Environmental and Development Economics
Module 7 - Climate and Migration

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2024-10-10

Lecture 12

Climate and Migration

Housekeeping

- APEC Seminar Tomorrow: Stephanie Onder
- Peer review due at midnight
  - I will return tomorrow
- Proposal presentations start next week
  - **Oct 15:** 1) Matt B 2) Jovin L 3) Ryan M
  - **Oct 17:** 1) Gustavo M 2) Giang T 3) Sarah W
- Office hours will continue until proposal deadline

Replication Assignment (Due Oct 21st)

- Choose any envirodevonomics paper with data/code files
  - Must be published in either 1) general econ or 2) enviro/dev field journal
- Replicate at least 2 main tables/figures
  - Output everything to latex
- Write your own code and comment it!
- Extension
  - Must be "carefully thought out" and yield new insight
  - e.g. heterogeneity, non-linearity, robustness check
- Write-up (6 pages doubled spaced)
  - summary, replication process, results, extension
  - Compare your findings with original paper. Interpret.

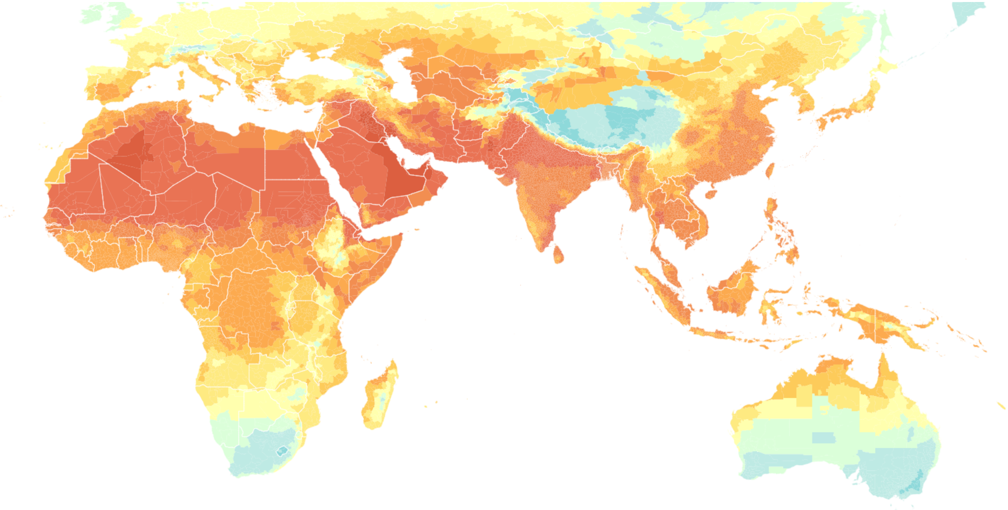
Climate and Migration

Environmental disasters are unequal

- Cross-country heterogeneity
  - Inequality in exposure (rich vs. poor countries)
- Within-country heterogeneity
  - Coastal regions hit harder by floods
  - Agricultural regions hit harder by droughts
  - Biodiverse regions hit harder by rainfall shocks
- Sectoral heterogeneity
  - Weather-dependent agriculture vs. services

Implication $\longrightarrow$ **migration!**

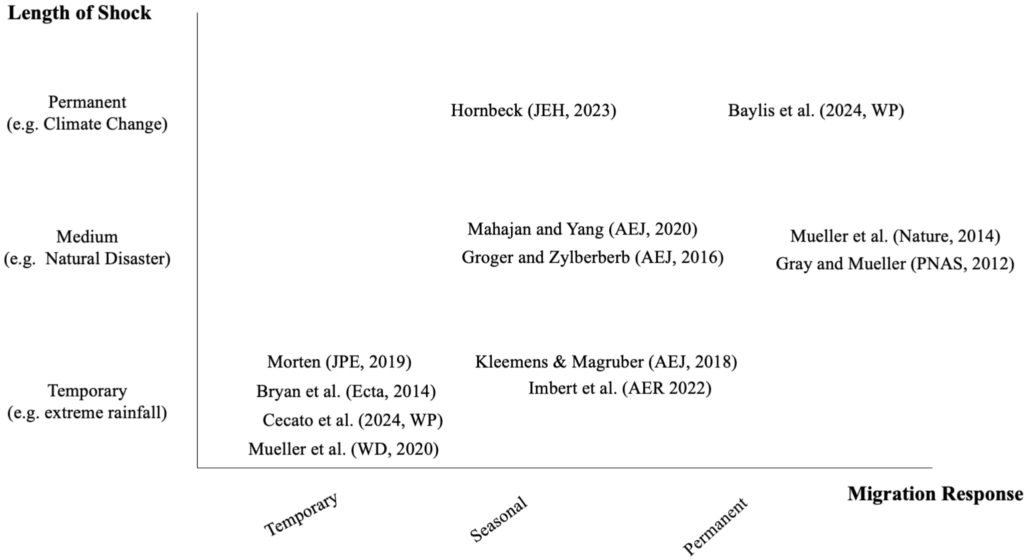
Historic average temperature (1986-2005)



How do we study flows of people in response to climate change?

- Impacted region (push factors)
  - Direct effect: environmental extremes push people out
  - Indirect effect: violence, famine, etc. push people out
- Receiving region (pull factors)
  - Direct effect: less exposure to environmental extremes draws migrants (wage impacts)
  - Indirect effect: e.g. housing prices
- Most research: environment $\leftrightarrow$ migration in partial equilibrium
  - Elasticity of migration w.r.t. environmental quality
  - Elasticity of wages w.r.t environmental quality
- **New frontier: general equilibrium!**

Existing Evidence



Spatial Models of Migration

- Economists are recently thinking about spatial equilibrium
- Migrants choose where to live based on costs and benefits
  - Not only wage considerations
  - Amenity values, **exposure to environmental extremes**
- When there is an environmental shock to the system...
  - Who moves?
  - What adjustments take place? Housing, land, wages, etc.
  - What is the new spatial equilibrium?
  - What happens to inequality?
- This sets the framework for studying environment and migration

Model Set Up

- Individual i of wage group j choose location k to maximize utility:

$$\max_k \underbrace{v_{jk}}_{\text{observed}} + \underbrace{\epsilon_{ijk}}_{\text{unobserved}}$$

- The econometrician observes representative utility:

$$v_{jk} = \alpha_j p_k + \beta e_k + x_k \gamma + \delta_{jk}$$

- housing price p_k
- environmental "bad" e_k (flood risk, extreme temperature)
- observed amenities x_k, unobserved amenities δ_{jk}
- price elasticity can differ by wage group, α_j

Model Set Up

- Logit probability ($\epsilon_{ijk} \sim EV$) yields migration probability (see module 4 slides):

$$\pi_{ijk} = \pi_{jk} = \frac{e^{v_{jk}}}{\sum_l e^{v_{jl}}}$$

- since individuals w/n wage group j have common choice probabilities
- In equilibrium, prices $p = p_k$ clear housing markets

$$n_k^D(p^*) = n_k^S(p^*) \quad \forall k \quad \text{where} \quad n_k^D = \sum_i \pi_{ijk}, \quad n_k^S = \bar{n}_k$$

- **Migration arises from wage-specific price elasticities and endogenous prices**
  - Environmental shocks $\uparrow$ inequality. Why?

Estimation

- Goal: recover α_j, β, γ
  - Tells us equilibrium prices and choice probabilities for any pattern of e_k

- Inverting migration probabilty yields:

$$
\begin{aligned}
ln\pi_{jk} - ln\pi_{jo} &= v_{jk} - v_{j0} \\
&= \alpha_j \Delta p_k + \beta \Delta e_k + \Delta x_k \gamma + \Delta \delta_{jk}
\end{aligned}
$$

- **Challenge:** prices are endogenous i.e. correlated with unobserved amenities!
  - high-amenity places attract skilled migrants who bid up prices
  - Solution: cost shifting instrument

Hisao (2024): Sea Level Rise and Urban Inequality in Indonesia

- Flood exposure: grid cells $<$ sea level for 1,3, 5m sea level rise (hydrological model)
- Price instrument: ruggedness (housing cost supply shifter)
  - Exclusion restriction: terrain shifts housing supply but not demand
- Define object of interest for simulation: flood exposure for wage group j:

$$F_j = \sum_k f_k \pi_{jk}$$

- And price incidence by wage group j:

$$P_j = \sum_k p_k \pi_{jk}$$

Impact of flooding on inequality

	Flooding			Prices
	Low wages	High wages	$\frac{L}{H}$	$L - H$
Current	0.88	0.62	1.40	−0.10
Projected				
1 m sea level rise	1.03	0.68	1.52	−0.10
3 m sea level rise	2.00	0.96	2.09	−0.13
5 m sea level rise	5.77	2.20	2.62	−0.22
Projected, no sorting				
1 m sea level rise	1.02	0.73	1.39	−0.10
3 m sea level rise	1.93	1.32	1.47	−0.11
5 m sea level rise	5.47	3.72	1.47	−0.15

- Current flooding: poor people's flood exposure is 1.4x that of rich people
- 5m sea level rise: inequality of exposure doubles
- Prices: richer people move, lower prices compensate for higher flood exposure

Is inequality driven by prices or migration?

	Flooding			Prices
	Low wages	High wages	$\frac{L}{H}$	$L-H$
Current	0.88	0.62	1.40	−0.10
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- Evaluate F_j with projected flooding and current π_{jk} (no migration)
- Evaluation P_j with counterfactual prices and current π_{jk} (no migration)
- Reveals direct impact of floods on rich/poor **without migration**
- No Δ in inequality in this scenario i.e. **migration drives unequal exposure!**

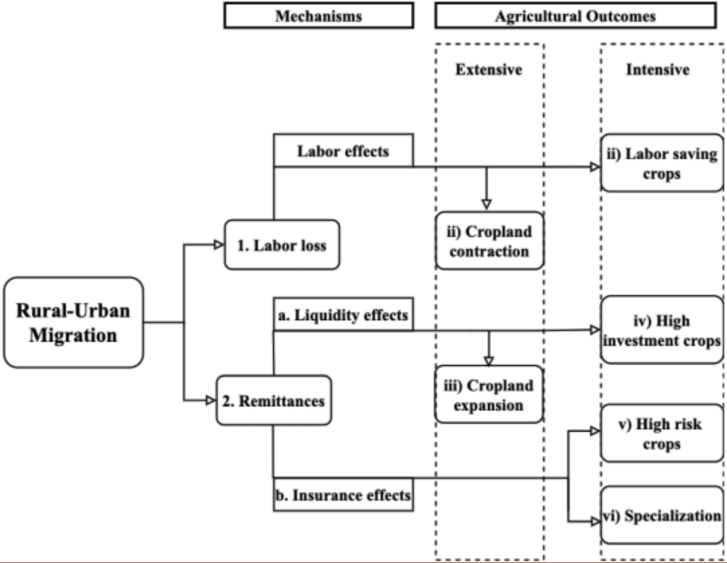
Reduced Form Literature

- **Impact of Migration on Environment**
  - Brewer et al. (2022, Uganda); Hornbeck and Naidu (2014, USA); Rozelle et al. (1991, China); Salemi (2021, Africa)}
- **Impact of Environment on Migration**
  - Morten (2019, India); Mueller et al. (many papers); Missrian and Schlenker (2017, dev countries); Chen et al. (2022, China)
- **Migration as Adaptation to Environmental Extremes**
  - Cecato et al. (2024, Indonesia); Blakeslee et al. (2020, India)
- **Migration and Environment in General Equilibrium**
  - Madhok et al. (2024, India); Asher et al. (2024, India); Blakeslee et al. (2022, India)

Impact of Migration on the Environment: Brewer et al. (2022)

- **Research Question:** What is the impact of rural-urban migration on land use?
  - What are the intensive vs. extensive margin impacts?
- **Setting:** Uganda from 2005-2019
  - 70% of land is agricultural
- **Data:** Many rounds of the LSMS survey (3200 households)
- **Research Design:** SSIV: urban consumption (shift) x migrant network (share)
- **Results:** Migration causes agricultural contraction and specialization
  - Leads to a reduction in tree cover loss

Conceptual Framework



Estimation

- 1st stage: $IHS(M_{ijt}) = \underbrace{\beta_{11} Z_{jt} M_{ij0}}_{\text{shift-share IV}} + \beta_{21} Z_{jt} + \beta_{31} W_{jst} + \alpha_{1i} + \psi_{1w} + \gamma_{1t} + \epsilon_{1ijt}$
- 2nd stage: $IHS(Y_{ijt}) = \beta_{12}(\hat{M}_{ijt}) + \beta_{22} Z_{jt} + \beta_{32} W_{jst} + \alpha_{2i} + \psi_{2w} + \gamma_{2t} + \epsilon_{2ijt}$
- Outcome: M_{ijt} is number of months that hh member i was absent in year t
- Shift-share IV:
  - $Z_{jt} = \sum_{d=1}^{n} (\frac{C_{dt}}{dist_{jd}})$
  - C_{dt} is mean consumption in district d
  - $Z_{jt} M_{ij0}$ is spatially weighted consumption shocks

Results: Agricultural extent

	OLS	IV
	IHS (cultivated area)	*IHS* (cultivated area)
IHS (Migration)	0.0065 (0.0043)	−0.0678 (0.0283)**
Urban consumption control	Y	Y
Drought control	Y	Y
Fixed effects		
Year	Y	Y
Season-region	Y	Y
Household	Y	Y
Observations	21,107	21,107

- rural-urban migration leads to agricultural contraction (extensive margin)
- rural-urban migration has no impact on area planted for annual vs. perennial crops

Results: Crop Specialization

	OLS		IV	
	Richness	Inverse Simpson	Richness	Inverse Simpson
IHS (Migration)	−0.0052 (0.0098)	−0.0095 (0.0078)	−0.1187 (0.0511)**	−0.0893 (0.0444)**
Urban consumption control	Y	Y	Y	Y
Drought control	Y	Y	Y	Y
Fixed effects				
Year	Y	Y	Y	Y
Season-region	Y	Y	Y	Y
Household	Y	Y	Y	Y
Observations	21,107	21,107	21,107	21,107

- migration causes households to specialize
- 1) reduce number of different crops, 2) invest proportionally more in fewer crops

Results: higher district level tree cover

	OLS	IV
	Tree cover[a]	**Tree cover**[a]
District migration[a]	0.0054	0.0583
	(0.0026)**	(0.0124)**
Controls		
Drought	Y	Y
Urban consumption	N	Y
Fixed effects		
Year	Y	Y
District	Y	Y
Observations	332	332
Kleibergen Paap *F*-statistic	–	20.1

Impact of Environment on Migration: Chen and Mueller (2018)

- **Research Question:** How do farmers adapt to sea-level rise?
  - At what point do farmers migrate?
- **Setting:** Coastal Bangladesh, 2003-2011
- **Data:** Several sources
  - Migration: Vital registration system
  - Agriculture: Household Income and Expenditure Surveys
  - Floods: NASA MODIS water index
- **Research Design:** Fixed effects regression
- **Results:** Indundation *does not* trigger migration
  - Migration is driven by adverse effects of soil salinity on agriculture

Conceptual Framework

- Recent studies show minimal migratory response to flooding
  - Monsoons lead to temporary displacement, but people return
  - Delayed yield benefits
  - Many farmers have adapted ag practices to accommodate inundation
- Inundation may not be the right "push' ' factor
  - What exactly is triggering flood-related migration?
- Hypothesis: gradual increases in salinity (not flooding) will bear modest effects on migration until less costly adaptation strategies in the agricultural sector have been exhausted

Empirical Strategy

- Impact of salinity and flooding on agricultural incomes:

$$Y_{hjt} = \theta_F F_{jt-1} + \theta_S S_{jt-1} + \beta Z_{hjt} + \delta X_{hjt-1} + \beta_S^{88} S_{j,1988} + \tau_t + \mu_{hjt}$$

- Y_{hjt} = annual crop revenue for household h in subdistrict j at time t
- F_{jt-1} = lagged flooding; S_{jt-1} = lagged salinity
- Z_{hjt} = demographic and wealth covariates
- X_{hjt-1} = lagged environmental exposure (rain, temp, etc.)

- Impact of salinity and flooding on migration

$$M_{hjt} = \beta_F F_{jt-1} + \beta_S S_{jt-1} + \alpha Z_{hjt} + \gamma X_{hjt-1} + \beta_S^{88} S_{j,1988} + \rho_t + \epsilon_{hjt}$$

Results: Effect of flooding/salinity on farm revenue

Table 1 | Effect of flooding and soil salinity on farm revenue in the coastal zone

	Crop revenue (Tk)				Aquaculture revenue (%)				Total revenue (Tk)			
Model	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
Inundated area	1,179	1,390			0.00105	−0.00109			4,719	4,503		
	(1.116)	(1.344)			(0.114)	(−0.118)			(1.334)	(1.302)		
Saline soil		−123.6**				0.00125*				126.7		
		(−2.069)				(1.849)				(0.701)		

- 1σ increase in salinity reduces crop revenue by 0.1σ (2500 taka)
- No impact on total farm revenue
- hh shift to aquaculture to mediate income risk as salinity compromises agriculture

Results: Effect of flooding/salinity on migration

Table 2 | Effect of flooding and soil salinity on household-level migration in the coastal zone

	Internal					International				
Model	**I**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**
Inundated area	0.00131	0.00134				-4.30×10^{-5}	-5.43×10^{-5}			
	(1.169)	(1.202)				(−0.171)	(−0.209)			
Saline soil		0.000166*					-7.26×10^{-5}**			
		(1.782)					(−2.593)			

- 1σ increase in soil salinity increases internal migration by 0.43pp
- 1σ increase in soil salinity decreases international migration by 0.19pp
- International migration and aquaculture may be substitutes

Migration as Adaptation: Cecato et al. (2024)

- **Research Question:** Can migration mitigate weather damages?
- **Setting:** Indonesia over 20 years
- **Data:**
  - Migration: 32,000 individuals from IFLS survey
  - Weather: Gridded rain/temperature
- **Research Design:** Shift-share IV
  - Shift: rainfall shock
  - Share: ethnic networks
- **Results:** $1\sigma \downarrow$ in precipitation at origin $\downarrow$ non-migrant consumption
  - Ability to migrate leads to 14% increase in consumption over medium run

Three facts

- There is high migration in Indonesia
  - 4.3% percent of population per year migrates internally
- Rainfall is an important determinant of migration in Indonesia
  - Kleemans and Magruder (2018)
- Mobility is associated with ethnicity
  - Propensity to migrate persists over time within groups (Auwalin 2020)

Estimation

- **First stage regressions:**

$$M_{ikt} = a_0 M_{ikt} + a_1(Networks_{ik} \cdot R_{kt}) + a_2 R_{kt} + \phi_i + \phi_t + X_{ikt} + \epsilon_{ikt}$$

$$M_{ikt} \times R_{kt} = b_0 M_{ikt} + b_1(Networks_{ik} \cdot R_{kt}) + b_2 R_{kt} + \phi_i + \phi_t + X_{ikt} + \epsilon_{ikt}$$

- **Second stage:**

$$Y_{ikt} + \beta_0 \hat{M}_{ikt} + \beta_1(\widehat{M_{ikt} \times R_{kt}}) + \alpha_1 R_{kt} + \phi_i + \phi_t + X_{ikt} + \epsilon_{ikt}$$

- Y_{ikt}: log consumption of hh i in county k in year t
- R_{kt}: rainfall shock (z-score)
- $Networks_{ik}$: share of ppl of same ethnicity in origin at age 12 who moved away

Results: Migration mitigates weather damage

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Total	Food	Non-food	Total	Food	Non-food
Rain (Zscore) x Change of Residence	0.0297**	0.0248*	0.0560***	-0.157**	-0.217***	-0.220**
	(0.0135)	(0.0136)	(0.0179)	(0.0645)	(0.0655)	(0.0931)
Rain (Zscore)	-0.00373	0.00142	-0.0125	0.0182**	0.0287***	0.0182
	(0.0117)	(0.0112)	(0.0178)	(0.00791)	(0.00804)	(0.0115)
Change of Residence	0.400***	0.396***	0.398***			
	(0.0183)	(0.0171)	(0.0243)			
Individual FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Observations	95,040	95,040	95,040	95,040	95,040	95,040
Number of individuals	32,788	32,788	32,788	32,788	32,788	32,788

- 1σ decrease in rainfall reduces consumption by 1.82%
- Ability to migrate more than offsets this

Migration and Agriculture in General Equilibrium: Madhok et al. (2024)

- **Research Question:** How does agriculture unfold when labor exits?
- **Challenge:** Two competing channels: labour (direct/PE) + prices (indirect/GE)
- **Setting:** India — very high labour misallocation
- **Data:** IHDS-I and IHDS-II panel surveys (42,000 households)
- **Research Design:** Shift-share IV
  - Shift: destination income shocks
  - Share: 1) inverse distance, 2) number of males at home
- **Results:** migration ↓ agriculture near cities, but ↑ in remote areas
  - i.e. spatial reorganization of agriculture

Partial Equilibrium

- **Shift share IV:**

$$z_{idt} = \underbrace{\varphi_i}_{\text{productivity (share I)}} \times \underbrace{\sum_{d' \in \Theta / d} \frac{1}{\tau_{dd'}}}_{\text{inverse distance (share II)}} \times \underbrace{(inc_{d't} \cdot pop_{d'})}_{\text{shift}}$$

- **2SLS Equations:**

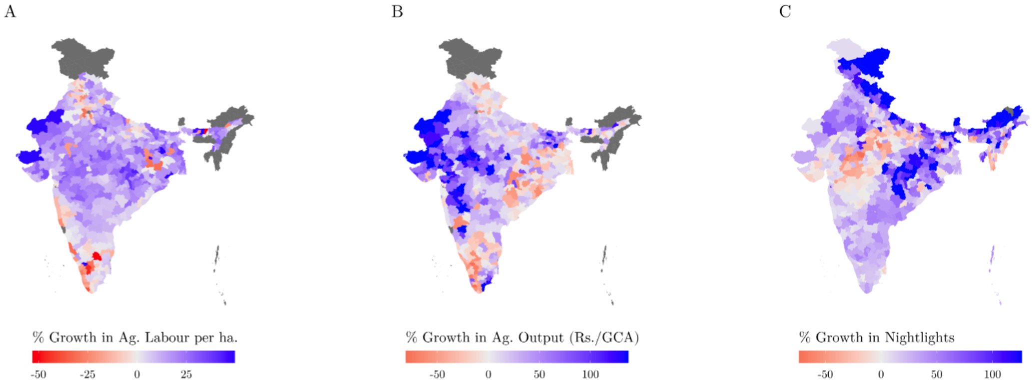
$$M_{idt}^{labor} = \mu_1 z_{idt} + \mu_2 s_{dt} + \mu_3 inc_{dt} + \Gamma X'_{dt} + \alpha_i + \gamma_t + \varepsilon_{ijdt}$$

$$Y_{idt} = \beta_1 \widehat{M_{idt}^{labor}} + \beta_2 s_{dt} + \beta_3 inc_{dt} + \Gamma X'_{dt} + \alpha_i + \gamma_t + \eta_{ijdt}$$

PE Results: No labor-capital substitution

	Technology Index		Land (ac.)	Labour		Profits (Rs.)
	(1) Expenses	(2) Machinery	(3) Cultivated	(4) Wage Bill	(5) Man-days	(6) Crops
Male Migrants (σ)	-1.046***	-0.709***	-1.218***	0.076	-1.877***	-1.347***
	(0.205)	(0.182)	(0.229)	(0.158)	(0.311)	(0.224)
Wt. Income (s_{dt})	Yes	Yes	Yes	Yes	Yes	Yes
Origin Income (inc_{dt})	Yes	Yes	Yes	Yes	Yes	Yes
Outcome SD	-	-	3.621	150.176	211.329	21071.048
Explanatory SD	0.524	0.521	0.533	0.518	0.518	0.513
HH FEs	✓	✓	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓	✓	✓
Observations	25928	24970	29346	20910	20910	25854
F-Stat	58.9	55.1	53.3	55.4	55.4	63.4

Spatial Equilibrium: Visual Evidence



Migration and Market Adjustments

	(1) Crop Price	(2) Land Price (rent in)	(3) Land Price (rent out)
Crop region emigration	0.137***		
(indirect crop channel)	(0.052)		
Village emigration		-0.052**	-0.063*
(indirect land channel)		(0.025)	(0.034)
Aggregation	District-year	Village-year	Village-year
District FEs	✓		
Village FEs		✓	✓
Year FEs	✓	✓	✓
Observations	586	1222	1296
R^2	0.892	0.667	0.633

- Mass migration from the crop market increases crop prices
- Mass migration from the land market lowers land prices

Migration and the Spatial Reorganization of Agriculture

	Technology Index		Land (ac.)	Labor		Profits (Rs.)
	(1) Expenses	(2) Machinery	(3) Cultivated	(4) Wage bill	(5) Man-days	(6) Crops
Male Migrants	-1.078***	-0.735***	-1.269***	0.082	-2.009***	-1.358***
(direct labor channel)	(0.207)	(0.189)	(0.237)	(0.167)	(0.332)	(0.224)
Village emigration	0.237***	0.191***	0.259***	-0.022	0.419***	0.247***
(indirect land channel)	(0.049)	(0.044)	(0.052)	(0.037)	(0.082)	(0.054)
Crop region emigration	0.207***	0.040	0.242***	-0.015	0.422***	0.178***
(indirect crop channel)	(0.045)	(0.039)	(0.046)	(0.029)	(0.066)	(0.043)
HH FEs	✓	✓	✓	✓	✓	✓
Year FEs	✓	✓	✓	✓	✓	✓
Observations	25924	24966	29342	20906	20906	25852
F-Stat on Direct Effect	63.9	56.8	55.7	55.8	55.8	67.5

- PE (agricultural contraction) dominates in peri-urban areas
- GE (agricultural expansion) dominates in remote areas
- Result: food shortage induced by direct channel compensated by markets

New Directions for Environment and Development Economics

Open Research Areas

Exciting Area for Research

- **Main takeaway from course:**
  - Many reasons for poor environmental quality in LMICs
  - Evidence on many topics is very thin!

- Barriers to research are falling
  - Remote sensing (e.g. cashews in West Africa)
  - Administrative data (e.g. Annual Survey of Industries)
  - Poverty proxies (e.g. nightlights, other geospatial proxies)

Much Room for Methodological Innovations

- I have tried to emphasize **applied theory**
  - We can take existing models and adapt them to LMIC contexts
  - E.g. add credit constraints, factor market constraints
  - Many new insights we can take to the field!

- Other methodological innovations
  - Demand estimation (e.g. Ito and Zhang, 2020; Kremer et al., 2013)
  - Field experiments (e.g. Saavedra, 2024; Duflo et al., 2013)
  - Lab-in-the-field (e.g. Dean and Berkouwer, 2022)
  - Reduced form quasi-experimental

Innovation in Theory

1. Environmental and development econ study market failures
   - New theory can help explain interactions
   - e.g. Burgess et al. (2012), Jack et al. (2024), Madhok and Gulati (2024), Braganca and Dahis (2022)
2. IO and behavioural economics have clear intersections w/ envirodevonomics
   - WTP elicitation (revealed pref, stated pref, etc.)
   - e.g. Ito and Zhang (2020), Berkhouwer and Dean (2022), Kremer et al. (2013)
   - See reading list for many other WTP for environment papers
3. [New] Macro-structural and trade

Research Frontiers: $MWTP_e$

- What is $MWTP_e$ in poor countries?
  - Lots of work on pollution (air/water)
  - Less work on biodiversity/forests
- What is the role of market failures in explaining low $MWTP_e$?
  - Credit markets, labor markets, property rights, information access
- Is low state capacity reflected in low MWTP?

Research Frontiers: Environmental policy design in LMICs

- What determines successful environmental policy in LMICs?
  - What is role of monitoring, enforcement, information asymmetries?
  - New areas: e.g. trust (Jack et al., 2024)

- Does information provision to public change exposure to environmental risk?

- How can environmental policy be tailored to accommodate informal sector?

Research Frontiers: Political Economy

- How do political structures lead to rent-seeking and overexploitation?
  - Can conservation policy mitigate rent-seeking behavior?
- How does leader identity influence environmental outcomes?
  - Ethnic alignment (e.g. Madhok and Gulati, 2024)
  - Gender (e.g. Jagnani and Mahadevan, 2024)
  - Minority/majority: e.g. (Gulzaar et al, 2023)
- Do extractive institutions cast a "long shadow" on the environment?

Thank you!

Next week: Proposal Presentations