Economics 270c

Development Economics

Lecture 14 – April 24, 2007

Lecture 1: Global patterns of economic growth and development (1/16)

The political economy of development

Lecture 2: Inequality and growth (1/23)
Lecture 3: Corruption (1/30) – Guest lecture by Ben Olken
Lecture 4: History and institutions (2/6)
Lecture 5: Democracy and development (2/13)
Lecture 6: Ethnic and social divisions (2/20)
Lecture 7: Economic Theories of Conflict (2/27)
Lecture 8: War and Economic Development (3/6)

Human resources

Lecture 9: Human capital and income growth (4/3)
Lecture 10: Increasing human capital (4/10)
Lecture 11: Health and nutrition (3/13)
Lecture 12: The Economics of HIV/AIDS (3/20)
Lecture 13: Labor markets and migration (4/17)

☆Lecture 14: Environment and development (4/24)
Lecture 15: Social Learning and Technology Adoption (5/1)

- I will pass back graded problem set #1's at the end of class today

- Problem set #2 is due at the end of class today

- Last lecture next Tuesday May 1st – beer and pizza at LaValls after class (5:30pm)

- Final exam in class on Tuesday May 8th (3:30pm)

Lecture 14 outline

(1) Environment and economic development

(2) Pollution and health outcomes: air pollution (Jayachandran 2006)

(3) The political economy of water usage (Duflo and Pande 2006)

(4) Water quality, health, and the valuation of environmental amenities (Kremer et al. 2007)

(5) Does economic development lead to environmental degradation? (Foster and Rosenzweig 2003)

(6) Climate change and economic development

(1) Environment and development

- What is the impact of environmental pollution (air, water) on health and other outcomes?
- Who loses the most from pollution? Can wealthy (or educated) people shield themselves?
- What are the distributional impacts of large-scale environmental changes during the course of economic development more generally?
- What is the best way to provide clean water to rural households? How much do they value clean water?

(1) Environment and development

- What is the impact of environmental pollution (air, water) on health and other outcomes?
- Who loses the most from pollution? Can wealthy (or educated) people shield themselves?
- What are the distributional impacts of large-scale environmental changes during the course of economic development more generally?
- What is the best way to provide clean water to rural households? How much do they value clean water?
- Should we expect economic growth to lead to the deterioration of environmental resources, or most investment in such resources?
- How will climate change affect economic development?

(1) Environment and development

- Why is studying the environment any different from studying other resources?
- Externalities and spillovers are central to understanding environmental issues (e.g., pollution in China)

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- Why is studying the environment any different from studying other resources?

- Externalities and spillovers are central to understanding environmental issues (e.g., pollution in China)

- Information asymmetries are often severe (e.g., arsenic poisoning in Bangladeshi ground water)

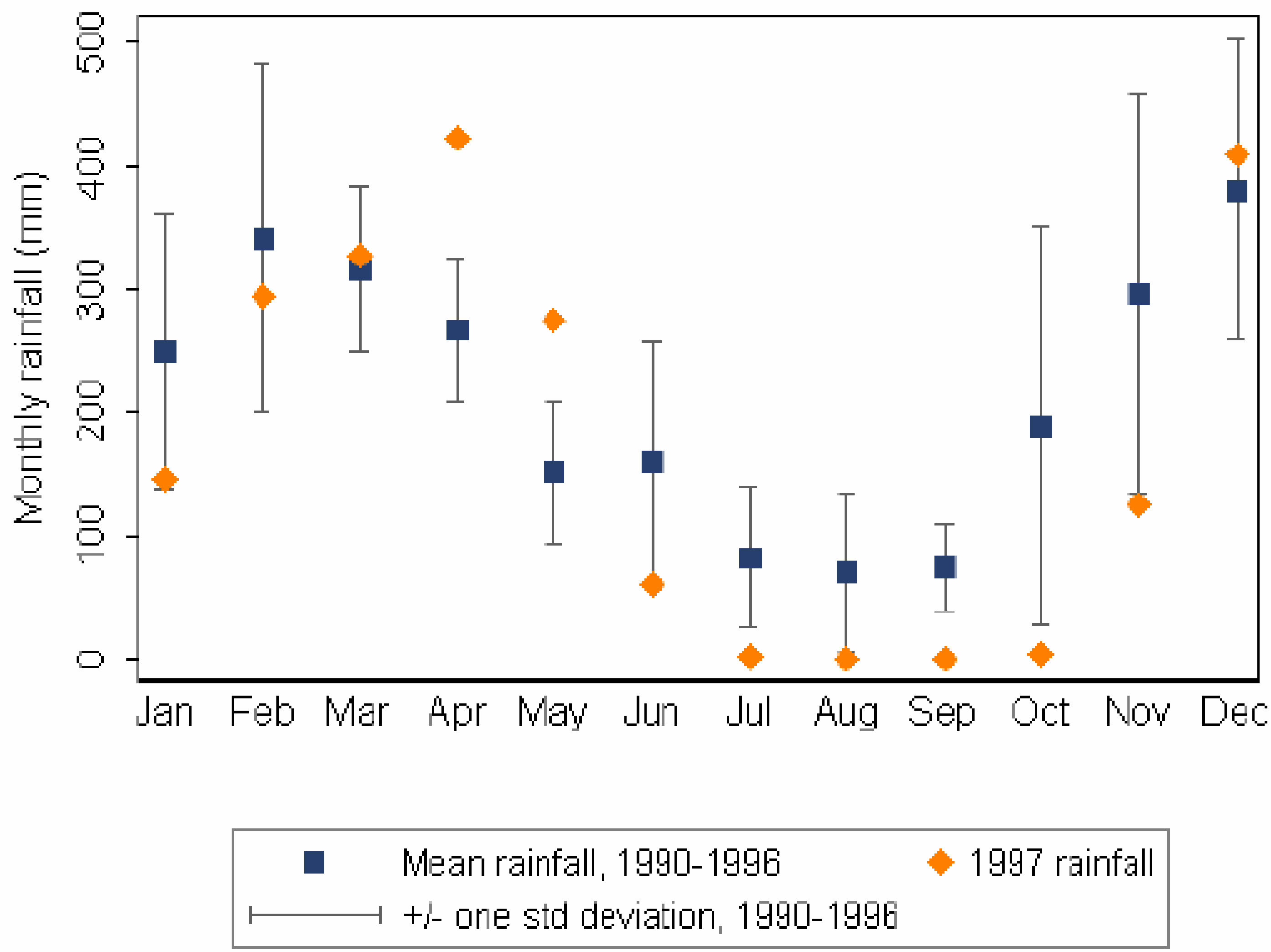
- The possibility of extinction of animal and plant species could be extremely costly (e.g., for future pharmaceutical development) → intergenerational concerns

(2) Jayachandran (2006)

- There were massive wildfires (set off by commercial logging companies) in Indonesia in late 1997

- The fire followed several months of abnormally low rainfall in an El Niño year that led to strange weather in many other parts of world (dry season flooding in Kenya)

Figure 1: Rainfall at Palembang Airport meteorological station, South Sumatra, 1990-97



(2) Jayachandran (2006)

- There were massive wildfires (set off by commercial logging companies) in Indonesia in late 1997
- The fire followed several months of abnormally low rainfall in an El Niño year that led to strange weather in many other parts of world (dry season flooding in Kenya)
- Smoke blanketed much of Indonesia (and neighbors) at particulate matter concentrations far above safe levels: air pollution exceeded the PM_{10} EPA standard of 150 $\mu g/m^3$ (not to be exceeded more than one day per year) for months at a time → what impact on infant mortality?

Figure 2: Satellite images of smoke over Indonesia

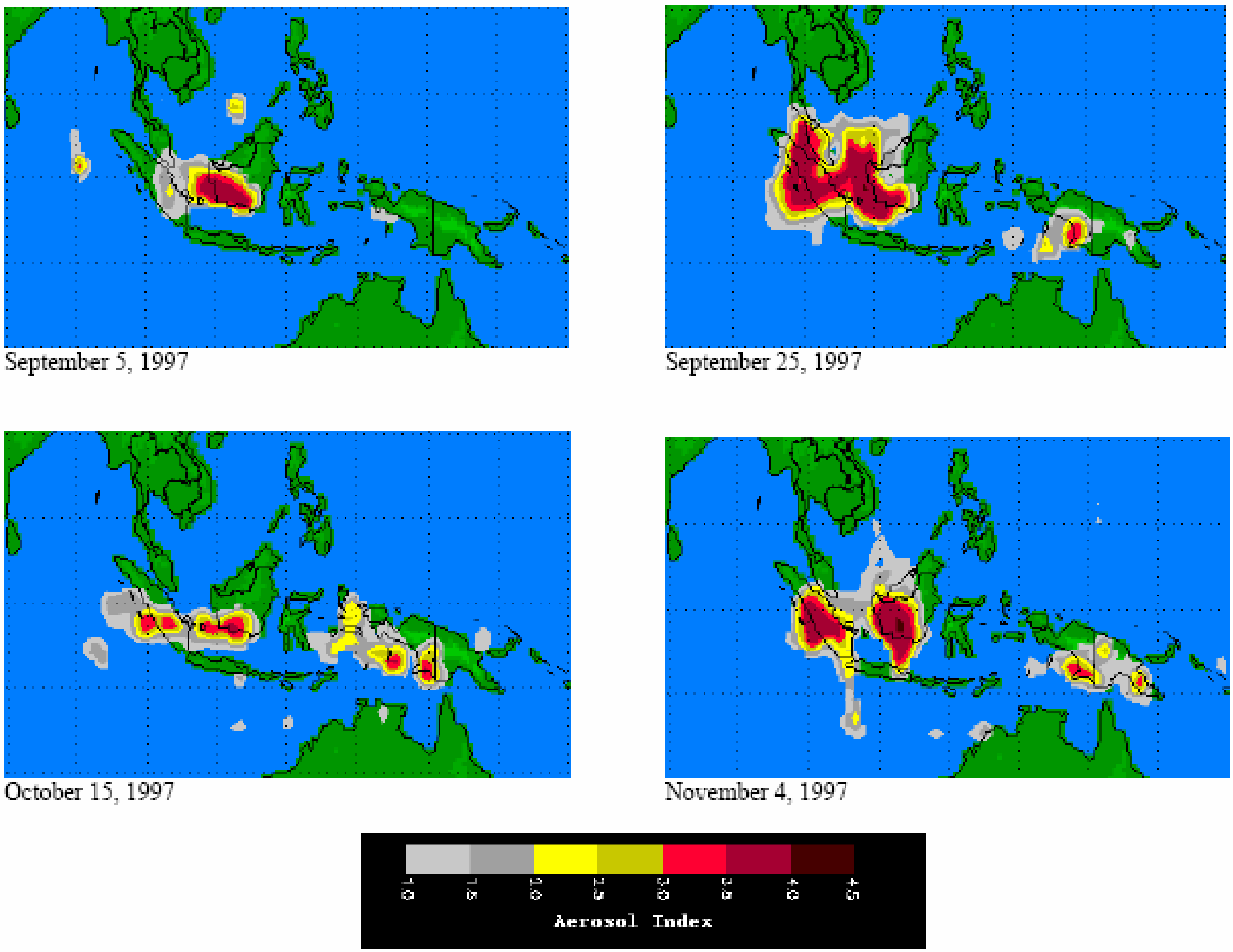
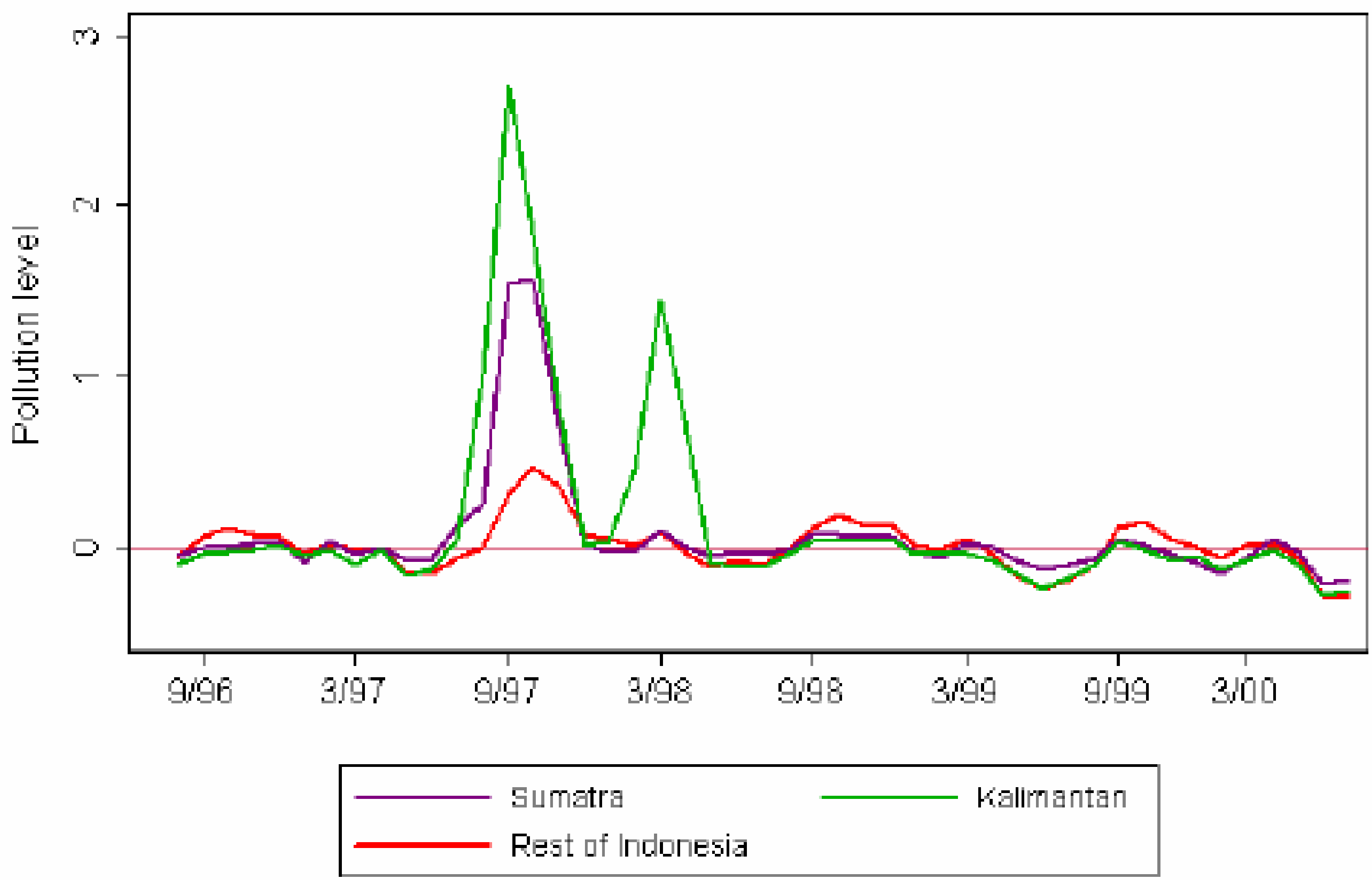


Figure 3: Timing and location of the pollution



(2) Jayachandran (2006)

- There are no reliable mortality records in Indonesia, but one can use census data (collected in 2000) to capture “missing children”

- Fertility could also be affected by the wildfires, but this is less of a concern if we focus on women already pregnant at the start of the unusual weather in mid-1997

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- There are no reliable mortality records in Indonesia, but one can use census data (collected in 2000) to capture "missing children"

- Fertility could also be affected by the wildfires, but this is less of a concern if we focus on women already pregnant at the start of the unusual weather in mid-1997

- Jayachandran estimates the impact of being *in utero* versus newly born at the time of the greatest wildfires (September to November 1997). The question of which period in child development is most influential (or where people are most vulnerable) is of general interest

Thus, the approach I take is to infer fetal and infant mortality by measuring "missing children."[9] The outcome measure is the cohort size for a subdistrict-month calculated from the complete 2000 Census of Population for Indonesia. The estimating equation is

$$\begin{aligned} ln(CohortSize)_{jt} = &\beta_1 Smoke_{jt} + \beta_2 PrenatalSmoke_{jt} + \\ &\beta_3 PostnatalSmoke_{jt} + \delta_t + \alpha_j + \varepsilon_{jt}. \end{aligned} \tag{3.2}$$

The dependent variable, $ln(CohortSize)_{jt}$, is the natural logarithm of the number of people born in month t who are alive and residing in subdistrict j at the time of the 2000 Census. $Smoke_{jt}$ is the pollution level in the month of birth, and the variables $PrenatalSmoke_{jt}$ and $PostnatalSmoke_{jt}$ are included to explore the different timing of exposure, as discussed below. To obtain parameters that represent the average effect for Indonesia, each observation is weighted by the subdistrict's population (the number of people enumerated in the Census who were born in the year prior to the sample period).

Table 2
Relationship Between Air Pollution and Cohort Size

Dependent variable: Log cohort size

	Statistic used for smoke measures						
	Median	Median	Mean	% high-smoke days	Median	Mean	% high-smoke days
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Smoke	-.0005		-.001	-.010	.001	.018	.035
	(.006)		(.007)	(.020)	(.009)	(.014)	(.036)
Prenatal Smoke ($Smoke_{t-1,2,3}$)	-.035 ***	-.032 ***	-.032 **	-.085 **			
	(.012)	(.011)	(.013)	(.033)			
Postnatal Smoke ($Smoke_{t+1,2,3}$)	-.014		-.016 +	-.042 +			
	(.009)		(.010)	(.025)			
$Smoke_{t-1}$					-.010	-.028 *	-.069 *
					(.009)	(.016)	(.040)
$Smoke_{t-2}$					-.023 ***	-.006	-.035
					(.008)	(.013)	(.038)
$Smoke_{t-3}$					-.003	-.005	.005
					(.013)	(.015)	(.030)
$Smoke_{t+1}$					-.010	-.019	-.030
					(.009)	(.014)	(.031)
$Smoke_{t+2}$					-.005	-.003	-.034
					(.008)	(.014)	(.034)
$Smoke_{t+3}$					.001	-.001	.010
					(.009)	(.012)	(.031)
Observations	67454	67454	67454	67454	67454	67454	67454
Subdistrict and month FEs?	Y	Y	Y	Y	Y	Y	Y

(2) Jayachandran (2006)

- One concern is endogenous migration: she captures people where they live in 2000, but perhaps many households with children fled from high smoke areas during or after the wildfires

Table 3

Distinguishing between Mortality and Migration

Dependent variable: Log cohort size

	District of residence versus birthplace versus mother's 1995 residence		
	Residence	Birthplace	Mother's 1995 residence
	(1)	(2)	(3)
Smoke	-.002	.002	.002
	(.006)	(.006)	(.006)
Prenatal Smoke	-.035 ***	-.037 ***	-.038 ***
	(.012)	(.012)	(.012)
Postnatal Smoke	-.013	-.015	-.016
	(.010)	(.010)	(.010)
Observations	5829	5829	5829
Fixed effects	month, district	month, district	month, district

(2) Jayachandran (2006)

- One concern is endogenous migration: she captures people where they live in 2000, but perhaps many households with children fled from high smoke areas during or after the wildfires

- Households in poor areas are significantly more negatively affected than others by the wildfires: air pollution seems to have a very “regressive” impact

Table 5
Effects by Gender and Income

Dependent variable: Log cohort size

	By gender	By income (log consumption) of the district						
					<------ one regression ------>			
					Top quartile	3rd quartile	2nd quartile	Bottom quart.
	(1)	(2)	(3)	(4)	(5)			
Smoke	-.008	-.060 ***	-.024	-.013	-.004	-.011	-.028	.002
	(.007)	(.021)	(.016)	(.017)	(.009)	(.010)	(.024)	(.045)
Prenatal Smoke	-.030 **	-.158 ***	-.129 ***	-.090 ***	-.058 ***	-.076 ***	-.094 **	-.121 **
	(.012)	(.037)	(.028)	(.015)	(.018)	(.017)	(.047)	(.061)
Postnatal Smoke	-.019 *	-.158 ***	-.047 *	-.035 **	-.025	-.040 ***	-.046	.009
	(.010)	(.027)	(.024)	(.019)	(.016)	(.014)	(.032)	(.052)
Male	.014 ***							
	(.003)							
Smoke * Male	.016 ***							
	(.005)							
Prenatal Smoke * Male	-.009							
	(.007)							
Postnatal Smoke * Male	.010							
	(.006)							
Smoke * High Consum.		.066 ***	.017					
		(.021)	(.014)					
Prenatal Smoke * High Consum.		.127 ***	.072 ***					
		(.038)	(.027)					
Postnatal Smoke * High Consum.		.161 ***	.017					
		(.026)	(.014)					
Observations	134734	63158	63158	63158	<------ 63158 ------>			
Fixed effects included	subdistrict, month	subdistrict, month	subdistrict, month * high cons.	subdistrict, month * high cons.	subdistrict, month*quartile of log consumption			

Table 6

Effects By Urbanization, Wood Fuel Use, and Health Care Sector

Dependent variable: Log cohort size	(1)	(2)	(3)	(4)	(5)
Prenatal Smoke	-.121 ***	.015	-.115 ***	-.113 ***	-.007
	(.028)	(.032)	(.027)	(.028)	(.025)
Prenatal Smoke * Urbanization	-.013				
	(.013)				
Prenatal Smoke * Wood Fuel Use		-.155 ***			-.120 ***
		(.036)			(.026)
Prenatal Smoke * Maternity Clinic			.030 ***		.011 **
			(.009)		(.005)
Prenatal Smoke * Doctors				.048 ***	.016
				(.015)	(.013)
Prenatal Smoke * High Consum.	.071 ***	.048 *	.058 **	.052 **	.044 *
	(.027)	(.025)	(.025)	(.025)	(.025)
Observations	63158	63158	63158	63158	63158
Subdistrict and month FEs?	Y	Y	Y	Y	Y

(2) Jayachandran (2006)

- One concern is endogenous migration: she captures people where they live in 2000, but perhaps many households with children fled from high smoke areas during or after the wildfires

- Households in poor areas are significantly more negatively affected than others by the wildfires: air pollution seems to have a very “regressive” impact

- 16,000 excess infant/fetal deaths. Valuing a life at US$1 million leads to a valuation of US$16 billion (ignoring costs for survivors). Total timber and palm oil industry revenues per year was only US$7 billion!

(3) Duflo and Pande (2007, *QJE*)

- Water resources are very high profile in India: using dams to store water facilitates irrigation and flood control, boosting agricultural productivity.

  -- But flooding upstream area (“behind” the dam) often displaces thousands of households, and possibly ruining valuable environmental resources

(3) Duflo and Pande (2007, *QJE*)

- Water resources are very high profile in India: using dams to store water facilitates irrigation and flood control, boosting agricultural productivity.

  -- But flooding upstream area ("behind" the dam) often displaces thousands of households, and possibly ruining valuable environmental resources

- Is there a trade-off between economic progress (agricultural production) and the environment?

- What are the distributional implications of these large-scale dam projects in India – who wins and loses?

(3) Duflo and Pande (2007, *QJE*)

- Duflo and Pande develop an innovative empirical approach to estimating these effects: IV for dam location with geographic suitability, related to the slope of land

- Controlling for state fixed effects (and time trends) and local elevation controls, they find that certain intermediate levels of land "gradient" in a district are associated with more dams being built there. They also focus on periods where "pro-dam" governments were in power at the state level. This interaction between suitability and government is their instrumental variable

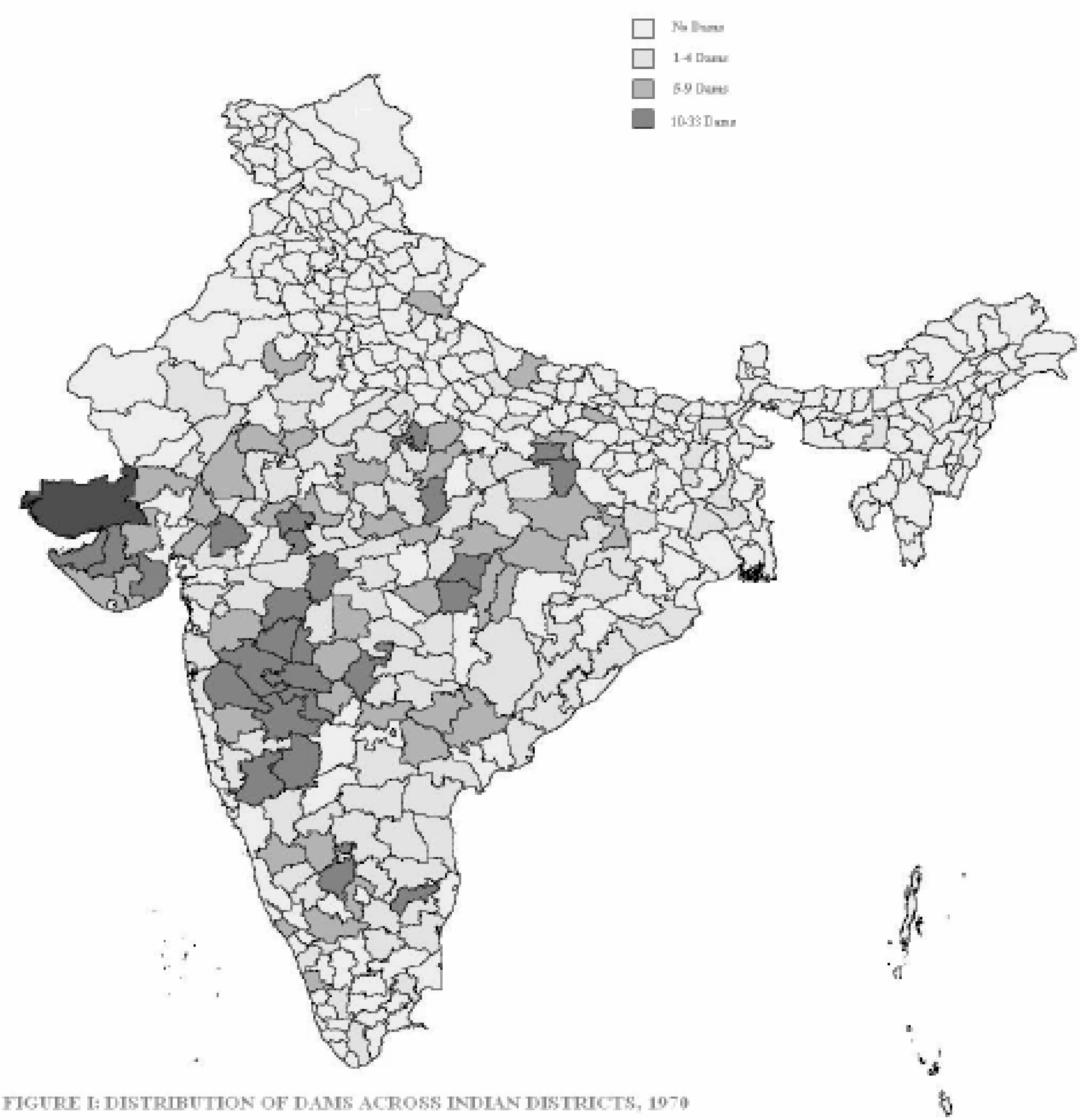


FIGURE I: DISTRIBUTION OF DAMS ACROSS INDIAN DISTRICTS, 1970

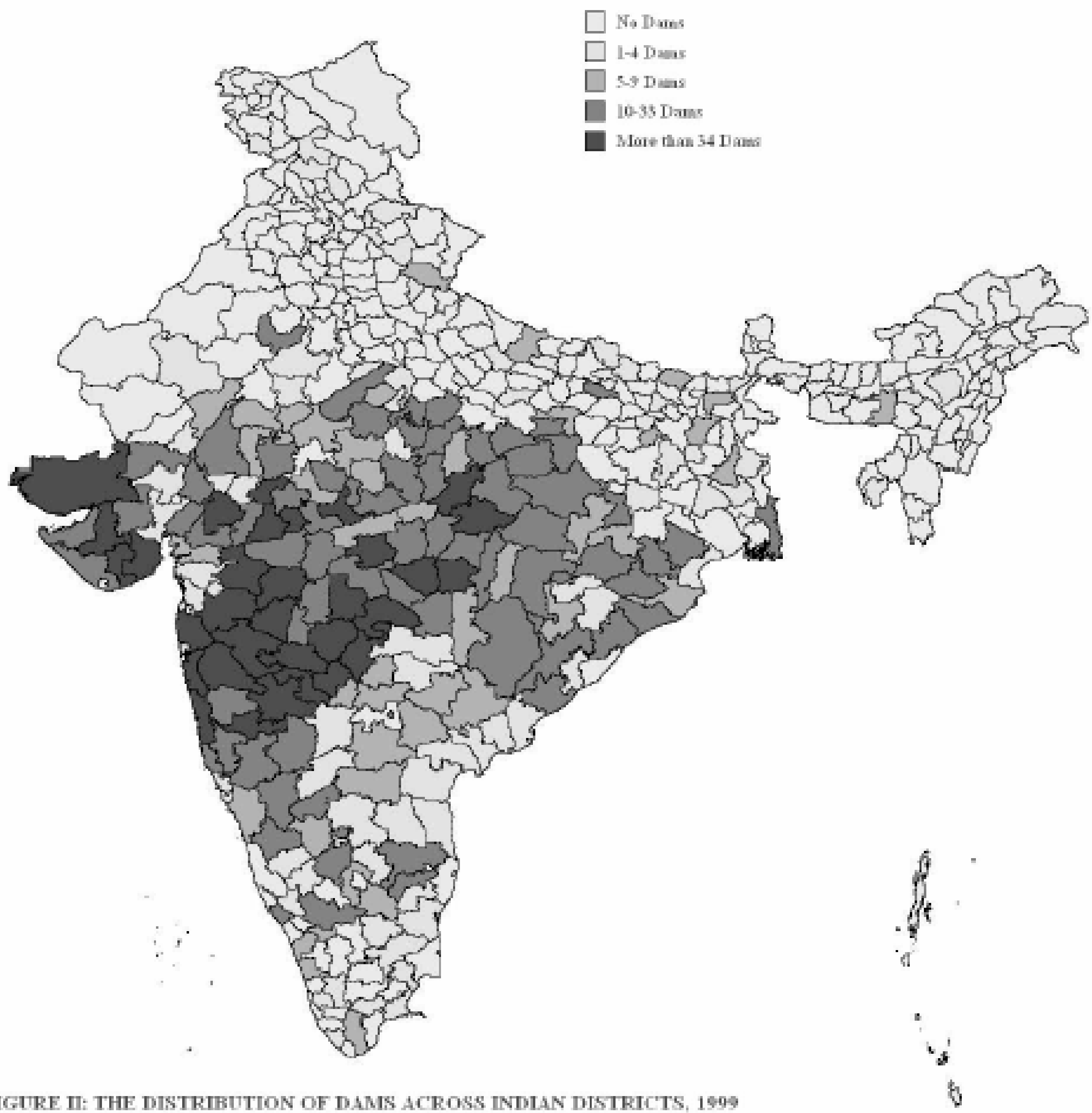


FIGURE II: THE DISTRIBUTION OF DAMS ACROSS INDIAN DISTRICTS, 1999

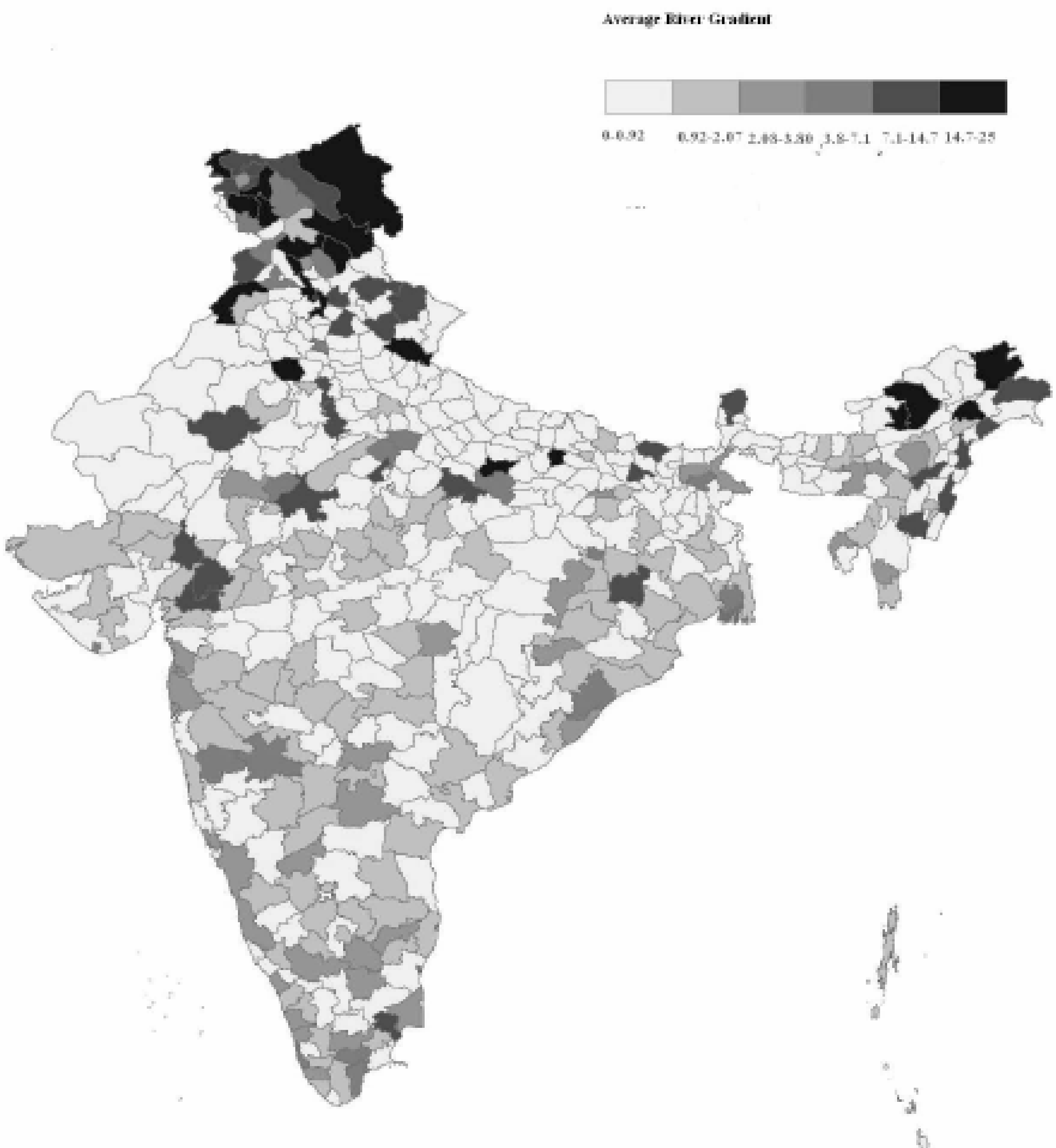


FIGURE IV: AVERAGE RIVER GRADIENT (IN PERCENTAGE), BY DISTRICT

Table II
Geography and Dam Construction

Dependent variable	Number of Dams		
Sample	Cross-section (1999)	Poverty sample	Production sample
Interaction of Geography variables	Not interacted	Interacted with predicted number of dams in the state	
	(1)	(2)	(3)
Fraction river gradient 1.5-3%	0.278	0.152	0.176
	(0.122)	(0.040)	(0.094)
Fraction river gradient 3-6%	-0.210	-0.190	-0.219
	(0.127)	(0.064)	(0.128)
Fraction river gradient above 6%	0.014	0.075	0.097
	(0.033)	(0.030)	(0.043)
F-test for river gradient	1.760	6.372	7.68
[p-value]	[0.15]	[0.000]	[0.053]
Geography Controls	Yes	Yes	Yes
State*year and river gradient*year interactions	No	Yes	Yes
Fixed effects	State	District	District
N	374	1855	7743

Notes:

1. Geography controls are river length (in kilometers), district area (in sq. kms), three elevation variables (fraction district area with elevation 250-500m, 500-1000m and above 1000m respectively), three district gradient variables (fraction district area with gradient 1.5-3%, 3-6% and above 6% respectively). Columns (2) and 3 regressions also include a full set of state*year interactions and river gradient*year interactions.

2. Columns (2) and 3 regressions include a full set of state*year interactions and river gradient*year interactions. For these regressions the geography controls and the river gradient measures are all interacted with predicted dams. The column (2) regression is estimated by OLS with standard errors clustered by NSS region*year and the column (3) regression by GLS with standard errors clustered by district.

3. Regression coefficients are multipled by 100. Standard errors are in parentheses.

4. In columns (1) and (2) the sample includes 374 districts as defined by 1981 census). The poverty sample includes the years 1973, 1983, 1987, 1993 and 1999. The production sample includes annual data for 271 Indian districts (using the 1961 Indian census definition) for the years 1971-1999. Missing district-year observations account for actual sample size.

(3) Duflo and Pande (2007, *QJE*)

- Duflo and Pande estimate increases in poverty in districts with dams, and reductions in poverty in downstream districts (where the dam is "upstream"). Taking into account the winners and losers, overall dams do <u>not</u> look like a very cost-effective investment in India

Table IV
The Reach of Dams: 2SLS Estimates

	Log (Agricultural Production)	Headcount ratio	Poverty Gap
	(1)	(2)	(3)
PANEL A. NEIGHBORING DISTRICTS			
Dams			
Own district	0.345	0.594	0.223
	(1.148)	(0.306)	(0.101)
Upstream	0.665	-0.170	-0.045
	(0.220)	(0.078)	(0.023)
Downstream	-0.107	0.073	0.022
	(0.260)	(0.060)	(0.021)
Neighboring but not	-0.175	0.013	-0.008
upstream/downstream	(0.203)	(0.072)	(0.026)
N	7078	1799	1799
PANEL B. TIME EFFECTS			
Dams			
Own district	0.196	0.888	0.417
	(1.233)	(0.444)	(0.194)
Own district, completed in	-1.046	2.004	0.963
next 5 years	(1.366)	(1.213)	(0.433)
Upstream	0.290	-0.156	-0.049
	(0.267)	(0.154)	(0.058)
Upstream, completed in	-0.970	0.061	-0.025
next 5 years	(0.541)	(0.372)	(0.137)
N	4992	1443	1443

Notes:

(3) Duflo and Pande (2007, *QJE*)

- Two concerns: (i) the exclusion restriction
  (ii) externalities

(i) Is the district land gradient correlated with agricultural productivity / outcomes?

- This is basically taken care of with the district FE

(ii) Are broader positive impacts being left out of the cost-benefit analysis?

- Positive electricity generation spillover effects may be experienced in distant districts, and these are ignored

(3) Duflo and Pande (2007, *QJE*)

- Duflo and Pande estimate increases in poverty in districts with dams, and reductions in poverty in downstream districts (where the dam is “upstream”). Taking into account the winners and losers, overall dams do <u>not</u> look like a very cost-effective investment in India

- The political economy punch line is important: even in the case of dams where winners and losers of a policy are easy to identify, redistribution typically fails to take place in India. Similar environment lessons from China?

(3) Duflo and Pande (2007, *QJE*)

- Districts with high inequality landlord histories (Banerjee and Iyer 2005) have more poverty after a dam is built
  - Local institutions appear to be important
- 47% of those displaced by dams belong to socially marginalized Scheduled Tribes (ST)
  - The interaction effect of (DAMS)*(ST) is suggestive
  - What are the implications for other social groups in India, or outside of India?
  - Resonates with Jayachandran’s findings about environmental winners and losers in Indonesia

Table IX
Institutions and Dams: 2SLS estimates

	Log (Agricultural Production)	Headcount ratio	Poverty Gap
	(1)	(2)	(3)
Dams	-0.746	1.072	0.332
	(1.823)	(0.539)	(0.178)
Dams*	-0.294	-0.639	-0.193
Non landlord dummy	(1.077)	(0.309)	(0.102)
Dams*	1.114	0.711	0.087
Tribal population share	(2.308)	(0.790)	(0.276)
Upstream Dams	1.181	-0.393	-0.131
	(0.740)	(0.293)	(0.102)
Upstream Dams*	0.058	0.196	0.061
Non landlord dummy	(0.722)	(0.264)	(0.085)
Upstream Dams*	-0.654	-0.057	-0.015
Tribal population share	(0.644)	(0.191)	(0.060)
N	3977	914	914

Notes:

(4) Kremer et al (2007)

- The provision of piped, treated water can eliminate the transmission of most water-borne disease, a major cause of infant mortality

  -- However, it is too expensive in many rural areas in less developed countries, with low population density

- US$10 billion spent annually on water in poor countries, mostly on supply infrastructure projects (e.g., wells)
  - Development economists have had relatively little to say about the rural water sector until recently

- A randomized evaluation of spring protection (source water improvement) in 184 communities in rural Kenya

(4) Kremer et al (2007)

1) Does spring protection substantially improve source water quality?

2) How much of these gains translate into home water quality improvements? Are these improvements larger for households with better hygiene practices, sanitation?

3) What are the child health and nutrition impacts of these water quality gains?

4) How much do households value water quality gains? (How much do households value child health gains?)

Various ways to reduce diarrhea

- Environmental health hardware and “software”:
  - Improving source water quality*
  - Increasing water quantity
  - Providing point-of-use (POU) treatment
  - Sanitation access
  - Hygiene/hand washing behavioral change

- Medical approaches: oral rehydration therapy, rotavirus vaccine, breastfeeding promotion, micronutrient supplementation

Drinking water in rural Kenya

- Infant mortality in Kenya is high at 68 per 1000 live births (2001), and even higher in rural areas
  - Diarrheal disease is a leading cause

- In rural areas people live on their own farms, not in villages/towns, making piped water expensive

- Drinking water is often from sources where it is exposed to the environment before collection
    - Naturally occurring springs
    - Shallow wells

Spring "protection"

- Protecting a spring involves: excavating the "eye" of the spring, installing pipes for the water, and concrete casing for protection and drainage

- Protection does not prevent all contamination at the source (i.e., groundwater contamination)
- Contamination in transport, storage still possible

- Analytically convenient: spring protection improves water quality without changing quantity

(4) Kremer et al (2007)

- 200 natural springs identified in 2004
  - Springs stratified by baseline water contamination, divided into four treatment groups
  - 16 springs later dropped as unsuitable for protection (e.g., seasonal water only)
  - Order of protection determined randomly

- Across three survey rounds (2004, 2005, 2006), there are 175 springs with complete water and household data

- One quarter of baseline sample phased into spring protection in early 2005, one quarter in late 2005

Water quality data

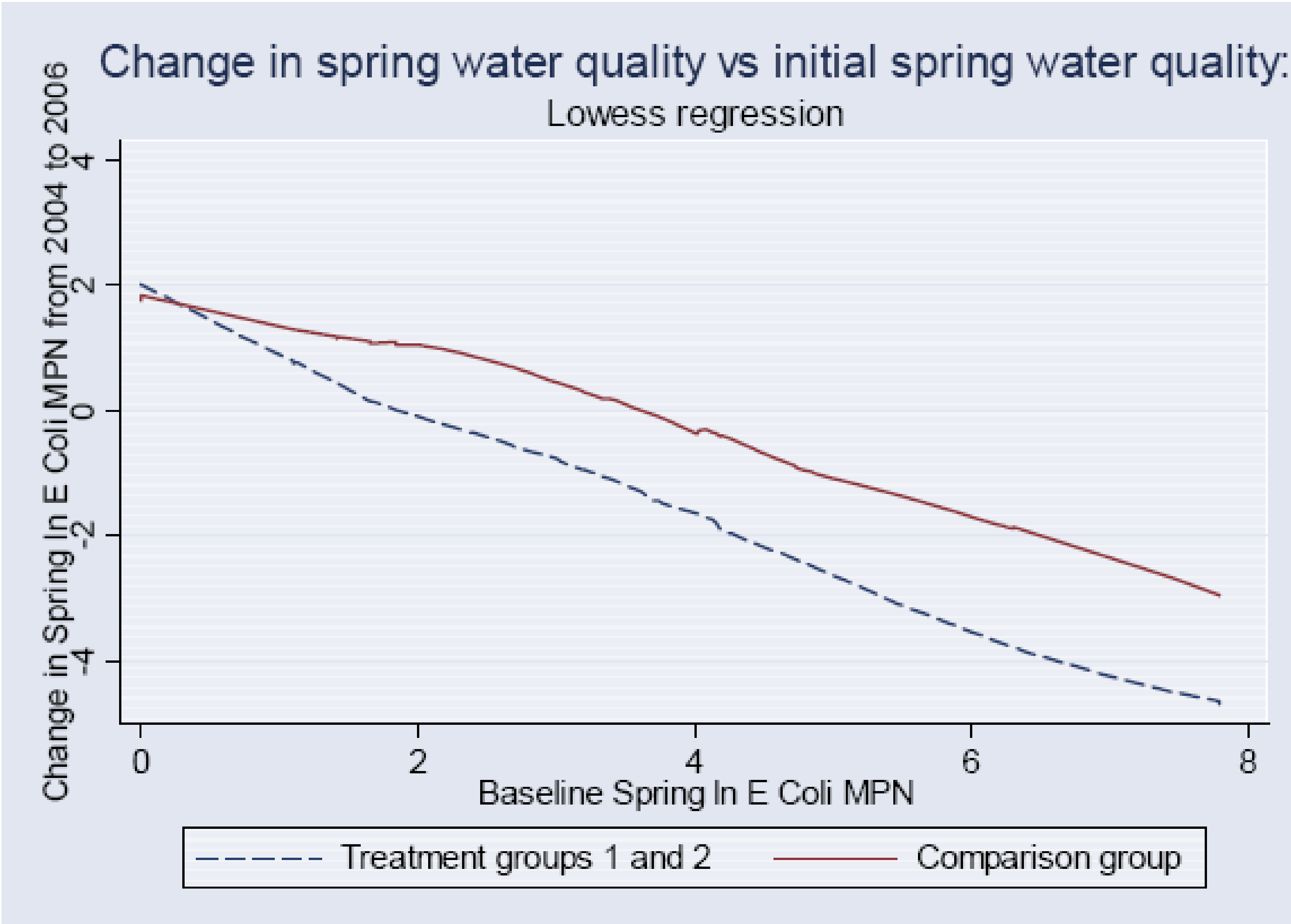
- Water quality data collected at the spring and at homes, both before and after spring protection
  - Measure contamination with fecal indicator bacteria *E. coli*
  - U.S. EPA water quality standards:
    - Drinking (*E. coli* CFU/100ml = 0)
    - Swimming (*E. coli* CFU/100ml < 100)

(4) Kremer et al (2007)

- Randomization produced similar treatment and comparison groups, in water quality and household characteristics (Table 1)

- Source water contamination fell 72-77% after treatment (Tables 2 and 3), and gains were especially large for more contaminated springs (Figure 3)

Figure 3: Change in water contamination from 2004 to 2006 versus baseline (2004) water contamination



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- Source water contamination fell 72-77% after treatment (Tables 2 and 3), and gains were especially large for more contaminated springs (Figure 3)

- Protection leads households to increasingly use the protected sample spring (Table 4)

A simple model of water source choice

- Households trade-off water quality vs. travel time

- The walking distance to a source is D and the monetary value of time is $C > 0$

- $V(W)$ captures the health (and non-health) impacts of water contamination level W, where $V' < 0$

- A household chooses to use the spring ("*s*") rather than the alternative source ("*a*") if:

$$\{V(W_s) - CD_s\} - \{V(W_a) - CD_a\} \geq 0$$

(4) Kremer et al (2007)

- Home water quality gains are larger for sole source users than for multi-source user households (Table 5)
- No interaction effects of spring protection with baseline hygiene, sanitation measures (Table 6)
- Focusing on sole source users (who overwhelmingly use the spring throughout), an IV approach indicates water recontamination between source and the home is smaller than is often claimed (Table 7)

Table 7: The elasticity of household water quality with respect to spring water quality

	Dependent variable: ln(Home water *E. coli* MPN)		
	Full sample	Sole-source users	Sole-source users
	OLS	OLS	IV
	(1)	(2)	(3)
ln (Spring water *E. coli* MPN)	0.22***	0.23***	0.66**
	(0.02)	(0.03)	(0.31)
Diarrhea prevention knowledge score	-0.010	-0.046*	-0.046
	(0.021)	(0.028)	(0.032)
Latrine density	-0.72**	-1.14**	-1.18*
	(0.35)	(0.51)	(0.64)
Baseline boiled water yesterday indicator	0.111	0.135	0.147
	(0.095)	(0.111)	(0.126)
District-wave (season) fixed effects	Yes	Yes	Yes
R^2	0.06	0.08	--
Observations (spring clusters)	3282 (174)	1803 (159)	1803 (159)
Mean (s.d.) of dep. var. in comparison group	3.09 (2.26)	3.22 (2.14)	3.22 (2.14)

(4) Kremer et al (2007)

- No statistically significant impacts on child diarrhea, weight or height after 18 months
  - This holds also for the sole-source users households, who showed the largest home water quality gains

- Statistical precision is a possible concern. Still we can reject moderate gains – weight gains >0.72 kg and height gains >0.53 cm – with 90% confidence among sole-source user households

Table 8: Child health outcomes (for children under age three at baseline, or born since 2004)

	Dependent variable: Diarrhea in past week			Dependent variable: Weight (kg.)			Dependent variable: Height (cm.)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treatment (protected) indicator	-0.026	-0.012	-0.027	0.211	0.136	0.198	-0.808	-0.405	-0.828
	(0.036)	(0.042)	(0.036)	(0.331)	(0.368)	(0.325)	(0.508)	(0.582)	(0.521)
Baseline multi-source user		-0.034			0.166			-0.871	
* Treatment indicator		(0.053)			(0.305)			(0.841)	
Treatment (protected) indicator,			0.011			0.237			0.380
Year 2 of protection			(0.034)			(0.481)			(0.690)
Child fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.57	0.57	0.55	0.80	0.80	0.78	0.97	0.97	0.97
Child-year observations	5537	5537	5537	3655	3655	3655	3795	3795	3795
Mean (s.d.) dep. var. in comp. group	0.18	0.18	0.18	11.71	11.71	11.71	82.54	82.54	82.54
				(4.33)	(4.33)	(4.33)	(16.46)	(16.46)	(16.46)

(4) Kremer et al (2007)

- Spring protection led to large source water quality gains (72-77% reduction in contamination). These translate into moderate home gains for sole source spring users

- Home water quality impacts were no larger for households with better hygiene or sanitation

- No evidence (after 18 months) of any sizeable child health or nutrition gains from spring protection

- Moderate household valuation for spring protection is consistent with households learning that child health gains are non-existent

(5) Foster and Rosenzweig (2003)

- Does economic growth lead to deforestation? The cross-country evidence is unclear

- These authors argue that local economic growth, by boosting the demand for forest products / the price of fuel, can increase forest cover rather than decrease it

- Evidence from the U.S. historically and India recently are consistent with the view that economic growth could promote afforestation

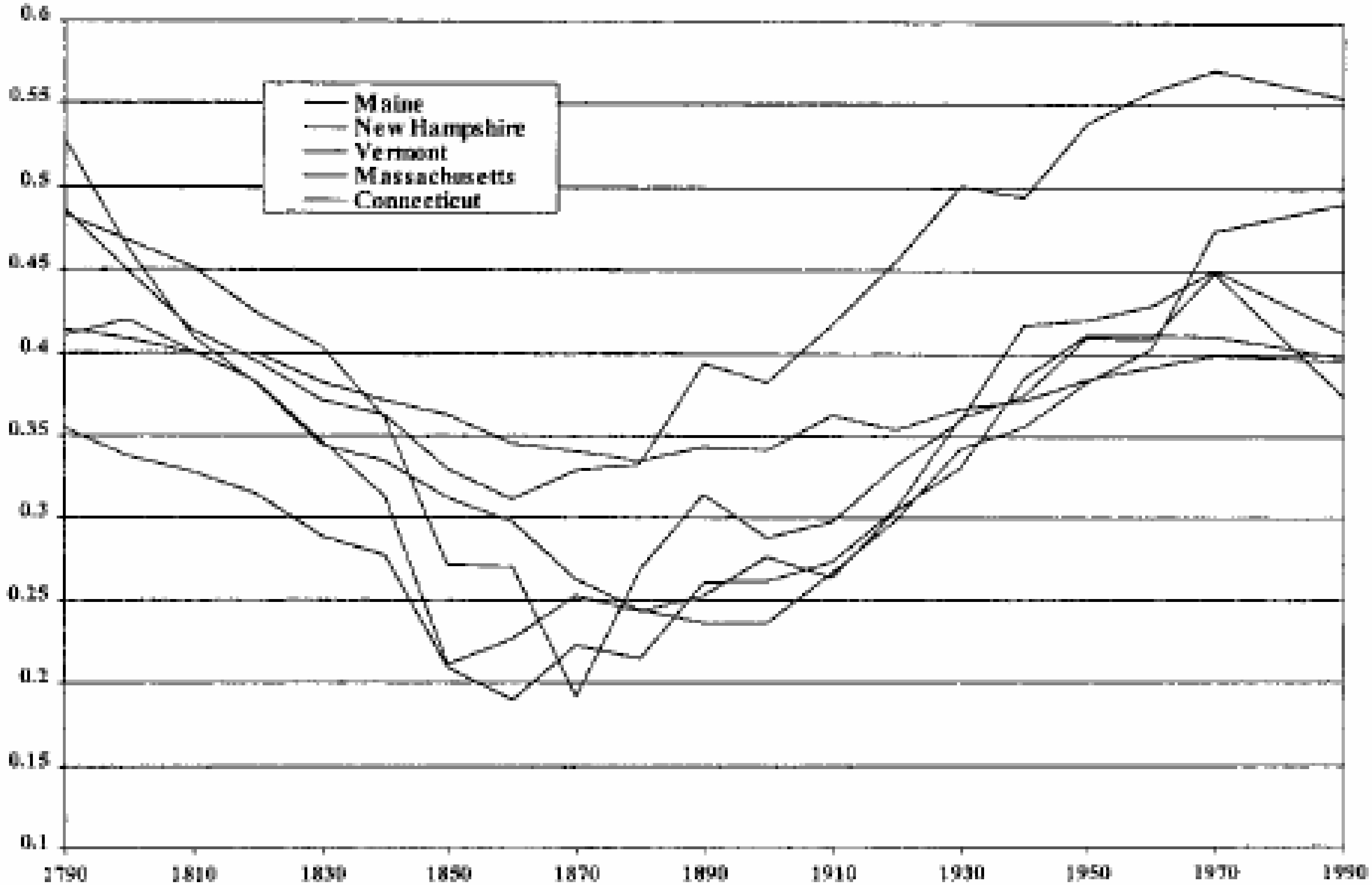


FIGURE I
Proportion of Total Land Forested, by State, U. S. New England States
1790–1990

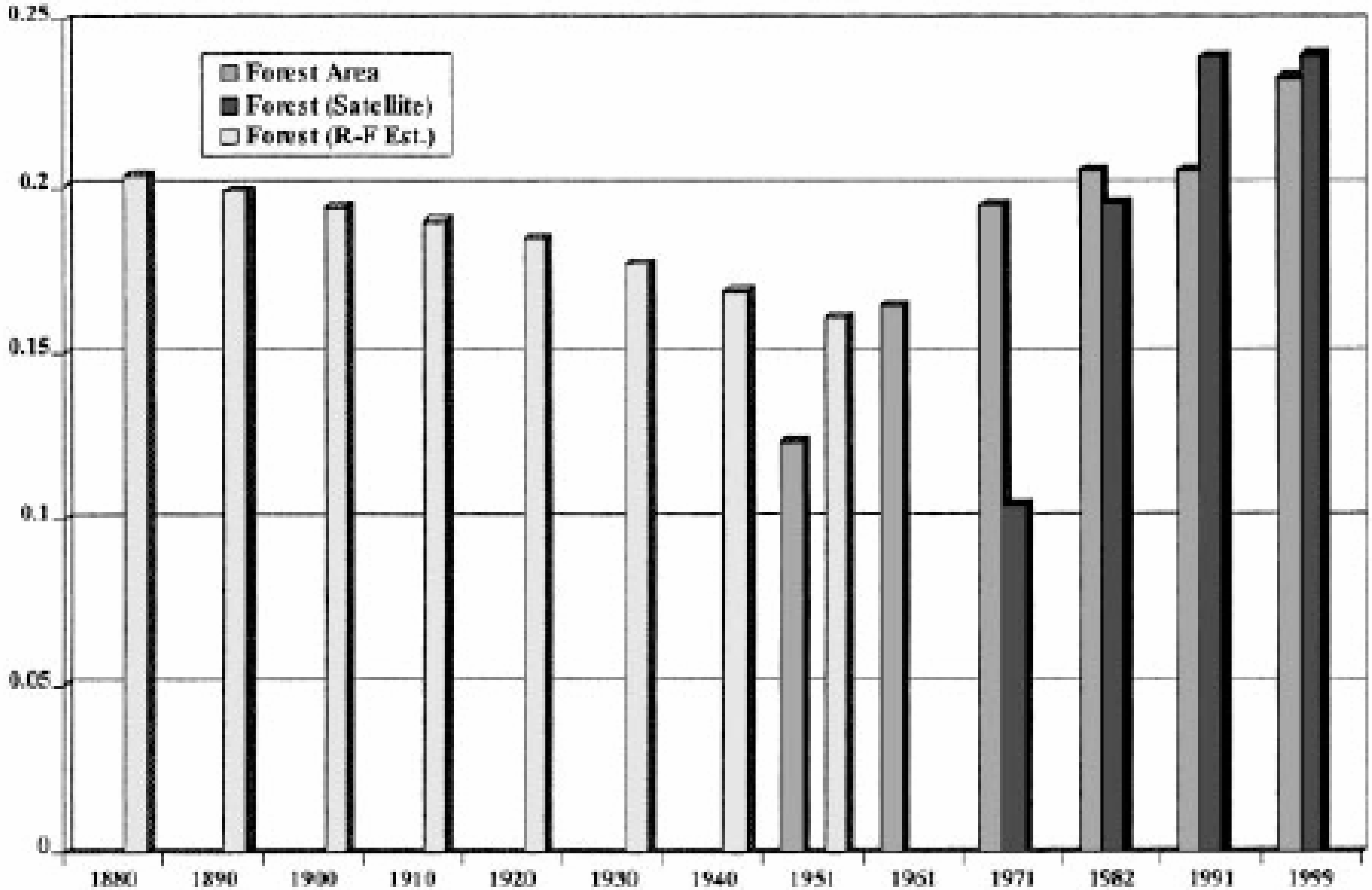


FIGURE II

Proportion of Total Land Area Classified as Forest (Government Statistics) and Proportion of Land Forested (Richards and Flint Estimates and Satellite Data for Survey Villages), India 1880–1999

One possibility is that income growth leads to a greater demand for environmental amenities and direct efforts to conserve resources such as trees. The recycling of paper in the United States and Europe is motivated in part by tree "conservation." For example, one U. S. environmental organization promoting recycling provides the estimate that there will be a four-pound reduction in carbon dioxide for every pound of paper recycled [Environmental Defense 2001]. This implies that saving paper increases trees. An alternative view is that economic growth leads to an increase in the demand for forest products and that, like other renewable resources, this leads to a shift in land use toward trees. If this is the case, then efforts to conserve paper would curtail forest growth not promote it. Thus, an improved understanding of the linkages between economic growth and forest change has important implications for environmental policies in all countries.

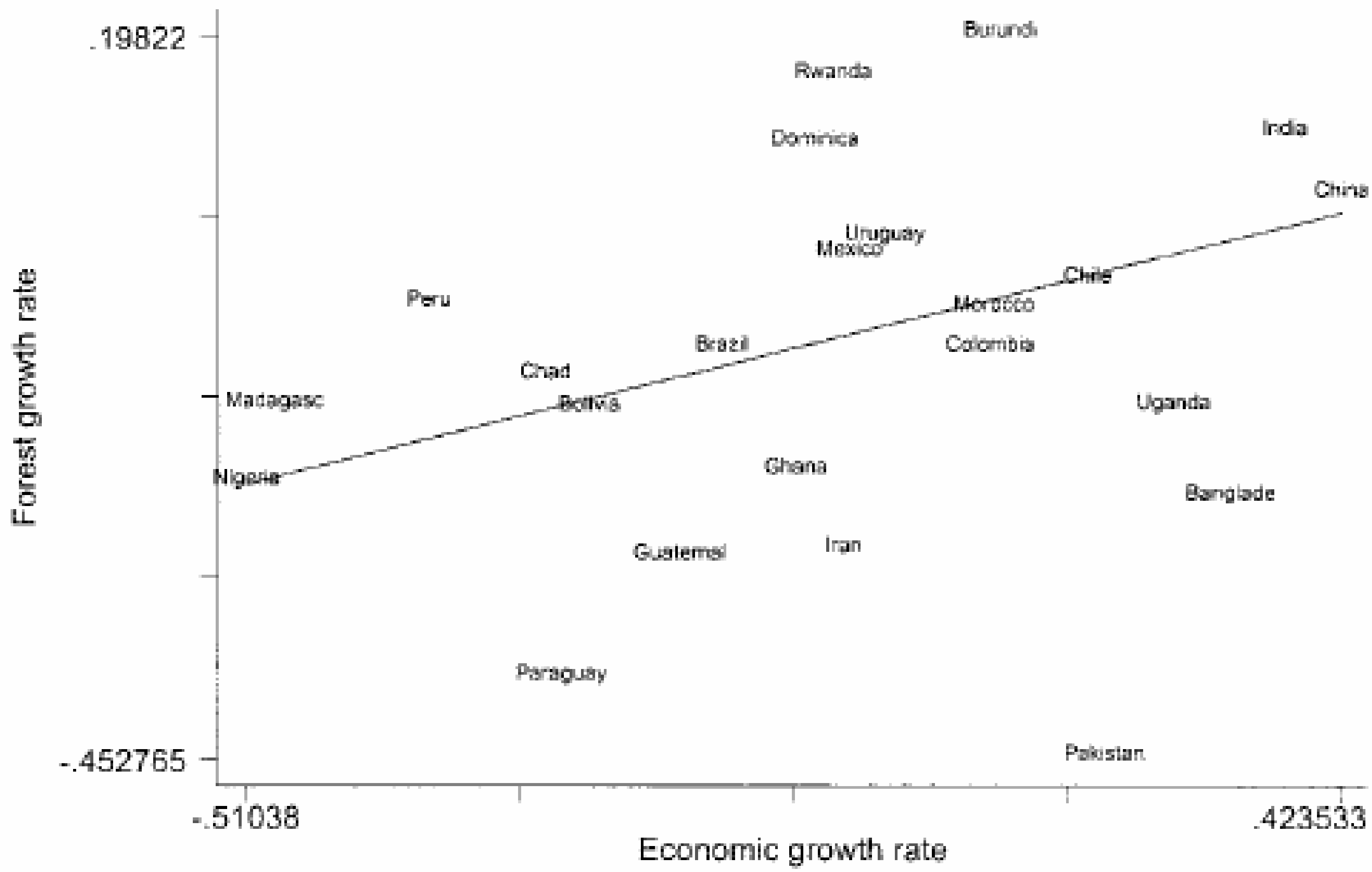


FIGURE VI
Economic Growth and Forest Growth, 1980–1995: Closed Economies

TABLE IV

EFFECTS OF AGRICULTURAL PRODUCTIVITY, WAGE RATES, INCOME, AND POPULATION ON FORESTED AREA (NDP), FOREST BIOMASS (NDT), AND (LOG) PROPORTION LAND AREA CULTIVATED: CROSS-SECTION OLS, VILLAGE FIXED EFFECTS, AND FE-IV ESTIMATES[a]

Variable	NDP			NDT			Log proportion land cultivated		
Estimation procedure	OLS	FE	FE-IV	OLS	FE	FE-IV	OLS	FE	FE-IV
Log HYV productivity (rupees)[b]	.0262	−.0490	−.264	.00780	−.0170	−.110	.145	.107	.566
	(0.87)[c]	(2.32)	(2.72)	(0.66)[c]	(2.36)	(3.09)	(1.04)	(2.02)	(1.68)
Log of wage rate[b]	.0308	−.0722	−.268	.0154	−.0242	−.0823	−.558	−.320	−1.17
	(0.71)	(1.49)	(1.11)	(1.02)	(1.46)	(0.92)	(4.67)	(3.03)	(1.51)
Log household income[b]	.0852	.0493	.0392	.0185	−.00451	−.0416	.149	.0600	.391
	(1.54)	(1.01)	(0.22)	(1.09)	(0.27)	(0.64)	(0.98)	(0.56)	(0.95)
Log household size	−.0671	−.106	−.263	−.0310	−.0303	−.0894	.123	−.00512	.0802
	(1.61)	(1.98)	(2.86)	(1.82)	(1.66)	(2.64)	(0.81)	(0.04)	(0.32)
Log population	.0778	.137	.119	.0221	.0359	.0312	−.194	.0112	.00484
	(5.50)	(5.10)	(3.28)	(5.57)	(3.91)	(2.33)	(2.97)	(0.17)	(0.04)
Rainfall (mm $\times 10^{-3}$)	.0534	.0238	.0331	.0250	.0362	.0202	—	—	—
Number of obs.	568	568	568	568	568	568	672	672	672

a. All specifications include year-effects dummy variables and dummy variables indicating missing values for population and household size.
b. Endogenous variable in columns 4, 7, and 10. Instruments are rice-, wheat-growing regions and IADP interacted with year indicator variables.
c. Absolute value of t-ratio in parentheses is corrected for nonindependence of errors within villages.

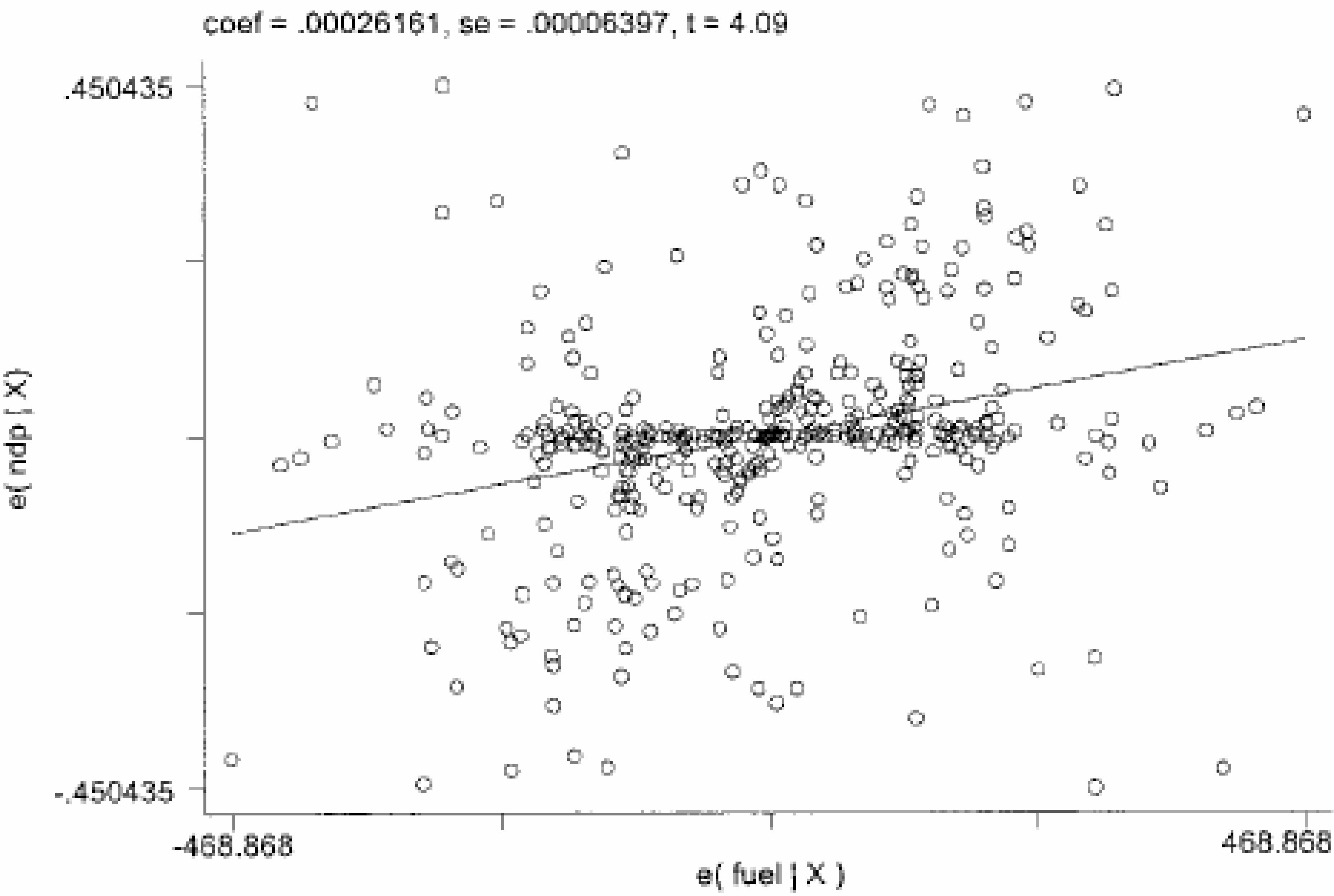


FIGURE VII
Relationship between Change in Fuel Expenditures and Change in NDP, Indian Villages, 1971–1982

(5) Foster and Rosenzweig (2003)

- Institutions matter here: common pool / overfishing problems could be important in the absence of strong government authorities able to define and enforce private property rights

- Particular forests may have intrinsic value (Yosemite), or rare species near extinction

Our findings should not be interpreted as meaning that issues of forest management emphasized in the literature are not important. The translation of increased demand for forest products into expanded forests is not automatic, but depends importantly, as expressed by Arrow et al. [1995], on the "context of growth" [p. 521]. In part, this context is itself affected by growth. In India, in particular, the increase in the demand for marketable tree products is in part responsible for the implementation of the Joint Forest Management Program in the 1980s, which provides villagers with a share of the sales proceeds from timber extracted from public forests. Clearly, without appropriate incentives in place, shifts in demand and supply would not be aligned. However, it is possible that without the shift in demand for forest products, effective policy reforms expanding forests may not have been feasible. Finally, future demand-led forest growth clearly will affect the composition of forests and their distribution worldwide. To the extent that tree species diversity, "natural" forests, or specific locations of forests are valued, and not just the aggregate world quantity of trees, restrictions on forest exploitation in particular contexts may be warranted.[18]

(6) Climate change and development

- Global climate change will shift around current patterns of rainfall and temperature. Some areas will become hotter (drier) and others cooler (wetter)
- Current predictions indicate that several LDC regions could be adversely affected: West Africa will become increasingly hot and dry. Bangladesh may suffer more frequent floods
- Future work could integrate these climate predictions with existing models to simulate future economic trajectories for different regions / countries

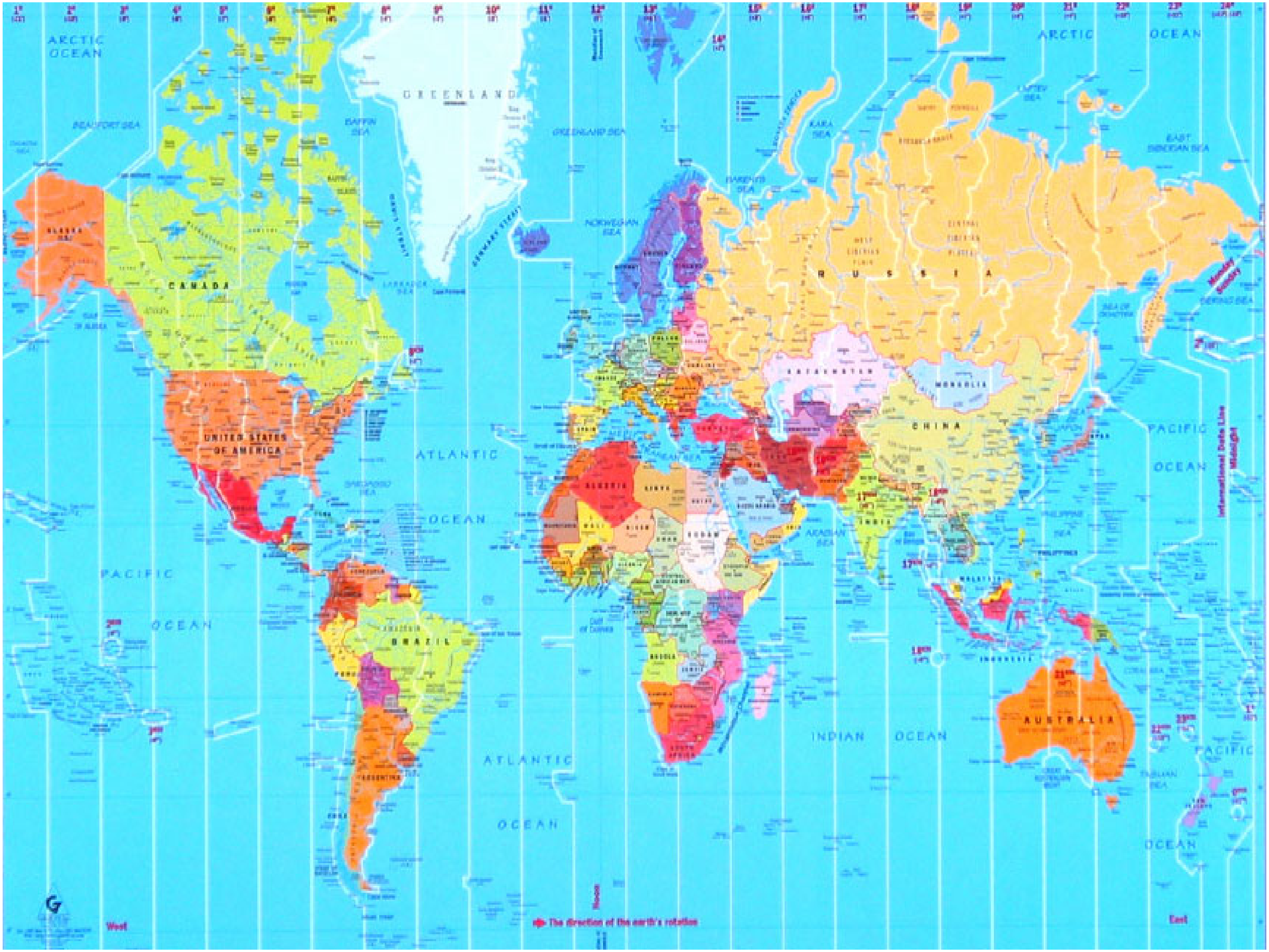
Whiteboard #1

Whiteboard #2

Whiteboard #3

Whiteboard #4

Whiteboard #5



ARCTIC OCEAN
GREENLAND
BEAUFORT SEA
BAFFIN SEA
GREENLAND SEA
NORWEGIAN SEA
BARENTS SEA
KARA SEA
LAPTEV SEA
EAST SIBERIAN SEA
BERING SEA
SEA OF OKHOTSK
ALASKA
CANADA
UNITED STATES OF AMERICA
BRAZIL
ARGENTINA
RUSSIA
KAZAKHSTAN
MONGOLIA
CHINA
INDIA
ALGERIA
LIBYA
SUDAN
NIGER
MALI
ANGOLA
SOUTH AFRICA
AUSTRALIA
INDONESIA
PHILIPPINES
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
ARABIAN SEA
TASMAN SEA
International Date Line
Midnight
West
East
The direction of the earth's rotation