 (.042)***	.954 (.042)***	.728 (.068)***	.046 (.002)***	-.993 (.062)***
Ln(total population in 1995)	.142 (.024)***	.144 (.024)***	.036 (.034)	.010 (.001)***	-.040 (.025)
Ln(slope)	-.052 (.005)***	-.053 (.005)***	-.009 (.010)	-.003 (.0002)***	-.029 (.006)***
Ln(road density)	-.059 (.026)**	-.056 (.026)**	.025 (.053)	-.004 (.001)***	-.010 (.027)
Observations	58,587	58,587	15,758	58,587	5,545
Ecoregion controls	Yes	Yes	Yes	Yes	Yes

Results: Fuzzy RDD / Instrumental Variables

- Very strong first stage: eligibility \uparrow probability of enrollment ($\tau_1 = 0.8$)

	IV Tobit				IV OLS	
	Full Estimation Sample			Restricted Sample	Deforestation (0/1)	% Deforested (If 1)
	(1)	(2)	(3)	(4)	(5)	(6)
Treated	.584 (.280)**	1.293 (.715)*		1.038 (.609)*	.031 (.019)*	1.264 (.680)*
Proportion treated			3.453 (1.870)*			
Marginality index	.521 (.042)***	.641 (.106)***	.244 (.298)	-.072 (.339)	.028 (.003)***	-.005 (.101)
Index ²		.177 (.116)	.391 (.221)*		.004 (.004)	.162 (.119)
Index ³		-.091 (.035)***	-.053 (.031)*		-.003 (.001)***	-.036 (.030)
Index ⁴		-.010 (.015)	-.037 (.022)*		-.0003 (.0005)	-.019 (.014)
Baseline area in forest, 2000	-.0005 (.001)	-.0008 (.001)	-.001 (.001)	.003 (.002)**	.0006 (.0001)***	.004 (.001)***
Ln(polygon area)	.963 (.043)***	.990 (.047)***	1.075 (.079)***	.756 (.070)***	.047 (.002)***	-.948 (.065)***
Ln(total population in 1995)	.055 (.051)	-.056 (.116)	-.305 (.245)	-.097 (.086)	.005 (.003)	-.262 (.120)**
Ln(slope)	-.054 (.005)***	-.057 (.006)***	-.064 (.008)***	-.012 (.010)	-.003 (.0002)***	-.033 (.007)***
Ln(road density)	-.075 (.027)***	-.092 (.033)***	-.119 (.043)***	.016 (.054)	-.005 (.001)***	-.049 (.036)
Observations	58,587	58,587	58,587	15,758	58,587	5,545
Ecoregion controls	Yes	Yes	Yes	Yes	Yes	Yes

- ▶ RD results show that CCT increases deforestation
- ▶ Why? What changes at the household level?
- ▶ Approach 1: Use experimental sample (Progresa) with household survey data
 - ▶ Progresa had randomized rollout at village level for first 3 yrs
- ▶ Approach 2: Heterogeneity by road density to study role of market access

Mechanisms: Consumption channel

- ▶ Before (1997-1998) and after (2000) data on consumption
- ▶ 506 villages, 320 treated, 186 control (not-yet-treated)
- ▶ Treatment at the village level

Difference in differences:

$$y_{it} = \gamma_0 + \gamma_1 Treat_i + \gamma_2 Post_t + \gamma_3 Treat_i \times Post_t + \epsilon_{it}$$

- ▶ y_{it} = consumption
- ▶ $Treat_i = 1$ if household i in treated locality
- ▶ cluster at locality level bc randomization was at locality level
- ▶ How do we interpret γ_3 ?

Hypothesis: $\gamma_3 > 0$

Mechanisms: Market channel

- ▶ Demand shock must be met by supply, which drives land use change
 - ▶ e.g. \uparrow consumption of milk met by \uparrow in grazing land
- ▶ But γ_3 captures partial equilibrium
 - ▶ Part of demand shock supplied locally. What about rest?
- ▶ Hypothesis: If consumption is driving deforestation
 - ▶ Then effect should be larger when infrastructure quality is low
 - ▶ Low market access: demand met by local supply
 - ▶ High market access: demand shock propagates across markets

Triple Differences:

Heterogeneity by infrastructure quality:

$$\begin{aligned} y_{it} = & \beta_0 + \beta_1 Treat_i + \beta_2 Post_t + \beta_3 (Treat_i \times Post_t) \\ & + \beta_4 Road_i + \beta_5 (Road_i \times Treat_i) + \beta_6 (Road_i \times Post_t) \\ & + \beta_7 (Road_i \times Treat_i \times Post_t) + \epsilon_{it} \end{aligned}$$

► $Road_i$ = inverse road density (km of road w/n 10km of village/polygon)

Hypothesis: $\beta_7 > 0$

Results: Increase in consumption of land intensive goods

	Rooms in Home		Days Ate Beef		Days Drank Milk	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment effect	.014 (.033)	.017 (.035)	.114 (.030)***	.118 (.031)***	.337 (.081)***	.331 (.087)***
Treatment \times inverse road density		-.034 (.148)		-.070 (.097)		.183 (.669)
Village chosen to receive Progresa	.0001 (.037)	.002 (.038)	-.025 (.029)	-.031 (.030)	-.133 (.111)	-.143 (.118)
Posttreatment year	.053 (.028)*	.049 (.029)*	-.137 (.024)***	-.138 (.025)***	-.655 (.061)***	-.664 (.065)***
Inverse of road density		.266 (.169)		-.156 (.069)**		.051 (.499)
Village \times inverse road density		.043 (.236)		.102 (.140)		.232 (.682)
Posttreatment \times inverse road density		.067 (.140)		.016 (.068)		.155 (.252)
Observations	23,318	23,318	33,128	33,128	33,128	33,128
Mean dependent Variable in baseline	1.557 (0.930)		0.388 (0.661)		1.440 (2.367)	

Higher beef and milk demand (land intensive products)

Demand-side impacts do not vary with market access (we didn't expect it to)

Results: No increase in local production

	Number of Plots		Log (1+ Total Hectares)		Number of Cows	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment effect	.030 (.039)	.031 (.040)	-.014 (.038)	-.015 (.039)	.092 (.057)	.036 (.057)
Treatment \times inverse road density		-.107 (.210)		.142 (.223)		.936 (.522)*
Village chosen to receive Progresa	.014 (.056)	.037 (.057)	-.004 (.040)	.017 (.040)	-.004 (.087)	.058 (.085)
Posttreatment year	-.094 (.032)***	-.077 (.033)**	.312 (.033)***	.317 (.033)***	-.239 (.046)***	-.180 (.046)***
Inverse of road density		.833 (.161)***		.820 (.227)***		2.122 (.799)***
Village \times inverse road density		-.263 (.317)		-.217 (.258)		-.760 (.872)
Posttreatment \times inverse road density		-.275 (.149)*		-.235 (.128)*		-.982 (.402)**
Observations	45,087	45,087	32,631	32,631	34,248	34,248
Mean dependent	0.824		1.724		0.604	
Variable in baseline	(0.955)		(3.535)		(2.304)	

Supply-side impacts do not vary with market access

Results: Deforestation higher in places with poor market access

Dependent Variable	Low Density		Medium Density		High Density		Interactions	
	(%)	(0/1)	(%)	(0/1)	(%)	(0/1)	(%)	(0/1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treated	1.619 (.868)*	.075 (.037)**	.554 (.836)	.019 (.030)	1.818 (1.472)	.023 (.021)	.778 (.600)	.008 (.015)
Treated \times low							1.041 (.582)*	.059 (.017)***
Low road density							-.550 (.400)	-.028 (.012)**
Observations	19,529	19,529	19,529	19,529	19,529	19,529	58,587	58,587

More deforestation in places with less market access (low road density)

Supports mechanism of increased demand for land-intensive goods

Thoughts?

- ▶ Do we believe the story about increased demand for land-intensive goods?
 - ▶ Less market access means less access to inputs
 - ▶ Underinvest in technology, leading to higher deforestation
 - ▶ Maybe this is a story about technology, not consumption
- ▶ Can you think of an alternate explanation?
- ▶ Other concerns?
- ▶ This all points to shortcomings of RCTs in general
 - ▶ we cannot answer why

Same results in Colombia! Malerba (2020)

- ▶ Question: What is the impacts of CCT on consumption, energy, and deforestation?
- ▶ Context: Familias en Accion CCT project (2001-2005)
- ▶ Design: Matched Difference in Differences
- ▶ Result: Increased beef and milk (land intensive) consumption
 - ▶ Mediated by markets
 - ▶ Negligible \uparrow in deforestation (counterintuitive)
 - ▶ No impact on CO₂

- ▶ CCT program launched in 2000
 - ▶ Non-random: Municipalities selected on amenities (banks, education, health)
 - ▶ 721 eligible: slow phase-in
- ▶ Study sample: 5,477 households
- ▶ Variation: compare outcome in treated hh before/after enrollment relative to control hh
- ▶ **Identification assumptions**

Number of municipalities enrolled (annual)	
2000	2
2001	360
2002	244
2003	6
2004	0
Total	612

Results: Increased beef and milk consumption

Household DiD:

$$\Delta Y_i = \alpha + \delta T_i + X_i + \epsilon_i$$

Variables	(1) Beef, days per week	(2) Beef, days per week	(3) Milk, days per week	(4) Milk, days per week
FA	0.416** (0.166)	0.879** (0.333)	0.720** (0.282)	1.099** (0.547)
FA *distance to closest market		-0.010* (0.005)		-0.008 (0.008)
Households	2268	2268	2269	2269
R-squared	0.029	0.032	0.045	0.046

- ▶ Effect muted with low market access (very weak)
- ▶ Why is sample size declining from 5,477?

Design: Environmental Impacts

- ▶ Unit of analysis: Municipality
- ▶ Design: municipalities enrolled gradually over time
 - ▶ Many were not enrolled by 2004
- ▶ Define $Treat_i = 1$ if enrolled by 2004
- ▶ $Post_t = 1$ after treatment, zero for 2000

$$y_{it} = \beta_0 + \beta_1 Treat_i + \beta_2 Post_t + \beta_3 (Treat_i \times Post_t) + \beta_4 X_{it} + \epsilon_{it}$$

- Variation: Δ forest b/w 2000/05 for municipalities enrolled by 2004 rel. to non-enrolled

Results: No environmental impact

Variables	(1) % forest	(2) % forest, incl. ref.	(3) % forest
FA enrollment	0.510* (0.271)	0.369 (0.303)	0.523* (0.293)
FA enrollment, number of years			
FA enrollment * distance to closest market			−0.000 (0.001)
2005	−2.166*** (0.266)	−1.479*** (0.309)	−2.167***
Constant	22.361*** (1.588)	23.452*** (2.324)	22.358*** (1.615)
R-squared	0.370	0.196	0.370
Observations	1440	1440	1440

- ▶ Weakly positive deforestation (counterintuitive)
- ▶ **Why?**

Take a 5 minute break

Back to the question

How does development affect the environment?

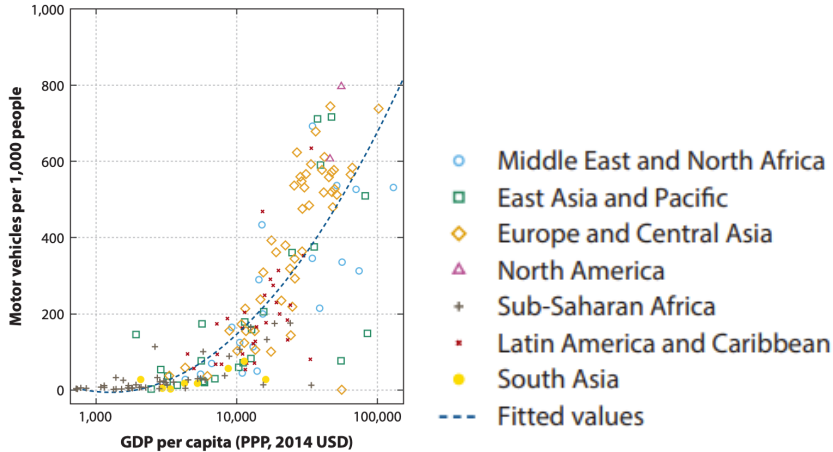
- ▶ Income
 - ▶ Land intensive consumption
 - ▶ **Energy**

- ▶ Next time: Technology and Infrastructure

Development, Energy, and the Environment

- ▶ Energy ladder: as income \uparrow , move from solid fuel \rightarrow gas \rightarrow electricity
 - ▶ Electricity may displace dirty energy (wood), which \downarrow pollution
- ▶ But, electricity also increases total energy (fridge, AC)
 - ▶ ... which \uparrow pollution
 - ▶ energy footprint increases with income
- ▶ Unless generated from solar, wind, etc
- ▶ People also buy cars as they get richer...

GDP and Car Ownership



Of course, these are correlations

But first, some theory

- ▶ Imagine we can exogenously vary income to poor households
- ▶ Will transfers to initially poor households yield **lumpy** investments?
 - ▶ Movements up the ladder involve big purchases
 - ▶ May explain why 1.3 billion people lack electricity (Gertler et. al, 2016)
- ▶ Credit constraints play an important role
 - ▶ Without credit markets, buy now but have nothing in next period
 - ▶ With savings, can save now, buy later (smooth consumption)
 - ▶ With borrowing, buy now, smooth consumption over time
- ▶ Lets formalize this

Model Set up

- ▶ Two periods with no discounting
- ▶ Agent i can consume two goods
 - ▶ non-durable gives per period utility: $u'(\cdot) > 0$, $u''(\cdot) < 0$
 - ▶ lumpy durable that gives static per period utility R , if owned
- ▶ Durable price = P ; non-durable is numeraire
- ▶ Let Y_1 , Y_2 be per period 1, 2 income
- ▶ Define $\bar{Y} = 1/2(Y_1 + Y_2)$ = average per period income

No credit constraints

Without credit constraints, if don't buy, total utility is:

$$u(\bar{Y}) + u(\bar{Y}) = 2u(\bar{Y})$$

If buy durable, spend P and spread cost equally across periods:

$$2u(\bar{Y} - \frac{P}{2}) + 2R$$

Purchase durable iff:

$$u(\bar{Y}) - u(\bar{Y} - \frac{P}{2}) \leq R$$

$u''(\cdot) < 0$ **implies acquisition increases in income**

1) With credit constraints: Buy in period 1

If don't purchase, total utility is:

$$u(Y_1) + u(Y_2)$$

If purchase in period 1:

$$u(Y_1 - P) + 2R + u(Y_2)$$

Purchase in period 1 iff:

$$\frac{u(Y_1) - u(Y_1 - P)}{2} \leq R$$

2) With credit constraints: Wait to buy in period 2

If don't purchase, total utility is:

$$u(Y_1) + u(Y_2)$$

If save in period 1, and buy in period 2:

$$2u(\bar{Y} - \frac{P}{2}) + R$$

Wait to buy in period 2 if:

$$u(Y_1) + u(Y_2) - 2u(\bar{Y} - \frac{P}{2}) \leq R$$

Intuition of Model

- ▶ $u''(\cdot) < 0$ means consumers gain from smoothing consumption
- ▶ Unconstrained household will buy in period 1
 - ▶ Use period 2 income (loan) to smooth consumption
- ▶ Credit constrained households cannot do this
 - ▶ If buy now, magnify consumption inequality across periods
 - ▶ Or, wait and buy in period 2, but delay utility gain
- ▶ Higher income in any period leads savers to buy more
- ▶ But, first period buyers respond only to first period income (lemma 1)
- ▶ But increase in *cumulative* income increases buying through delay/saving (lemma 2)

Testable Predictions

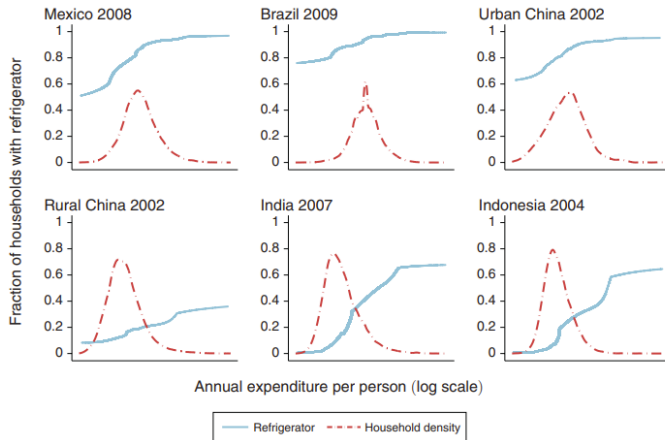
- ▶ Prediction 0: Acquisition increasing in income
- ▶ Prediction 1: S-shaped curve in acquisition

Gertler et al. (2016): Demand for energy-using assets among middle class

- ▶ **Question:** How does income affect energy demand?
- ▶ **Motivation:** 1.3 billion people live without electricity
- ▶ Should we expect linear climb up the energy ladder as incomes rise?
 - ▶ what about credit markets?

	Electricity access (percent of population)	Refrigerators (share of households)
Brazil	98.7	0.93
China	99.7	0.69
India	75.0	0.13
Indonesia	73.0	0.17
Mexico	97.9	0.83
Sub-Saharan Africa	32.5	0.11
Total	70.8	0.38
United States	100.0	0.99

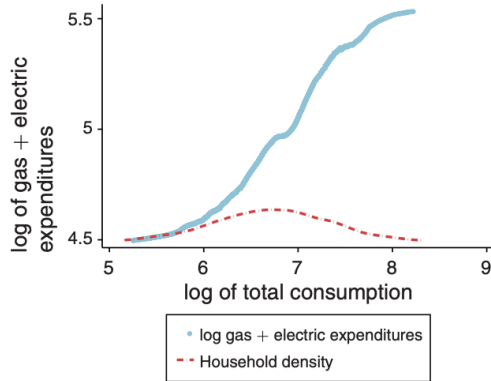
Non-linear relationship between income and fridges



- Are fridges representative of energy-intensive assets?
- Can aggregating non-linearities \rightarrow linearity?

S-shape appears robust

Panel A



Empirical Setting: Mexico Oportunidades (again)

- ▶ 320 randomly selected communities given early treatment (April 1998)
 - ▶ 52% were “eligible” for cash transfer
- ▶ 186 randomly selected communities given late treatment (October 1999)
- ▶ This paper: N=506 communities, 10,000 households surveyed (1997-2007)
 - ▶ Surveys done in 1998, 1999, 2000, 2003, and 2007
- ▶ Compare early and late treatment households (**not treatment vs. control**)
 - ▶ Similar b/c both groups selected on “vulnerability” characteristics
 - ▶ Strongly balanced on covariates
 - ▶ Assumes timing is random

- **Prediction 0:** Probability of asset purchase \uparrow in income

$$h(a_{it}) = Pr(a_{it} = 1 | a_{it-1} = 0) = \gamma_0 + \alpha_1 Cl_{it} + \beta X_i + \beta_t F_i + R_{rt} + \epsilon_{it}$$

- where $h(a)$ is the prob. that i buys a in time t conditional on not having it in $t - 1$.
- Cl_{it} is cumulative income
- X_i includes baseline household controls
- F_i are family structure variables interacted w/ survey round
- R_{rt} are state-year fixed effects

Hypothesis: $\alpha_1 > 0$

- **Prediction 1:** S-shaped curve in acquisition

$$h(a_{it}) = Pr(a_{it} = 1 | a_{it-1} = 0) = \gamma_0 + \alpha_1 Cl_{it} + \alpha_2 Cl_{it}^2 + \beta X_i + R_{rt} + \epsilon_{it}$$

Hypothesis: $\alpha_2 \leq 0$?

Measurement issues

- ▶ Cumulative Income is sum of wage, farm, business income, CCT transfers
 - ▶ Reporting biases in wage data
 - ▶ Income reported in survey year, not cumulative
 - ▶ Authors interpolate across years, adding noise
- ▶ Double counting problem if households invest CCT money into business
- ▶ **Solution:** use potential CCT **transfers** to instrument cumulative **income**

Identifying Variation

TABLE 2—OPORTUNIDADES BIMONTHLY SUPPORT LEVELS IN 2003 (*Pesos*)

Basic Support	155	
<i>Educational scholarship</i>		
Grade	Boys	Girls
Third	105	105
Fourth	120	120
Fifth	155	155
Sixth	205	205
Seventh	300	315
Eighth	315	350
Ninth	335	385
Tenth	505	580
Eleventh	545	620
Twelfth	575	655

Use maximum cumulative transfer as **instrument** for actual (cumulative) transfer

Plus variation from early/late enrollment

Identification Assumptions

- ▶ What is the exclusion restriction?
- ▶ Is it reasonable?

Results: Prediction 0

TABLE 4—BASIC RESULTS: REFRIGERATOR (*Income Effects*)

	Discrete time hazard		Household FE	Discrete time hazard		Household FE
	OLS	IV	IV	OLS	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Cumulative Transfers</i>	0.018*** [0.005]	0.020*** [0.007]	0.047*** [0.008]			
<i>Cumulative Income</i>				0.003*** [0.001]	0.016*** [0.005]	0.034*** [0.007]
Observations	30,414	30,414	30,258	30,414	30,414	30,258
R^2	0.103			0.104		
Kleibergen-Paap Wald F -Stat on excluded variables		2,503	2,060		92	108
Number of households			6,655			6,655

- For every 10,000 pesos, probability of buy fridge ↑ by 4.7 pp.

Results: Prediction 1

TABLE 5—BASIC RESULTS: REFRIGERATOR (*Nonlinear Income Effects*)

	Discrete time hazard		Household FE
	OLS (1)	IV (2)	IV (3)
<i>Cumulative Income</i>	−0.0007 [0.0011]	−0.0059 [0.0108]	0.0132 [0.0132]
<i>Cumulative Income</i> ²	0.0001*** [< 0.0001]	0.0009** [0.0004]	0.0008** [0.0004]
Observations	30,414	30,414	30,258
R^2	0.105		
Kleibergen-Paap Wald F -Stat on excluded variables		22	23
Number of households			6,655

- ▶ $\alpha_2 > 0$ implies convex relationship b/w cumulative income and asset purchase
- ▶ Since all households are poor, don't expect any to be past second inflexion point

Thoughts on paper?

Research gaps

- ▶ Does earned income have different effect than transfers?
- ▶ Can we trace out the full S-curve?
- ▶ Is there an S-curve for other technologies?
- ▶ Which externalities have highest income elasticities?

- ▶ How does development affect the environment?
 - ▶ **Technology and Infrastructure**

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