Collateral Damage

The Legacy of the Secret War in Laos

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Motivation

Studying the impact of conflict in the long-run

Question

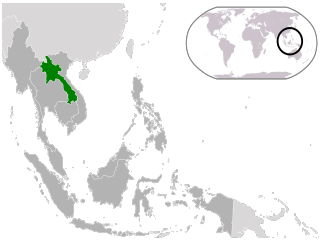
- What is the long-term impact of conflict on economic development?

- Extensive documentation on the negative short-term impacts of conflict
  - (Blattman and Miguel, 2010; Dube and Vargas, 2013; Bauer et al., 2016)
- When it comes to the long-term, the empirical evidence is mixed
  - No effect, sometimes even positive
    - Post WWII: Japan (Davis and Weinstein, 2002), Germany (Brakman et al., 2004)
    - Vietnam (Miguel and Roland, 2011)
    - Cross Country and State Capacity (Dincecco and Prado, 2012; Dincecco and Onorato, 2018)
    - Malthusian mechanism (Voigtländer and Voth, 2012)
- Part of new set of works (Fontana et al. 2017, Dell and Querubin 2017, Tur-Prats and Valencia 2019, Fergusson, Ibáñez and Riaño 2020, Alix et al., 2020)

This paper

Southeast Asia, Lao People's Democratic Republic

- To address this question we focus on Lao PDR (Laos)
  - One the poorest countries in the world (24% poor, 80% under $2.50/day, almost 70% rural population)
  - Most heavily bombed country in human history
    - Due to US secret bombing operations:
    - 9 years (1964 - 1973), it received $\approx$ 1 bomb / 8 min



- Can conflict be one of its causes of underdevelopment? (Collier et al. 2003; Miguel et al. 2004)
- If so, through which mechanisms?
  - We emphasize: The role of UXO (unexploded ordnance) and persistent effects on:
    1. Human Capital Accumulation: Health and Education
    2. Settlement Patterns: Population Density and Migration
    3. Labour Market Outcomes: Employment and Structural Transformation
  - Demining in Mozambique (Chiovelli, Michalopoulos and Papaioannou, 2017) in Colombia (Prem,Purroy, and Vargas, 2021)
  - Agricultural land use in Cambodia: (Lin, 2016)

Historical Background

Foreign intervention in Laos and Vietnam during two conflicts

- Laotian Civil War (1953-1975) ▸ Video 1: Operations ▸ Video 2: Cluster Bombs ▸ Video 3: A widespread problem
  - Communist Pathet Lao and Royal Lao Government
  - CIA covert operation, part of US counterinsurgency efforts in the region
  - Operation Menu, Steel Tiger, Tiger Hound and Commando Hunt
- Cambodian Civil War (1967 - 1975) (Lin, 2020)
  - Khmer Rouge supported by North Vietnam (Bruhl & Madestam, 2017)
  - Kingdom of Cambodia and the Khmer Republic (US, South Vietnam)
- Vietnam War (1955 - 1975) (Dell and Querubin, 2018)
  - North Vietnam (Soviet Union and China)
  - Government of South Vietnam (US, S.Korea, and Thailand)
  - US secret bombing campaigns in Laos and Cambodia
- 1'635,759 recorded missions $\approx$ 13'000,000 bombs

"When buffalos fight, it is the grass that suffers"- Lao proverb

On Laos

President Obama on September 6, 2016

To the People of Laos during the first official visit, Vientiane, Laos

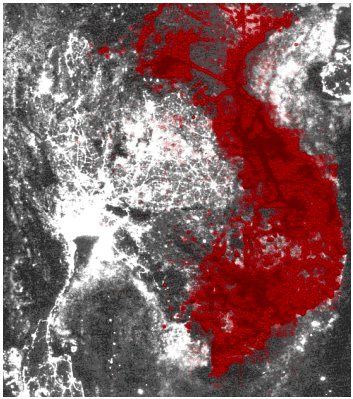
I realize that having a U.S. president in Laos would have once been unimaginable. Six decades ago, this country fell into civil war. And as the fighting raged next door in Vietnam, your neighbors and foreign powers, including the United States, intervened here. As a result of that conflict and its aftermath, many people fled or were driven from their homes. At the time, the U.S. government did not acknowledge America's role. It was a secret war, and for years, the American people did not know. Even now, many Americans are not fully aware of this chapter in our history, and it's important that we remember today.

Over nine years – **from 1964 to 1973** *– the United States dropped more than two million tons of bombs here in Laos – more than we dropped on Germany and Japan combined during all of World War II. It made Laos, per person, the most heavily bombed country in history [...] As one Laotian said, the "bombs fell like rain."*

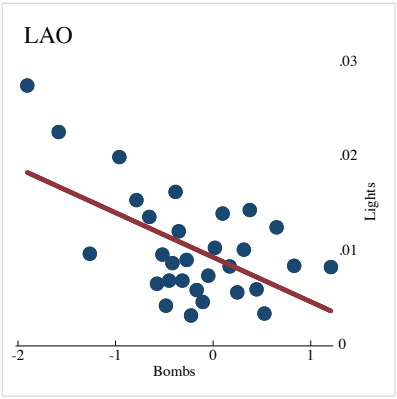
In a Nutshell

Indochina and the spatial distribution of our key variables

Stable lights 2013



US Bombing Events 1965 - 1973



Bin-scatter for Laos (+ controls)

Empirical Strategy

Summary

Three steps

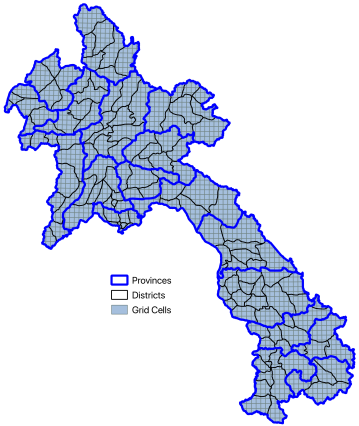
1. Grid cell level analysis 10km x 10km: Pooled OLS and Fixed Effects (year, province and district)
2. IV approach based on informational asymmetries from both sides of the conflict
3. UXO contamination, individual level data and cohort analysis DiD

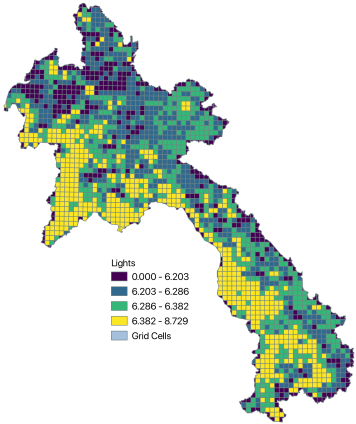
Data

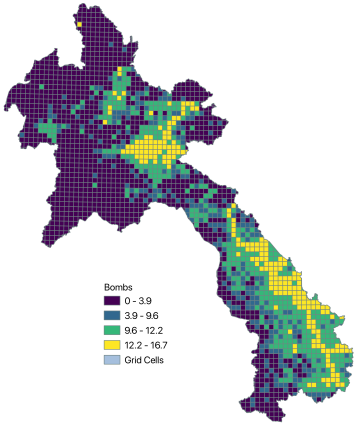
- Bombs: US Department of defense: Historical Records of US Combat Activities 1965 - 1975
- Night lights: U.S. Air Force Defense Meteorological Satellite Program, OLS, 1993, 2003, 2013
- Population and Agricultural Census: Swiss Agency for Development and Cooperation, 2005 and 2011 at the village level and 10% sample from IPUMS microdata
- Panel of UXO Accidents: National Regulatory Authority for Mine Action, 1950-2011

Grid Cell Level Analysis

Grid cells of 10km × 10km Back







Estimating Equations

Baseline specification: Geographical controls and province or district level fixed effects

- Cross-sectional specification ▸ Grids

$$Luminosity_{g,t=\tau} = \alpha_{d(g)} + \gamma_\tau \cdot TotalBombs_g + X_g'\Gamma + \epsilon_{g,t=\tau} \tag{1}$$

  - Total Bombs$_{g,d} \equiv \ln(1 +$ Total Weight in pounds Jettisoned from 1965 to 1973 per Km$^2)$
  - Luminosity$_{g,d,t=\tau} \equiv \ln(1 +$ Average Stable Lights in year τ per Km$^2)$
  - g, Indexes grids, t, Indexes years, $d =$ Districts or Provinces
  - $\tau = 1993, 2003, 2013$
  - $X_{g,t}'\Gamma =$ Geographic and Location Controls
- Or the Pooled OLS analogue

$$Luminosity_{g,t} = \lambda_t + \alpha_{d(g)} + \gamma \cdot TotalBombs_g + X_g'\Gamma + \epsilon_{g,t} \tag{2}$$

  - λ_t time fixed effects

Bombed areas are poorer...

Conditional correlations controlling for geography and location of the grids ◂ back

Dependent Variable:	Luminosity 1993			Luminosity 2003			Luminosity 2013		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Total Bombs	-0.0222***	-0.0221***	-0.0323***	-0.0271***	-0.0281***	-0.0388***	-0.0522***	-0.0569***	-0.0529***
	(0.0045)	(0.0043)	(0.0075)	(0.0057)	(0.0057)	(0.0088)	(0.0109)	(0.0110)	(0.0145)
Altitude		-0.0001**	0.0001**		-0.0001**	0.0001***		-0.0001**	0.0002***
		(0.0000)	(0.0000)		(0.0000)	(0.0000)		(0.0001)	(0.0001)
Ruggedness		-0.1355***	-0.1736***		-0.2152***	-0.2834***		-0.4316***	-0.6042***
		(0.0270)	(0.0333)		(0.0339)	(0.0419)		(0.0715)	(0.0811)
Temperature		-0.0015	0.0158***		-0.0014	0.0271***		0.0085	0.0689***
		(0.0033)	(0.0053)		(0.0048)	(0.0072)		(0.0102)	(0.0124)
Precipitation		-0.0001	-0.0002		-0.0000	-0.0001		0.0001	0.0007*
		(0.0001)	(0.0001)		(0.0001)	(0.0002)		(0.0002)	(0.0004)
|Latitude − 17°|			-0.0149***			-0.0212***			-0.0296***
			(0.0048)			(0.0060)			(0.0114)
Latitude			0.0003			0.0037			0.0223
			(0.0112)			(0.0141)			(0.0267)
Longitude			-0.0005			-0.0027			-0.0092
			(0.0127)			(0.0158)			(0.0297)
Distance to Vietnam Border			-0.0003**			-0.0005**			-0.0008*
			(0.0002)			(0.0002)			(0.0004)
Distance to Closest Capital			-0.0002***			-0.0004***			-0.0008***
			(0.0001)			(0.0001)			(0.0001)
Mean Dependent Var	**0.025**	**0.025**	**0.025**	**0.043**	**0.043**	**0.043**	**0.137**	**0.137**	**0.137**
Observations	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216
R-squared	0.0133	0.0492	0.0784	0.0118	0.0632	0.1042	0.0121	0.0974	0.1453

Variable 'Bombs' was standardized before running all the specifications to ease the interpretation of coefficients. Robust standard errors in parentheses

◂ Sum Stats ◂ Growth

... and not growing, or doing it at slower rates

Conditional correlations considering geography and geo-spatial distribution of grids Back

Dependent Variable	Growth 1993-2003			Growth 2003-2013			Growth 1993-2013		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bombs	-0.0028**	-0.0036**	-0.0044	-0.0136***	-0.0152***	-0.0055	-0.0178***	-0.0203***	-0.0120**
	(0.0014)	(0.0015)	(0.0028)	(0.0039)	(0.0039)	(0.0046)	(0.0044)	(0.0047)	(0.0048)
Altitude		-0.0000**	0.0000*		-0.0000**	-0.0000		-0.0001***	-0.0000
		(0.0000)	(0.0000)		(0.0000)	(0.0000)		(0.0000)	(0.0000)
Ruggedness		-0.0249***	-0.0375***		-0.0409	-0.0754**		-0.0758**	-0.1267***
		(0.0058)	(0.0084)		(0.0329)	(0.0370)		(0.0351)	(0.0409)
Temperature		-0.0008	0.0046**		0.0018	0.0032		0.0008	0.0095*
		(0.0009)	(0.0021)		(0.0026)	(0.0049)		(0.0034)	(0.0054)
Precipitation		0.0000	0.0001		0.0001	0.0003**		0.0001	0.0004**
		(0.0000)	(0.0001)		(0.0001)	(0.0001)		(0.0001)	(0.0002)
Latitude			0.0036			-0.0061			-0.0014
			(0.0035)			(0.0110)			(0.0127)
Longitude			0.0011			-0.0178			-0.0164
			(0.0036)			(0.0118)			(0.0132)
Distance to DMZ			-0.0036*			-0.0036			-0.0087**
			(0.0021)			(0.0032)			(0.0037)
Distance to Vietnam Border			-0.0000			-0.0002			-0.0002
			(0.0000)			(0.0002)			(0.0002)
Distance to Closest Capital			-0.0000***			-0.0002***			-0.0002***
			(0.0000)			(0.0000)			(0.0001)
Controlling initial levels	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216	2,216
R-squared	0.1097	0.1213	0.1323	0.1386	0.1586	0.1758	0.1478	0.1763	0.1993

*Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Baseline Results

Exploiting within Province and District level variation ◂ Back

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Dependent Variable Luminosity 1993						
Bombs	-0.0144***	-0.0260***	-0.0230*	-0.0229*	-0.0157**	-0.0155**
	(0.0037)	(0.0086)	(0.0113)	(0.0117)	(0.0075)	(0.0074)
Panel B: Dependent Variable Luminosity 2003						
Bombs	-0.0200***	-0.0338***	-0.0299**	-0.0295*	-0.0221**	-0.0220**
	(0.0047)	(0.0097)	(0.0141)	(0.0140)	(0.0102)	(0.0099)
Panel C: Dependent Variable Luminosity 2013						
Bombs	-0.0412***	-0.0492***	-0.0428**	-0.0433**	-0.0355***	-0.0369***
	(0.0074)	(0.0121)	(0.0180)	(0.0177)	(0.0129)	(0.0130)
Geographical Controls	Yes	Yes	Yes	Yes	Yes	Yes
Location Controls		Yes		Yes		Yes
Province Fixed Effects			Yes	Yes		
District Fixed Effects					Yes	Yes
Number of Provinces			18	18		
Number of Districts					141	141
Observations	2,216	2,216	2,216	2,216	2,216	2,216

Robust standard errors in parentheses, if FE are present se. clustered at the level of the FE. *** p<0.01, ** p<0.05, * p<0.1

Baseline Results: Pooled OLS Regressions

Henderson Storeygard and Weil (2012) ↑ *1 sd. Bombs* ⇒ **9.3% fall in GDP per capita**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	Luminosity$_{g,d,t} \equiv \ln(1 + \text{Stable Lights per Km}^2)$						
Total Bombs	-0.0338***	-0.0357***	-0.0315*	-0.0227**	-0.0413***	-0.0335**	**-0.0231****
	(0.0044)	(0.0044)	(0.0164)	(0.0112)	(0.0063)	(0.0151)	**(0.0109)**
Geographical Controls		Yes	Yes	Yes	Yes	Yes	Yes
Location Controls					Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province Fixed Effects			Yes			Yes	
Districts Fixed Effects				Yes			Yes
Number of Province FE			18			18	
Number of Districts FE				141			141
Observations	6,648	6,648	6,648	6,648	6,648	6,648	6,648
Adjusted R-squared	0.0324	0.0860	0.0624	0.0502	0.1201	0.0726	0.0528

Robust standard errors in parentheses, if Province or District FE are present se. clustered at that level. *** p<0.01, ** p<0.05, * p<0.1

▸ Cross sectional regressions ▸ GDP computation ▸ OLS by year

Endogeneity and Instrumental Variables Strategy

Bombing was probably not random, yet it was costly

OLS bias

- Underestimate: If it targeted key infrastructure for future development (roads, buildings, bridges, etc.)
- Overestimate: If it targeted mostly isolated and poor places
- Evidence supporting the former: Outliers | Quantile Reg | Spillovers | Rural/Urban | Pop density 1960
- Robust to: Conley SE | Transformation dep. var

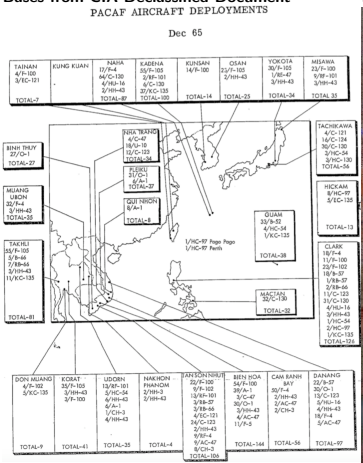
IV exploiting information asymmetries (historical maps both sides of conflict)

1. Proximity to US air bases based on declassified documents (Communist Side)
   - Distance to the closest base outside Laos (South Vietnam, Thailand and Japan)
   - Established before 1960 (Dube and Naidu, 2015; Bautista et al. 2021)
2. Distance to the the Ho Chi Minh Trail (CIA)
   - Strategic Supply Route to and from North Vietnam
   - It was not entirely known to US authorities at the time: we use the "hidden" part
   - Paths, roads, supply centers and tunnels

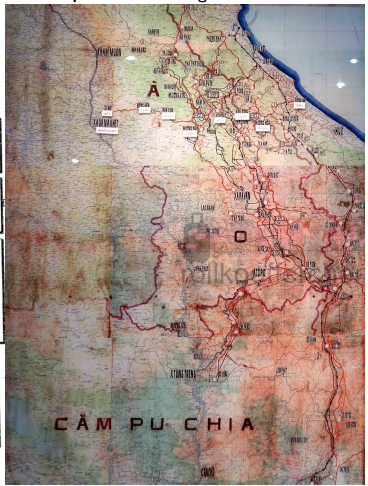
Instrument construction details

Information geo-referenced based on historical maps ▸ Asymmetry detail

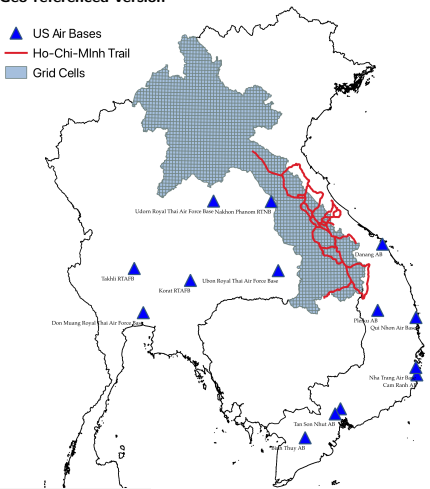
Bases from CIA Declassified Document



HMT map at the Ban Dong War Museum



Geo-referenced version

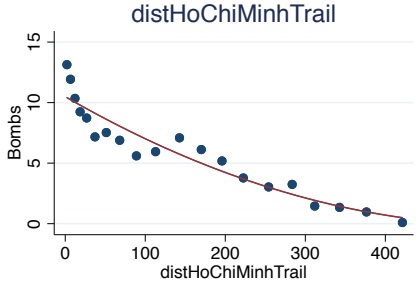


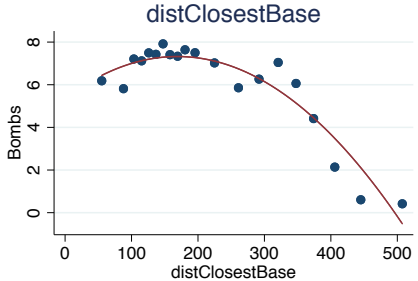
Bombing and Instruments

Distance to the Ho Chi Minh Trail and Distance to the Closest Air Base

- Quadratic / non-linear First Stage
- Allowing for heterogeneous effects (Dieterle and Snell, 2016)

$$\textbf{Total Bombs}_{g,d} = \delta_d + \beta_1 \cdot (\textbf{Instrument}_{g,d}) + \beta_2 \cdot \left(\textbf{Instrument}^2_{g,d}\right) + X_g'\Gamma + \epsilon_{g,t} \quad (3)$$





Pooled IV of Luminosity on Bombs

Individual Instruments Back

Part A - Instrument I: Distance to the Ho Chi Minh Trail	(1)	(2)	(3)
Panel A: Dependent variable is luminosity, model:	2SLS	2SLS	2SLS
Bombs	-0.1199***	-0.1235***	-0.0934***
	(0.0276)	(0.0331)	(0.0201)
Panel B: Dependent variable is Bombs, model:	FS	FS	FS
Distance to Ho Chi Minh Trail	-0.6614***	-1.0811***	-2.0007***
	(0.0420)	(0.0587)	(0.0918)
Distance to Ho Chi Minh Trail^2	-0.0548***	0.0520***	0.1459***
	(0.0089)	(0.0113)	(0.0209)
R-squared	0.5626	0.6352	0.7445
F-stat	656.5	163.1	77.81
Controls that apply for all panels			
Geographical Controls	Yes	Yes	Yes
Location Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Province Fixed Effects		Yes	
District Fixed Effects			Yes
Number of Provinces		18	
Number of Districts			141
Observations	6,648	6,648	6,648

Part B - Instrument II: Distance to the Closest US Air Base	(1)	(2)	(3)
Panel A: Dependent variable is luminosity, model:	2SLS	2SLS	2SLS
Bombs	-0.1448***	-0.1329***	-0.2651***
	(0.0336)	(0.0335)	(0.0779)
Panel B: Dependent variable is Bombs, model:	FS	FS	FS
Distance to closest US air base	1.2347***	1.2191***	0.4856***
	(0.0396)	(0.0504)	(0.0920)
Distance to closest US air base^2	-0.2322***	-0.1978***	-0.1487***
	(0.0071)	(0.0099)	(0.0184)
R-squared	0.5776	0.6375	0.7218
F-stat	697.9	167.2	30.79
Controls that apply for all panels			
Geographical Controls	Yes	Yes	Yes
Location Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Province Fixed Effects		Yes	
District Fixed Effects			Yes
Number of Provinces		18	
Number of Districts			141
Observations	6,648	6,648	6,648

Pooled IV of Luminosity on Bombs

Combining both Instruments ▸ Individual Instruments and FS ▸ North and South ▸ Dropping districts one-by-one

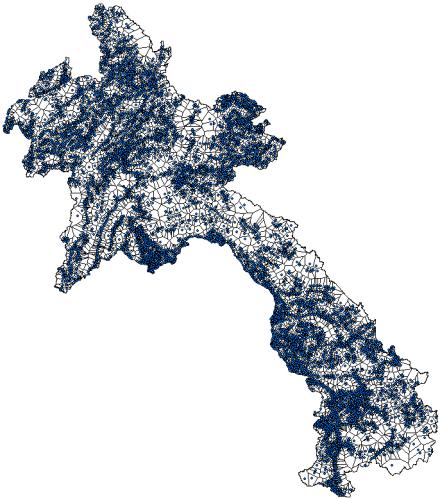
Dependent variable: Luminosity			
	(1)	(2)	(3)
Panel A: Instruments are distance to the Ho Chi Minh Trail and distance to the closest air base, **linear form**			
Model:	2SLS	2SLS	2SLS
Bombs	-0.1244***	-0.0968***	-0.1009***
	(0.0279)	(0.0230)	(0.0216)
Geographical Controls	Yes	Yes	Yes
Location Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Province Fixed Effects		Yes	
District Fixed Effects			Yes
Number of Provinces		18	
Number of Districts			141
Observations	6,648	6,648	6,648

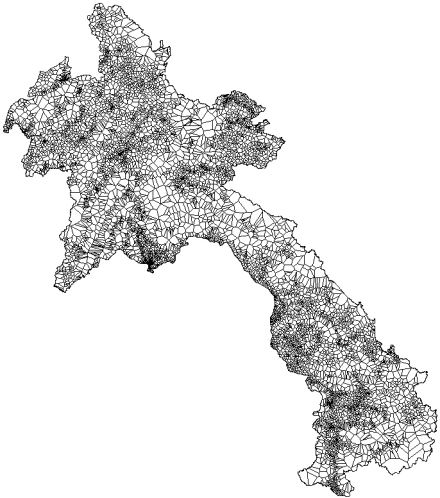
Dependent variable: Luminosity			
	(1)	(2)	(3)
Panel B: Instruments are distance to the Ho Chi Minh Trail and distance to the closest air base, linear plus **quadratic terms**			
Model:	2SLS	2SLS	2SLS
Bombs	-0.1301***	-0.1107***	-0.0915***
	(0.0291)	(0.0258)	(0.0199)
Geographical Controls	Yes	Yes	Yes
Location Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Province Fixed Effects		Yes	
District Fixed Effects			Yes
Number of Provinces		18	
Number of Districts			141
Observations	6,648	6,648	6,648

Notes: Observations are at the grid cell × year level. Variable Bombs is standardized. Robust standard errors in parentheses cluster at the grid cell level. *** p<0.01, ** p<0.05, * p<0.1

Census Data

Thiessen Polygons – Village Level Boundaries

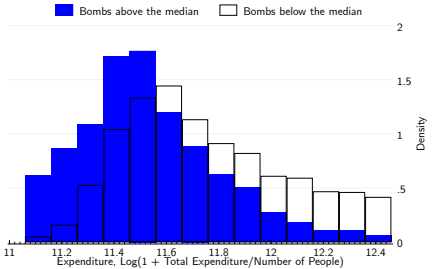




Beyond Luminosity: Is it just less nightlights?

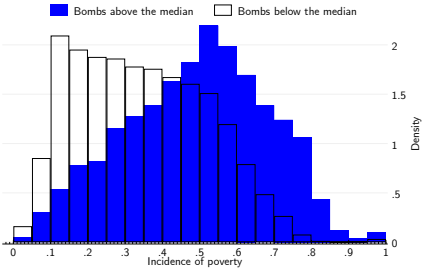
No, also lower expenditures and poverty rates at the **village** *level (Population Census)*

Expenditure



	(1)	(2)	(3)
Bombs	-0.1075***	-0.0395***	-0.0296**
	(0.0033)	(0.0039)	(0.0114)
Province FE			✓
Full Controls		✓	✓
Observations	10,522	10,280	10,280
R-squared	0.0921	0.2420	0.1585

Poverty Incidence



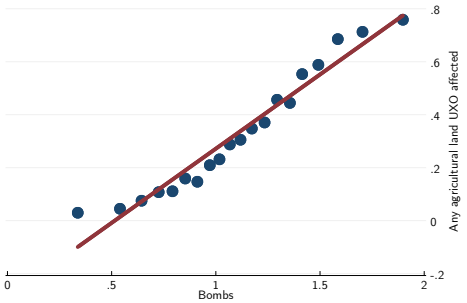
	(1)	(2)	(3)
Bombs	0.0713***	0.0277***	0.0195*
	(0.0019)	(0.0021)	(0.0093)
Province FE			✓
Full Controls		✓	✓
Observations	10,522	10,280	10,280
R-squared	0.1340	0.3021	0.2586

Mechanisms of Transmission

The UXO problem

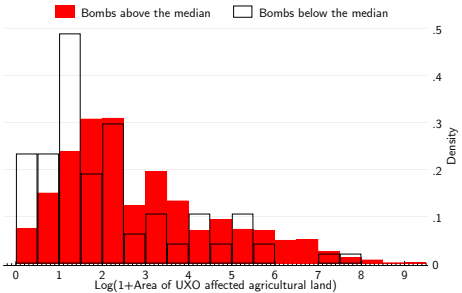
Bombs ⇒ UXO contamination of land (Agricultural Census)

Extensive



	(1)	(2)	(3)
Bombs	0.5699***	0.5455***	0.4130***
	(0.0166)	(0.0166)	(0.0901)
Province FE			Yes
Full Controls		Yes	Yes
Observations	8,559	8,413	8,413
R-squared	0.2730	0.2760	0.1461

Intensive

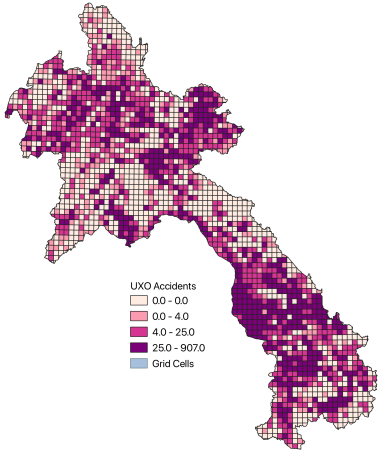


	(1)	(2)	(3)
Bombs	0.1896***	0.1829***	0.1392***
	(0.0041)	(0.0043)	(0.0254)
Province FE			Yes
Full Controls		Yes	Yes
Observations	8,643	8,497	8,497
R-squared	0.2164	0.2220	0.1140

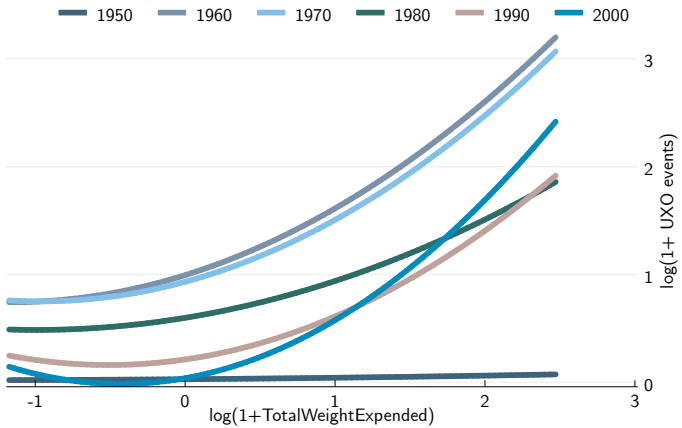
Main Mechanism of Transmission

UXO contamination ⇒ UXO accidents (Geolocated **daily** *panel data 1950-2011)*

Panel A: UXO Accidents



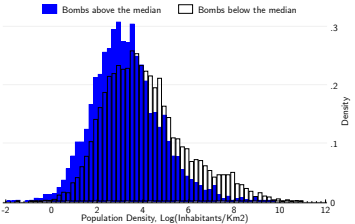
Panel B: Bombs and UXO accidents (Fits by decade)



Mechanisms of Transmission

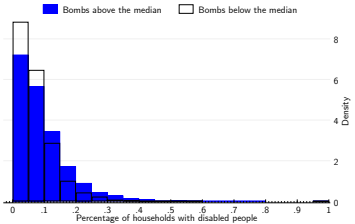
Urbanization, Health and Education

Population density



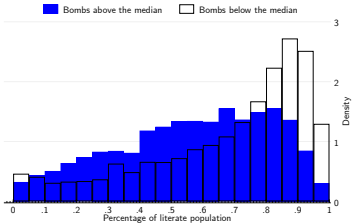
	(1)	(2)	(3)
Bombs	-0.3157***	-0.1418***	-0.1770***
	(0.0163)	(0.0178)	(0.0504)
Province FE			Yes
Controls		Yes	Yes
Observations	10,522	10,280	10,280
R-squared	0.0335	0.2702	0.1918

Disability



	(1)	(2)	(3)
Bombs	0.0113***	0.0084***	0.0019
	(0.0008)	(0.0009)	(0.0018)
Province FE			Yes
Controls		Yes	Yes
Observations	10,522	10,280	10,280
R-squared	0.0242	0.0825	0.0256

Literacy



	(1)	(2)	(3)
Bombs	-0.0574***	-0.0266***	-0.0276**
	(0.0026)	(0.0029)	(0.0130)
Province FE			Yes
Controls		Yes	Yes
Observations	10,522	10,280	10,280
R-squared	0.0499	0.2164	0.2448

Individual Level Data and DiD specification

Human Capital Accumulation, Labour Market Outcomes and Structural Change

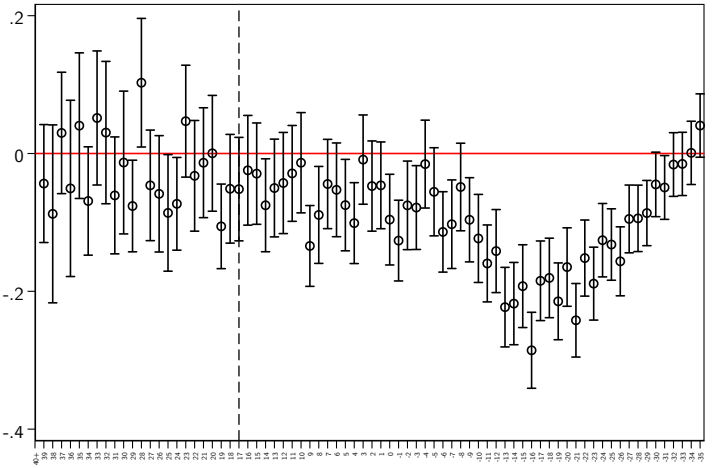
- Micro-data from the 2005 Census, 10% sample $\approx 561,000$ observations
- Individual level outcomes for educational attainment and labour market outcomes

$$E_{i,k} = \lambda_k + \delta_{p(i)} + \sum_k \gamma_k \left(\log(\textit{Bombs 1964-1973})_{p(i)} \times d_{i,p(i),k} \right) + \mathbf{X_i}'\beta + \epsilon_{i,p(i),k} \qquad (4)$$

- i indexes individuals, p province (of birth), and k cohorts.
- λ_k, δ_p Cohort and province of birth fixed effects
- $d_{i,p,k}$, indicator variable $= 1$ if individual i was born in province p and belongs to cohort k
- $\mathbf{X_i}$, sex and migration migration

Mechanisms of Transmission: Human capital accumulation

Less years of schooling and ▸ *Less likely to be employed*

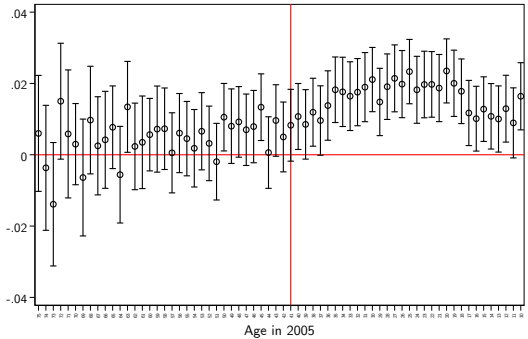


Age in 1964

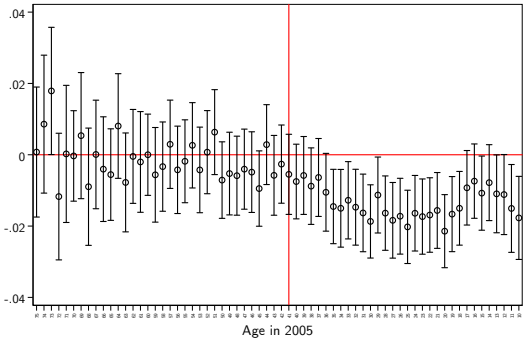
Mechanisms of Transmission: Sector of Employment

Structural Change: Main activity during the last 12 months

Agriculture



Services

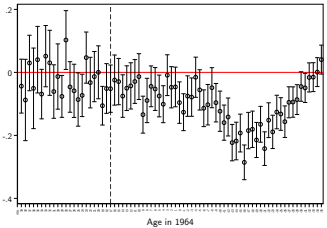


▸ Manufacturing

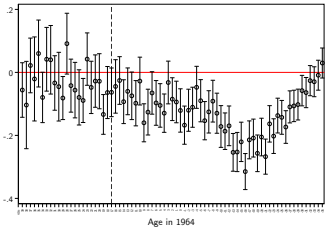
Human Capital effect concentrated in non-migrants

Triple interactions with long-term migration ▸ Less likely to migrate

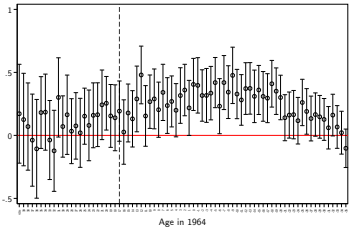
Pooled



γ_k: Non-migrants



η_k: Migrants



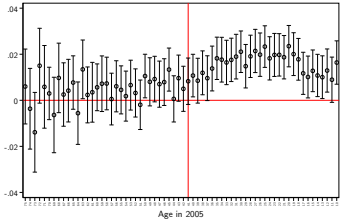
$$E_{ipk} = \delta_k + \lambda_p + \sum_k (B_p \times d_{ipk} \times M_i)\,\eta_k + \sum_k (B_p \times d_{ipk})\,\gamma_k + \sum_k (d_{ipk} \times M_i)\rho_k + \psi(B_p \times M_i) + \phi M_i + \epsilon_{ipk}$$

- Consistent with Porzio et al. (2020) and Lagakos (2020)

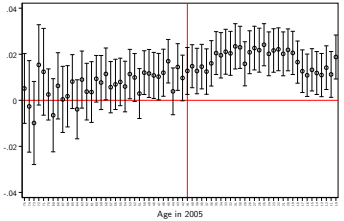
Working in Agriculture effect concentrated in non-migrants

Triple interaction

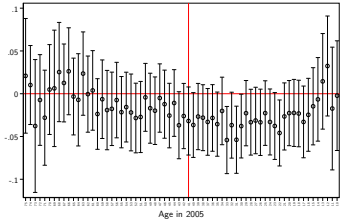
Pooled



γ_k



η_k

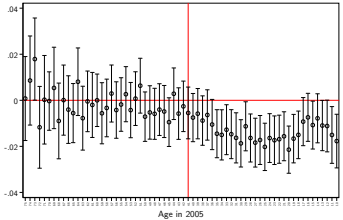


$$y_{ipk} = \delta_k + \lambda_p + \sum_k (B_p \times d_{ipk} \times M_i)\,\eta_k + \sum_k (B_p \times d_{ipk})\,\gamma_k + \sum_k (d_{ipk} \times M_i)\rho_k + \psi(B_p \times M_i) + \phi M_i + \epsilon_{ipk}$$

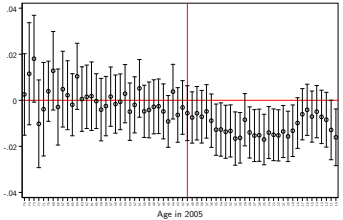
Working in Services effect concentrated in non-migrants

Triple interaction

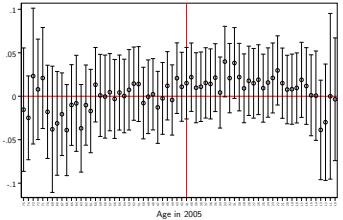
Pooled



γ_k



η_k



$$y_{ipk} = \delta_k + \lambda_p + \sum_k (B_p \times d_{ipk} \times M_i)\,\eta_k + \sum_k (B_p \times d_{ipk})\,\gamma_k + \sum_k (d_{ipk} \times M_i)\rho_k + \psi(B_p \times M_i) + \phi M_i + \epsilon_{ipk}$$

Discussion
External Validity

Our results are in line with recent papers in developing countries / rural settings

(Chiovelli, Michalopoulos and Papaioannou, 2017; Lin, 2020; Prem,Purroy, and Vargas, 2021)

They appear at odds with those in Vietnam and Japan (Davis and Weinstein 2002; Miguel and Roland, 2011)

1. Degree of disaggregation matters in conflict ▸ Aggregation

   (Montalvo and Reynal-Querol, 2017, Harari and Ferrara, 2018)

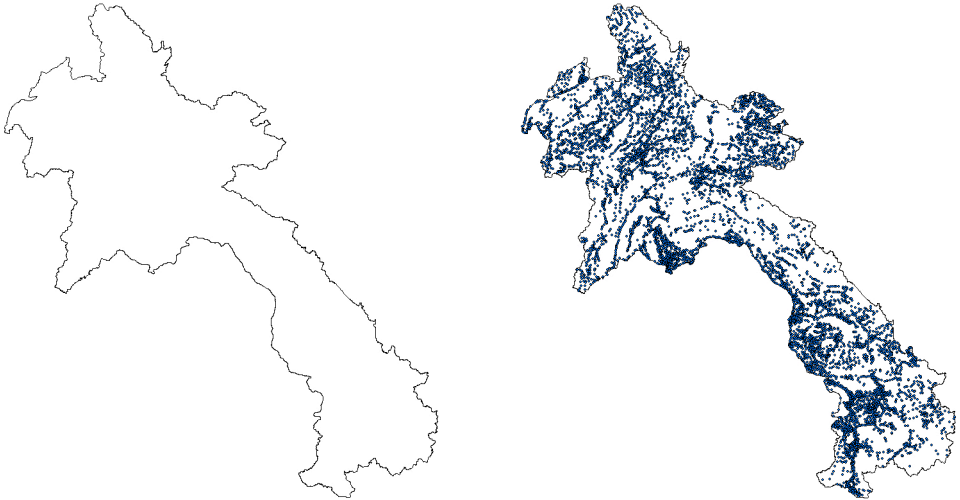
   - M&R $N = 584$ districts
   - We use $N = 6,648$ grid-cell-year observations, $N = 10,522$ Villages, $N = 500,000+$ individuals
   - Aggregating up does **not** change our conclusions
2. Outcomes considered
   - M&R use consumption, expenditure and poverty in 1999
   - We use nightlights in 1993, 2003 and 2013
   - Our conclusions do **not** change when using the same variables as M&R at the village level in 2005
3. Differences in post conflict investments
   - Differences in provision of public goods ▸ Schools ▸ Electricity ▸ Water
   - Differences in demining: In Laos only 1% of the mines have been cleared ($\leq$ one week of bombing)

Conclusions

- Using new and highly disaggregated data...
- We document the negative long-term economic impact of conflict
- Robust to IV estimation, suggesting a causal effect
- Not just for nightlights but also for poverty rates and expenditures
- Mechanisms of transmission UXO contamination its inherent impacts on
  - Settlement Patterns: ↓ Population Density and ↓ Migration
  - Human Capital Accumulation: ↓ Education and ↑ Disability
  - Labour Market Outcomes: ↓ Employment / slowering structural transformation
- Interaction effects with migration: concentrated on non-migrants

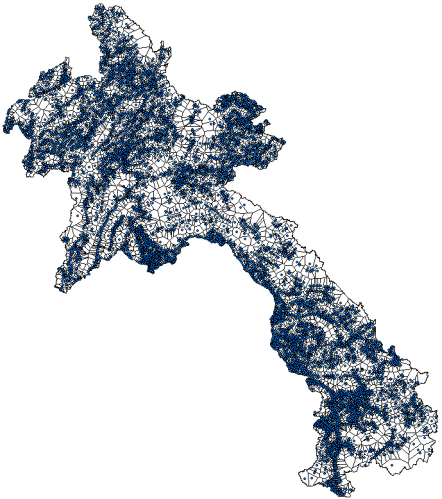
Census Data

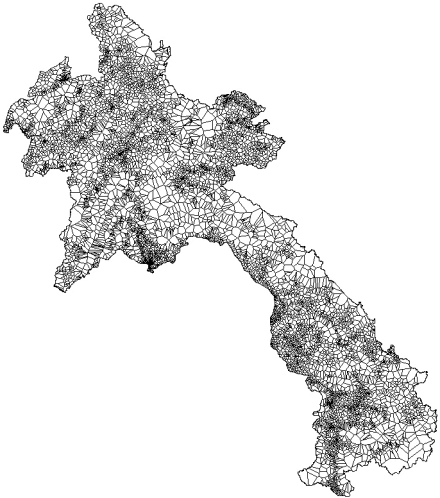
Thiessen Polygons – Village Level Boundaries



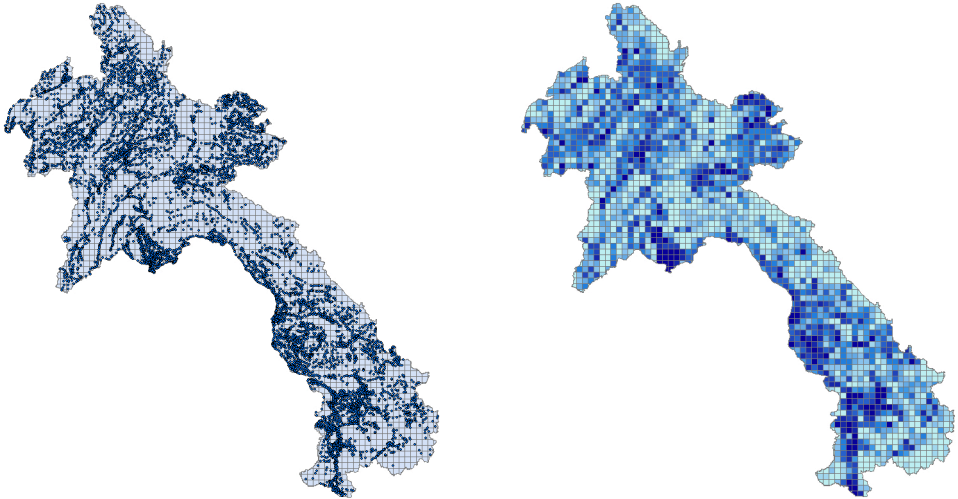
Census Data

Thiessen Polygons – Village Level Boundaries



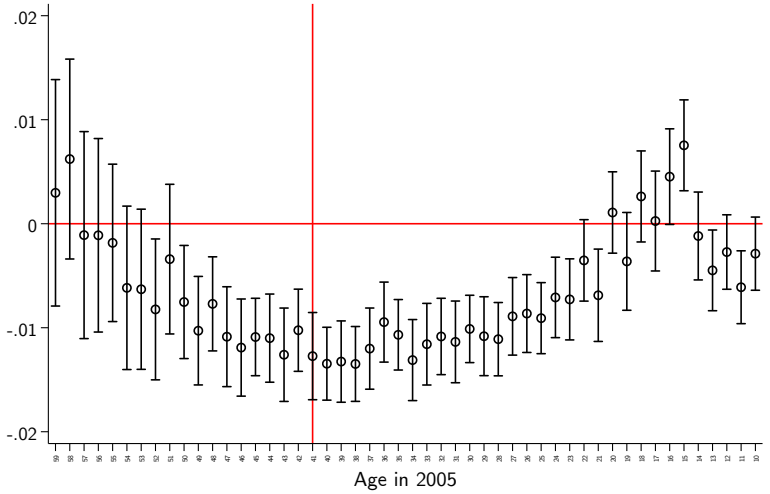


Settlement Patterns



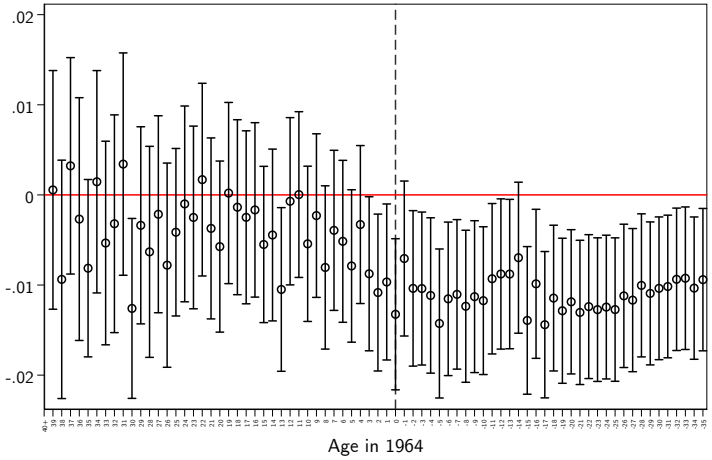
Employment

Likelihood of being employed Back



Mechanisms of Transmission: Long Term Migration

Places with more bombing exhibit lower rates of migration



Back

Public Goods

Primary Schools Back

Dependent variable:	Village has a primary school		
	(1)	(2)	(3)
Bombs	0.0055		0.0098
	(0.0146)		(0.0145)
UXO Contamination		-0.0113	-0.0134**
		(0.0066)	(0.0062)
R-squared	0.0139	0.0145	0.0147
Province fixed effects	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes
Location controls	Yes	Yes	Yes
Observations	10,382	10,382	10,382

Notes: Observations are at the village level. Independent variables are standardized. UXO Contamination is the logarithm of one plus the number of hectares contaminated by UXO normalized by the village area. Bombs is the log of one plus the total weight in pounds jettisoned within the village from 1965 to 1973 normalized by the village area. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Public Goods

Electricity Back

Dependent variable:	Village has electricity		
	(1)	(2)	(3)
Bombs	-0.0642***		-0.0621***
	(0.0154)		(0.0163)
UXO Contamination		-0.0192	-0.0063
		(0.0118)	(0.0127)
R-squared	0.1575	0.1476	0.1577
Province fixed effects	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes
Location controls	Yes	Yes	Yes
Observations	10,382	10,382	10,382

Notes: Observations are at the village level. Independent variables are standardized. UXO Contamination is the logarithm of one plus the number of hectares contaminated by UXO normalized by the village area. Bombs is the log of one plus the total weight in pounds jettisoned within the village from 1965 to 1973 normalized by the village area. Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Public Goods

Water Back

Dependent variable:	Village has water supply		
	(1)	(2)	(3)
Bombs	-0.0148***		-0.0137**
	(0.0044)		(0.0050)
UXO Contamination		-0.0064**	-0.0035
		(0.0028)	(0.0033)
R-squared	0.0333	0.0317	0.0335
Province fixed effects	Yes	Yes	Yes
Geographical controls	Yes	Yes	Yes
Location controls	Yes	Yes	Yes
Observations	10,382	10,382	10,382

Notes: Observations are at the village level. Independent variables are standardized. UXO Contamination is the logarithm of one plus the number of hectares contaminated by UXO normalized by the village area. Bombs is the log of one plus the total weight in pounds jettisoned within the village from 1965 to 1973 normalized by the village area. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Summary Statistics

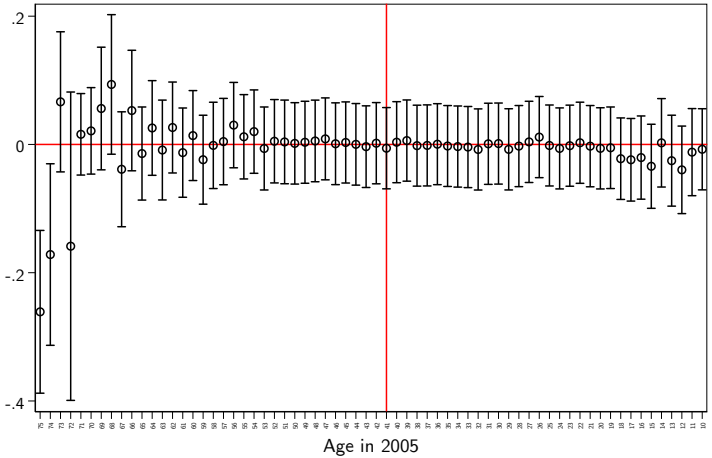
Grid cell level data Back

Variable	Mean	Std. Dev.	Min.	Max.	N
Bombs $\ln(1 + \text{Total Weight in pounds Jettisoned 1965-1973 per Km}^2)$	5.944	5.063	0	18.458	2216
Lights 1993 $\ln(1 + \text{Stable Lights 1993 per Km}^2)$	0.025	0.193	0	3.418	2216
Lights 2003 $\ln(1 + \text{Stable Lights 2003 per Km}^2)$	0.043	0.250	0	3.701	2216
Lights 2013 $\ln(1 + \text{Stable Lights 2013 per Km}^2)$	0.137	0.474	0	4.13	2216
Growth 1993-2003 Lights 2003 - Lights 1993	0.019	0.106	-0.336	1.444	2216
Growth 2003-2013 Lights 2013 - Lights 2003	0.094	0.302	-0.744	2.78	2216
Growth 1993-2013 Lights 2013 - Lights 1993	0.113	0.366	-0.336	3.341	2216

Decennial Logarithm Growth Rates. Observations are grid cells of 10km $\times$ 10km

Manufacturing

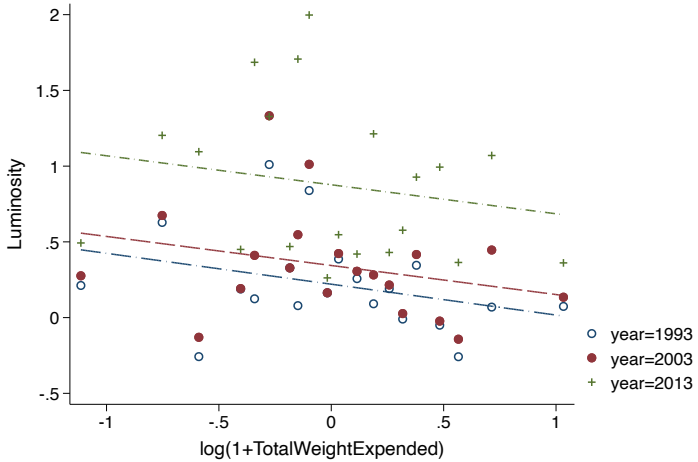
Likelihood of being employed in Manufacturing



Back

Aggregating at the district level

Back



Aggregating at the district level

Back

	(1)	(2)	(3)	(4)
	Lights	No Upper Tail Lights	No Lower Tail Lights	No Tails Lights
Bombs	-0.0828***	-0.0765***	-0.1348***	-0.1169***
	(0.0195)	(0.0143)	(0.0390)	(0.0282)
Year FE	✓	✓	✓	✓
Province FE	✓	✓	✓	✓
Observations	423	418	195	190
R-squared	0.4541	0.3601	0.4659	0.3893
Dep Var Mean	0.0805	0.0583	0.175	0.128

Note: Observations are at the District X Year level

Dropping outliers

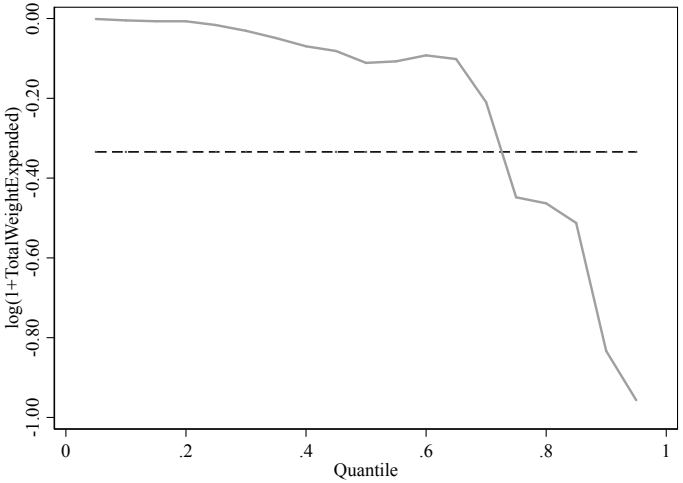
Back

	(1)	(2)	(3)	(4)
	P.FE Lights	No Upper Tail Lights	No Lower Tail Lights	No Tails Lights
Bombs	-0.0366***	-0.0056***	-0.2612***	-0.0497***
	(0.0039)	(0.0010)	(0.0403)	(0.0109)
Year FE	✓	✓	✓	✓
Province FE	✓	✓	✓	✓
Observations	6,648	6,581	550	483
R-squared	0.1192	0.0862	0.2017	0.1507
Dep Var Mean	0.0306	0.00992	0.370	0.135

Note: Observations are at the Grid X Year level

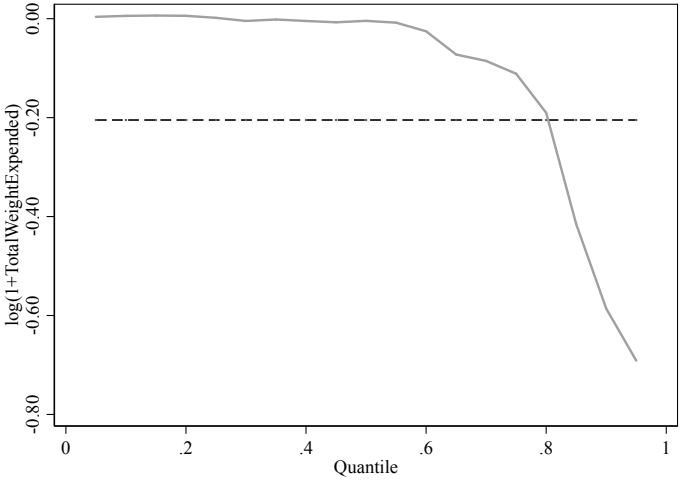
Quantile Regression 1993

OLS estimate vs Quantile Estimates Back



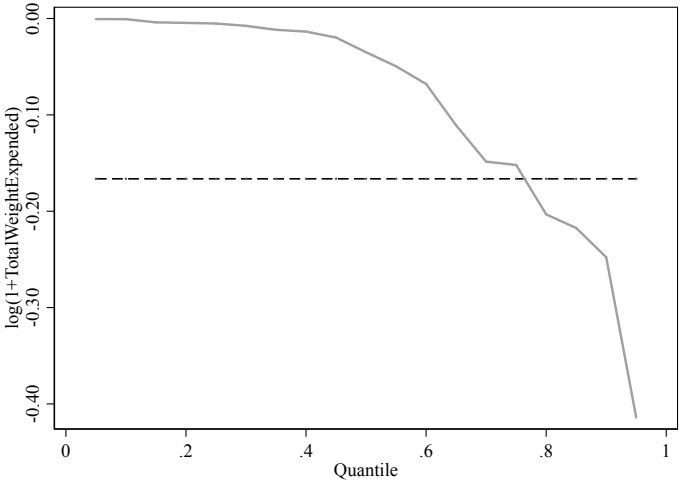
Quantile Regression 2003

OLS estimate vs Quantile Estimates Back



Quantile Regression 2013

OLS estimate vs Quantile Estimates Back



Conely Standard Errors

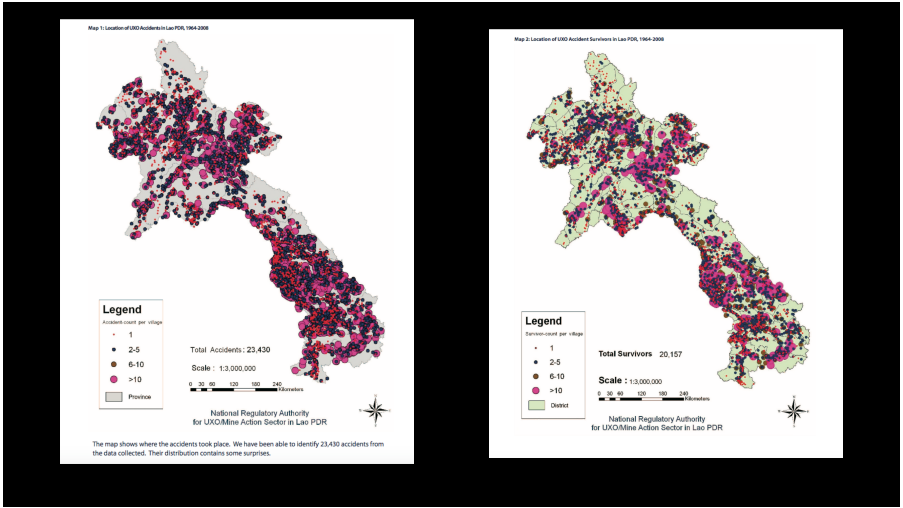
Back

Dependent Variable	Luminosity						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Threshold of influence	Cluster	$\leq$ 100 Km	$\leq$ 200 Km	$\leq$ 300 Km	$\leq$ 500 Km	$\leq$ 1000 Km	$\leq$ 1500 Km
Bombs	-0.0217**	-0.0217***	-0.0217**	-0.0217**	-0.0217**	-0.0217***	-0.0217***
	(0.0095)	(0.0078)	(0.0088)	(0.0094)	(0.0086)	(0.0063)	(0.0056)
Geographical Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Location Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Districts Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Districts	141	141	141	141	141	141	141
Observations	6,648	6,648	6,648	6,648	6,648	6,648	6,648
R-squared	0.3126	0.3126	0.3126	0.3126	0.3126	0.3126	0.3126

Notes: Observations are at the grid cell $\times$ year level. Variable Bombs is standardized. Conley standard errors in parentheses, using as the threshold reported in each column. Column 1 report cluster standard errors at the district level for reference. *** p<0.01, ** p<0.05, * p<0.1

UXO

Incidence and survival rates



Back

UXO

Example of UXO

Back

UXO

...and Agriculture

Back

Robustness

Back

UXO accidents per capita

	(1)	(2)	(3)
	Lights 1993	Lights 2003	Lights 2013
Bombs	-0.0118**	-0.0171**	-0.0325***
	(0.0058)	(0.0079)	(0.0112)
UXO accidents per capita	-0.0130	-0.0171*	-0.0145
	(0.0079)	(0.0098)	(0.0123)
Bombs × UXO accidents per capita	0.0072	0.0092	0.0128
	(0.0049)	(0.0061)	(0.0086)
Geographical Controls	✓	✓	✓
Location Controls	✓	✓	✓
District Fixed Effects	✓	✓	✓
Observations	2,193	2,193	2,193
R-squared	0.0139	0.0187	0.0232
Number of Districts	140	140	140

Robustness

Back

Spillover Effects

	(1)	(2)	(3)	(4)	(5)	(6)
	Lights 1993		Lights 2003		Lights 2013	
	Coeff	Spillover	Coeff	Spillover	Coeff	Spillover
Bombs	-0.03191***	0.01136	-0.04192***	0.01576	-0.07823***	0.05627***
	(0.00684)	(0.00934)	(0.00820)	(0.01120)	(0.01263)	(0.01725)
Geographical Controls		✓		✓		✓
Location Controls		✓		✓		✓
Observations		2,216		2,216		2,216
Moran's test p-value		0.841		0.00121		0.00111
Direct		-0.0319***		-0.0419***		-0.0782 ***
		(0.00684)		(0.0103)		(0.0113)
Indirect		0.0105		0.0145**		0.0518***
		(0.00614)		(0.00736)		(0.0126)
Total		-0.0214***		-0.0274***		-0.0264**
		(0.00860)		(0.00820)		(0.0159)

*** p<0.01, ** p<0.05, * p<0.1

Robustness

Back

Roads as bad control in OLS

	(1)	(2)	(3)
	Lights 1993	Lights 2003	Lights 2013
Bombs	-0.0122**	-0.0172**	-0.0338***
	(0.0061)	(0.0081)	(0.0114)
Number of Roads	0.0056	0.0092	0.0226***
	(0.0046)	(0.0056)	(0.0080)
Length of Roads	-0.0022*	-0.0034**	-0.0050***
	(0.0011)	(0.0014)	(0.0019)
District Fixed Effects	Yes	Yes	Yes
Full Controls	Yes	Yes	Yes
Observations	2,216	2,216	2,216
R-squared	0.0138	0.0208	0.0268
Number of Districts	141	141	141

*** p<0.01, ** p<0.05, * p<0.1

Robustness

Back

Roads as bad control in IV, instrument: Distance to the Ho Chi Minh Trail

	(1)	(2)	(3)
	Lights 1993	Lights 2003	Lights 2013
Bombs	-0.0466**	-0.0711***	-0.1548***
	(0.0189)	(0.0251)	(0.0454)
Number of Roads	0.0066	0.0108*	0.0263***
	(0.0049)	(0.0058)	(0.0085)
Length of Roads	-0.0018*	-0.0028**	-0.0037**
	(0.0010)	(0.0013)	(0.0018)
District Fixed Effects	Yes	Yes	Yes
Full Controls	Yes	Yes	Yes
Observations	2,213	2,213	2,213
Number of Districts	138	138	138

*** p<0.01, ** p<0.05, * p<0.1

Infrastructure

Back

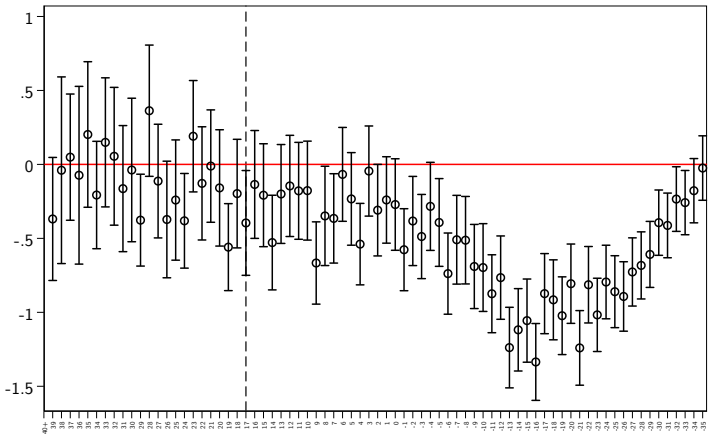
Presence and extent of roads today

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of Roads			Length of Roads		
Bombs		0.4447***	0.2947***		2.6265***	1.6992***
		(0.0698)	(0.0634)		(0.4041)	(0.3688)
UXO Accidents	0.5776***		0.5299***	3.5267***		3.2719***
	(0.0362)		(0.0365)	(0.1982)		(0.1984)
Bombs × UXO Accidents			0.0256			0.0660
			(0.0298)			(0.1508)
Geographical Controls	✓	✓	✓	✓	✓	✓
Location Controls	✓	✓	✓	✓	✓	✓
District Fixed Effects	✓	✓	✓	✓	✓	✓
Observations	2,216	2,216	2,216	2,216	2,216	2,216
R-squared	0.1663	0.0876	0.1802	0.2062	0.1090	0.2210
Number of Districts	141	141	141	141	141	141

Mechanisms of Transmission

Human capital accumulation: Years of schooling

Back



Long term migration

Back

People tend to live in the same province they were born

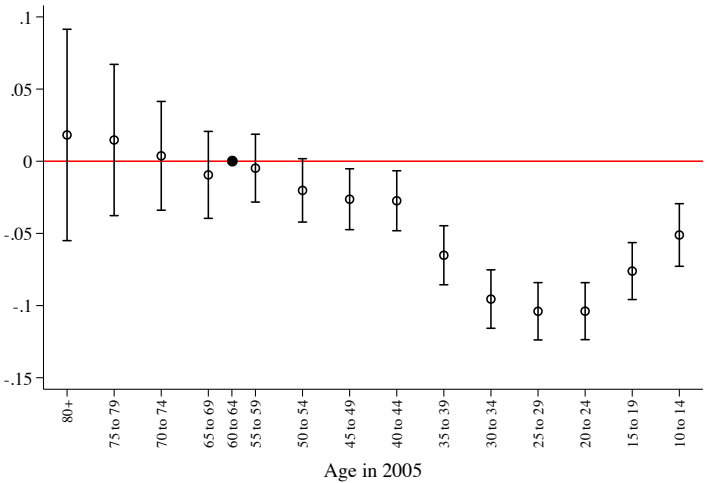
- Exposure to Bombing in the census is based on the province where the individual was born.
- In the presence of high rates of migration our approach may be misleading.
- However, less than the 12% of the population resides in a different province than the one where they were born
- Furthermore, places with more bombs exhibit, if something, lower rates of migration
- We control for a dummy that indicates if the individual migrated in all the specifications that use micro data.

Migration	Freq	Percent
0	496,431	88.57
1	64,049	11.43

Mechanisms of Transmission

Structural Change: Services were the main activity during the last 12 months

Back



Robustness

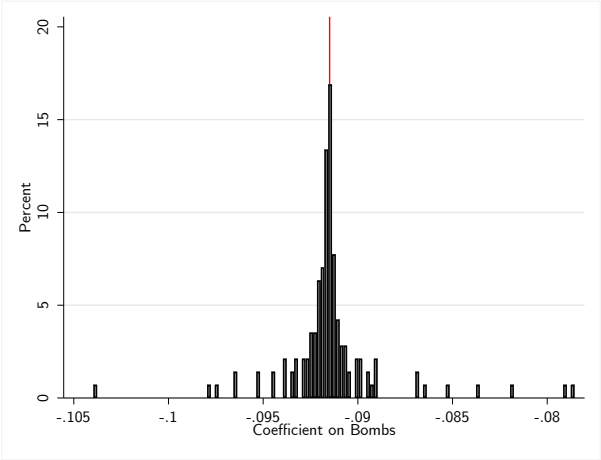
Pooled OLS: Rural vs. Urban Back

	(1)	(2)	(3)
		Lights	
	All	Urban	Rural
Bombs	-0.0277**	0.0037	-0.0259**
	(0.0106)	(0.0030)	(0.0118)
District Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Full Controls	Yes	Yes	Yes
Observations	6,648	780	5,868
R-squared	0.0757	0.0399	0.0791
Number of Districts	138	45	138

*** p<0.01, ** p<0.05, * p<0.1

Distribution of Coefficients Dropping Individual Districts

Back



Notes: Distribution of the effect of Bombs on Lights when dropping one district at the time. The IV estimate of the pooled sample is represented by the red line.

Controlling for population density 1960

Back

	(1)	(2)	(3)	(4)	(5)
Dependent variable: Luminosity					
Bombs	-0.0226***	-0.0266***	-0.0202**	-0.0278***	-0.0218**
	(0.0030)	(0.0032)	(0.0093)	(0.0049)	(0.0099)
Population density 1960	0.3327***	0.3111***	0.3059***	0.2997***	0.2985***
	(0.0476)	(0.0500)	(0.0618)	(0.0492)	(0.0613)
Geographical Controls		Yes	Yes	Yes	Yes
Location Controls				Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Province fixed effects			Yes		Yes
Number of Provinces			18		18
Observations	6,648	6,648	6,648	6,648	6,648
R-squared	0.1037	0.1126	0.0968	0.1271	0.0989

Notes: Observations are at the grid cell × year level. Variable Bombs is standardized. Robust standard errors in parentheses, if province fixed effects are present standard errors clustered at that level. *** p<0.01, ** p<0.05, * p<0.1

IV Heterogeneous Results: North and South

Back

	(1)	(2)
Dependent variable: Luminosity		
Sample of grids:	North	South
Bombs	-0.0940***	-0.1074**
	(0.0261)	(0.0540)
Geographical Controls	Yes	Yes
Location Controls	Yes	Yes
District Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Observations	4,812	1,836

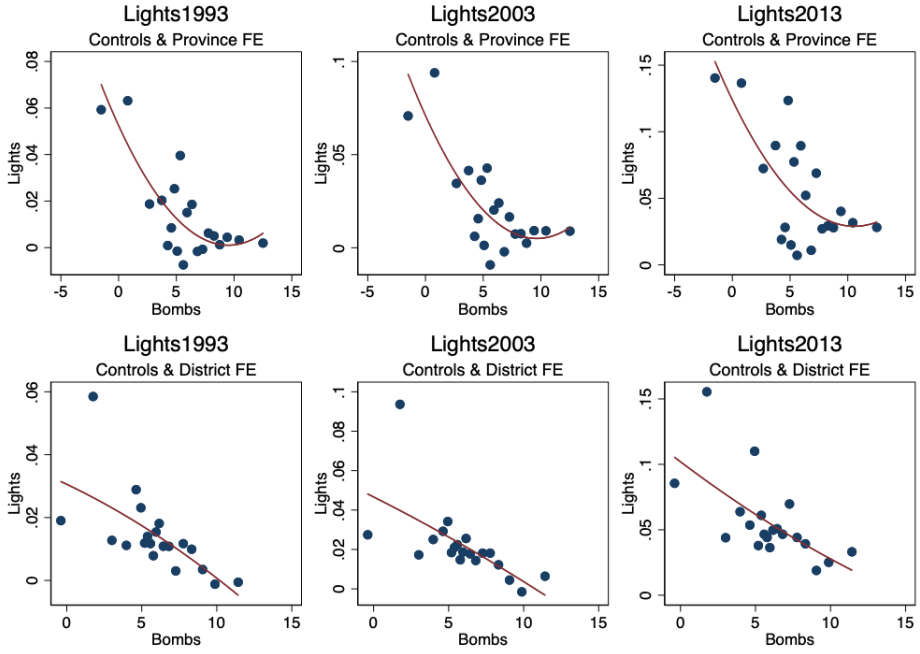
Notes: Observations are at the grid cell × year level. Column 1 includes all the grids that are above the 17th parallel. Column 2 includes all the grids that are below the 17th parallel. Variable Bombs is standardized. Robust standard errors in parentheses clustered at the district level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Transformation of the dependent variable

Back

	(1)	(2)	(3)
Panel A: Dependent Variable		$\log(1 + Lights/Km2)$	
Bombs	-0.0363***	-0.0319**	-0.0248**
	(0.0059)	(0.0141)	(0.0096)
Panel B: Dependent Variable		$\log\left(Lights/Km2 + \sqrt{(Lights/Km2)^2 + 1}\right)$	
Bombs	-0.0443***	-0.0388**	-0.0307**
	(0.0071)	(0.0171)	(0.0118)
Panel C: Dependent Variable		$\log(0.0001 + Lights/Km2)$	
Bombs	-0.2318***	-0.2049*	-0.1300*
	(0.0362)	(0.1034)	(0.0736)
Geographical Controls	Yes	Yes	Yes
Location Controls	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Province Fixed Effects		Yes	
Districts Fixed Effects			Yes
Observations	6,648	6,648	6,648

Notes: Observations are at the grid cell × year level. Variable Bombs is standardized. Robust standard errors in parentheses, if province or district fixed effects are present standard errors clustered at that level. *** p<0.01, ** p<0.05, * p<0.1


Lights1993
Controls & Province FE
Lights
Bombs
Lights2003
Controls & Province FE
Lights
Bombs
Lights2013
Controls & Province FE
Lights
Bombs
Lights1993
Controls & District FE
Lights
Bombs
Lights2003
Controls & District FE
Lights
Bombs
Lights2013
Controls & District FE
Lights
Bombs

How much does it mean in terms of GDP?

Using estimates by Henderson Storeygard and Weil (2012)

TABLE 2—BASELINE RESULTS FOR THE WORLD: 1992–2008; GROWTH IN REAL GDP (*constant LCU*)

	ln(GDP) (1)	ln(GDP) (2)	ln(GDP) (3)	ln(GDP) (4)	ln(GDP) (5)	ln(GDP) (6)	ln(GDP) (7)	ln(GDP) (8)
ln(lights/area)	0.277***	0.2618***	0.2662***	0.286***	0.282***		0.166***	0.284***
	[0.031]	[0.0344]	[0.0314]	[0.034]	[0.046]		[0.051]	[0.030]
ln(lights/area) sq.		−0.0058						
		[0.0060]						
ln(count top-coded + 1)			0.0115*					
			[0.0059]					
ln(unlit)			−0.0124					
			[0.0122]					
Spatial Gini				0.165				
				[0.194]				
ln(KWH)						0.283***	0.201***	
						[0.047]	[0.041]	
Observations	3,015	3,015	3,015	3,015	1,853	1,853	1,853	3,015
Countries	188	188	188	188	128	128	128	188
(Within country) R^2	0.769	0.769	0.770	0.769	0.757	0.767	0.782	0.770

Notes: All specifications include country and year fixed effects. Column 8 excludes regions with gas flares. Robust standard errors, clustered by country, are in brackets.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

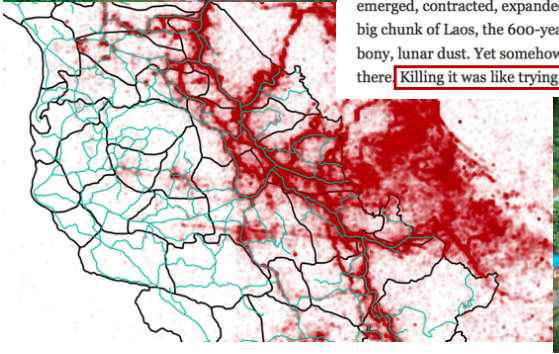
- ↑ one std in Bombs
- It is associated with a $\frac{-0.0231}{0.0683} \times 0.277 = -0.093$
- 9.3% fall in GDP per capita
- ◂ Back

The Ho Chi Minh Trail

The US did not know exactly where the location was Back

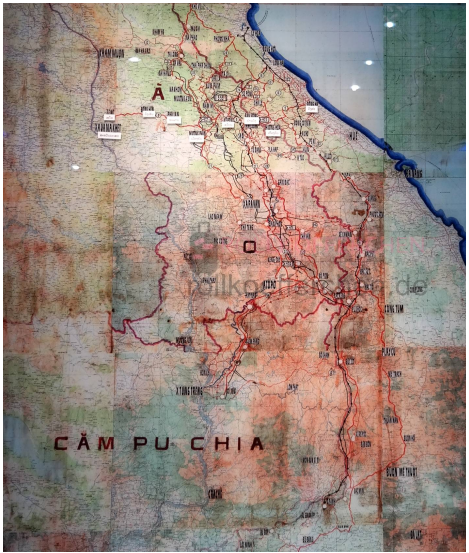
We wanted to blow it all up, the trucks and supplies and infrastructure, but what we could see was the road itself. So we attacked choke points, thinking we'd do the next best thing and block the way. But the next day, bypasses appeared. We rolled avalanches into the roadbed, and the trail somehow slithered around them. We made mud and soon found corduroy. We cratered fords that somehow filled up and widened.

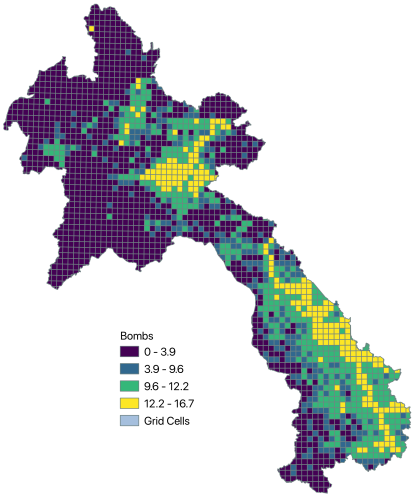
More a maze than a road, the trail disappeared, returned to view, dissolved, emerged, contracted, expanded, split, reunited, vanished, materialized. We blasted a big chunk of Laos, the 600-year-old monarchy, the Land of a Million Elephants, to bony, lunar dust. Yet somehow the Ho Chi Minh Trail, itself the enemy, was always there. Killing it was like trying to put socks on an octopus.



The Ho Chi Minh Trail

The US did not know exactly where the location was (Laotian Map vs Bombing)





On the left: Map from the Ban Dong War Museum. On the right: Bombs heat map.

US Air Bases outside Laos

Pre Existing US Air Bases used in the bombing (CIA Declassified Document)