

# Land Mines and Spatial Development

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# Special Thanks





# Land Mines. An International Problem

- ▶ Serious threat in more than 50 countries around the world
  - Extensive use during World War II (by national military forces)
  - Wide use during Cold War (e.g., Angola, Mozambique, Congo, Cambodia, Vietnam, etc)
  - Declining trend (but use in Iraq, Afghanistan, Colombia)
  - Recent use (e.g., Iraq, Syria, Ukraine, Yemen)
- ▶ 14 international agencies under UN Mine Action Program, operating in roughly 40-50 countries

(Halo Trust, Humanity & Inclusion, Norwegian's People Aid, etc.)
- ▶ 700 mln USD spent yearly from 2010-2014 (LandMine Monitor)
- ▶ “*Weapons of the poor*”: cost 1\$-3\$ (even anti-tank mines cost less than 10\$) and can be manufactured by militias

## Land Mine Clearance. Resources Spent

Figure: Landmine Monitor 2016.



## Land Mines. The Problem

- ▶ **“Land-mines** *are uniquely savage in the history of modern conventional warfare not only because of their appalling individual impact, but also their **long-term social and economic destruction**”*

UN General Assembly Resolution 48/157, 1996

- ▶ **UN motto:** *“Land mines keep poor people poor, decades after the conflict”*

**Yet, very little academic work assessing the impact of demining activities on regional development.**













# Costs



# Costs

- ▶ Health: Injuries; Disabled.
- ▶ Psychological Costs
- ▶ Education
- ▶ Environment (degradation, animals)
- ▶ **Economic Activity** (access land, trade, commute)
  - **Local effects [Policy Relevance]**
  - **Spatial (general equilibrium) effects [Spillovers]**
  - **Policy Simulation [Cost of Not Coordination]**

# Our Paper

## We focus on Mozambique from 1992 to 2015

- ▶ Mozambique is the only heavily mined country to be fully cleared (October 2015)
- ▶ Wide-use of land mines by all parties during war of independence (1964-1974) and subsequent civil war (1977-1992)
- ▶ Around 296,442 of land mines and UXOs [very conservative estimate]
  - Close to 7,423 locations of minefields and UXOs [conservative estimate]
  - Heterogeneity on location of land mines and objective
- ▶ Land mine clearance operations were not much coordinated, took place under a chaos, and have many quasi-random elements

# Approach and Results

## ► Local level

- Small to moderate positive effect of demining on local development
- Effect stronger for densely populated areas and localities connected through transportation network

## ► Aggregate level - “Market Access” Approach

(e.g., Donaldson and Hornbeck, 2016; Donaldson, 2016; Arkolakis, Costinot, and Rodriguez-Clare, 2012; Alder, 2015; based on Eaton and Khortum, 2002)

- Large positive effect on aggregate development
- Sizable externalities via infrastructure

## ► Policy Counterfactual Simulation

- Large costs associated to lack of centralization and prioritization

# Structure

- ▶ Related Literature
- ▶ Historical Background (civil war and land mine usage)
- ▶ Background Demining Process
- ▶ Data
- ▶ Preliminary Evidence Spatial Distribution of Land Mines
- ▶ Local Effect Estimates
- ▶ General Equilibrium Estimates
- ▶ Policy Counterfactual Simulation

## Related Literature

- ▶ **Foreign Aid and Allocation Scarce Resources.**

No estimates in the literature on the impact of land mine clearance.

- ▶ **Civil Conflict and Development** (Heterogeneity in recovery)  
(e.g. Blattman and Miguel (2010); Miguel and Roland (2011); Lin (2015);  
Blattman and Annan (2016))

- ▶ **Aggregate Effects of Infrastructure**  
(e.g. Donaldson and Hornbeck (2016); Arkolakis, Costinot, and Rodriguez-Clare  
(2012); Alder (2015); Donaldson (2016), Perez-Cervantes (2014))

- ▶ **Infrastructure on African Urbanization and Development**  
(e.g. Ayogu (2007); Huillery (2009); Chaves, Engerman, and Robinson (2014);  
Jedwab, Kerby, and Moradi (2016); Jedwab and Moradi (2016); Jedwab and  
Storeygard (2018))

- ▶ **African Political Economy**  
(e.g. Wantchekon and Garcia-Ponce (2014))

## War of Independence (1964 – 1974)

Rebel groups (mostly FRELIMO) backed by Tanzania and other African countries fight the Portuguese for independence

- ▶ Use of land mines by Portugal to protect key infrastructure (e.g., Cahora Bassa dam) and block Northern border with Tanzania
- ▶ Use of land mines by FRELIMO to delegitimize government and terrorize Portuguese troops
- ▶ Use of land mines during military operations (by both parties, as well as private agents)

## Civil War (1977 – 1992)

Rebels backed by Rhodesia (1977-1980) and subsequently by South African forces fight against the FRELIMO-controlled government.

- ▶ Very low number of battles between fighting parties; a war almost exclusively targeting civilians.  
(HRW Report 1992. Conspicuous Destruction)
- ▶ Use of land mines by all participants (degree disputed)
- ▶ RENAMO to terrorize civilian population and delegitimize government. Also as part of military operations
- ▶ FRELIMO to protect infrastructure (e.g., electricity pylons, power generators), "development" villages and military camps. Also to terrorize locals.
- ▶ South African and Rhodesian covered officers and RENAMO rebels to block borders with South Africa and Zimbabwe
- ▶ Others (militias, thugs, private firms) also used land mines.



## Mozambique at the End of the Civil War

- ▶ 100,000-150,000 fatalities in rebel and government raids
- ▶ 7,000-30,000 victims from land mines only
- ▶ 1-2 millions deaths from starvation and famine
- ▶ 2-3 millions people displaced in refugee camps or in the capital
- ▶ 1.5-2 millions people in refugee camps in neighbouring countries
- ▶ 200,000 children left orphaned
- ▶ tens of thousands of incidents of tortures, rapes, and mutilations, mostly targeting children and women
- ▶ Mozambique appears the third poorest country out of 167 in 1992 (Penn World Table); Real GDP pc around 390 USD
- ▶ Destroyed infrastructure

## In a Nutshell..

- ▶ *“Most of the country’s economic infrastructure is destroyed or inoperable, and much of the population is dependent on a massive international aid program. Hundreds of thousands of people are refugees in neighbouring countries or displaced inside Mozambique. Many rural areas have been reduced to a stone age condition, without trade or modern manufactured goods, education or health services, and suffering from constant insecurity. Mozambique needs to be built almost from scratch.”*

Human Rights Watch Country Report 1992.

- ▶ **Legacy of land mines**

## Anti-Personnel Land Mines



## Anti-Tank Land Mines



## Anti-Vehicle Land Mines



## Unexploded Ordnances (UXOs)



## Main Reasons for Land Mine Use ▶ Example

- ▶ Block borders
- ▶ Block access to roads and railways
- ▶ Protect key infrastructure (dams, electricity pylons, power stations, ports)
- ▶ Terrorize civilians
- ▶ Military purposes
- ▶ Farms: force people out of their villages (to rebel-controlled regions), deny an economic base to the government, scorched earth policy
- ▶ Protection villages

## Demining





## Removing of Land Mines (1992 – 2015)

- ▶ Phase 1 (1992 – 1999). Initial Phase
  - (1992 – 1994). Initiation
  - (1995 – 1999). Consolidation
- ▶ Phase 2 (2000 – 2006). Limited Coordination
- ▶ Phase 3 (2007 – 2015). Final Phase

## Phase 1. Starting phase (1992 – 1994)

- ▶ Peace Agreement was signed in October 1992 in Rome
- ▶ UN ONUMOZ mission tried to coordinate mine clearing effort
  - ONUMOZ was not prepared and coordination was weak
  - HALO Trust impact survey [SHAMAN] (981 SHA areas)
  - Some clearing took place: e.g. RONCO consultancy as a contract for USAID

## Phase 1. Consolidation (1995 – 1999)

- ▶ Starts with democratic transition in October 27<sup>th</sup>-29<sup>th</sup> 1994
- ▶ No centralization, no strategic planing, no prioritization, and no coordination.
- ▶ Demining operations emerged across three geographical areas:
  - HALO Trust (UK) in the 4 Northern Provinces (north of Zambezi River)
  - Norwegian's People Aid (NPA) in Central Provinces
  - Accelerated Demining Program (ADP) in the South.  
Many private commercial firms (South Africa, Zimbabwe, and Mozambique). Limited success; allegations of corruption

## Phase 2. Limited Coordination (2000 – 2006)

- ▶ National Institute of Demining (IND) created in 1999
- ▶ Massive floods in 2000 and 2001.
- ▶ Landmine Impact Survey 2001 by Canadian CIDC  
[heavily criticized, best effort given local conditions]
  - 123 of 128 Admin-2 units affected
  - 1.5 millions people lived in 791 mine-affected communities
  - Survey was not perfect but it provided input for the 5-year demining plan by IND

## Phase 3. Completion (2007 – 2015)

- ▶ IND commission HALO Trust surveys in the North (2007) and Centre-South (2008) regions
- ▶ North declared mine-free in 2007
- ▶ From 2008, clearing process of the remaining threats (suspected hazardous areas) in South.
- ▶ Mozambique declared **mine-free** in October 2015.

## Demining Operation Issues

- ▶ Absence of maps depicting the initial distribution of land mines from both FRELIMO and RENAMO.
- ▶ The process of clearing is very slow
- ▶ Demining technologies: metal-detector vs animal
- ▶ Conditions in the end of the wars
- ▶ Lack of coordination and prioritization

## Data Overview. 1,187 Admin 4 Localities

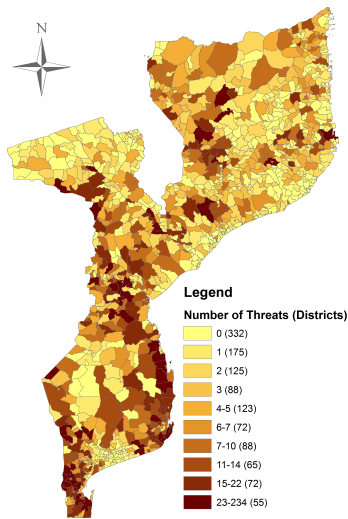
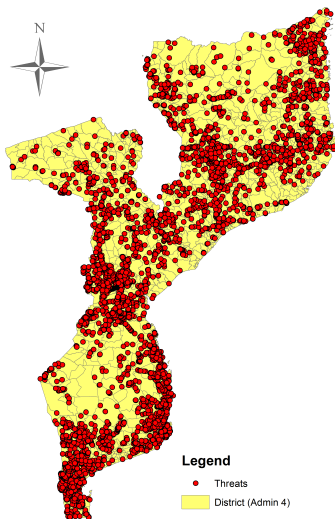
- ▶ Land Mine and UXO Removals
- ▶ Land Mine Level-1 Surveys (1994, 2001, 2007-8)
- ▶ Transportation (Roads and Railroads) (1973, 1999, 2004, 2011)
- ▶ Population Data (1980, 1997, 2007)
- ▶ Civil War [incomplete; ongoing research]
- ▶ Commercial Villages during Colonization
- ▶ Development (Luminosity)
- ▶ Other (DHS, Afrobarometer, Agriculture Census and Surveys)

## Land Mines Clearance Data (7,423 GPS locations)

- ▶ National Institute of Demining Dataset. [▶ GIS data](#)
  - Cross-Validation using original reports from individual operators (APOPO, HALO, HI, NPA, Afrovida, MGM, ADP)
    - [▶ GSG Report](#)
    - [▶ ADP Report](#)
    - [▶ NPA Report](#)
- ▶ HALO Trust (1994-2007 North; 2007-2015 Centre and South)
- ▶ Humanity & Inclusion (2001-2006)
- ▶ Norwegian People Aid (1993-1999; 2000-2004)
- ▶ UN Archives (1992-1994)
- ▶ Others commercial (Ronco 1994-1995 contract with USAID)
  - [▶ Ronco Map](#)
- ▶ (*Denel-Mechem, DYNASAFE/BACTEC*)



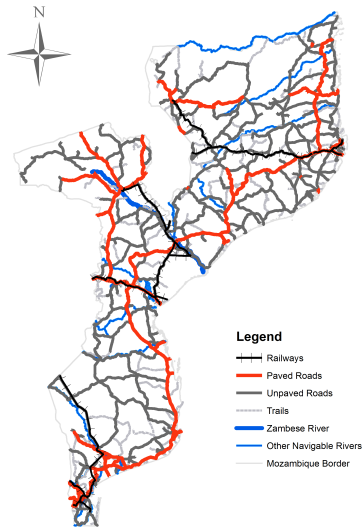
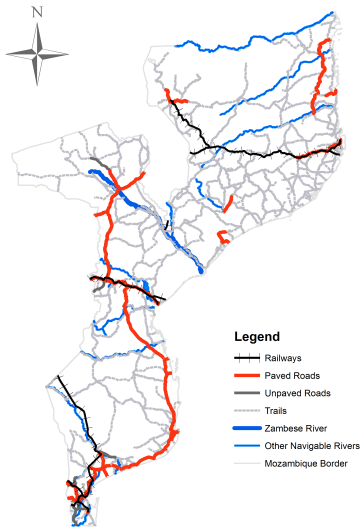
## Distribution of Land Mines across Localities



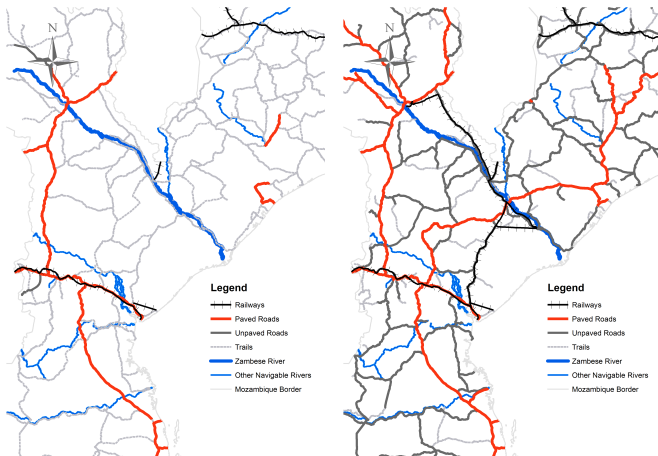
# Infrastructure

- ▶ Network 1973 [Colonial Map]
- ▶ Network 1999 [National Road Agency]
- ▶ Network 2003 [National Road Agency]
- ▶ Network 2011 [National Road Agency]

## Infrastructure in 1973 and 2011



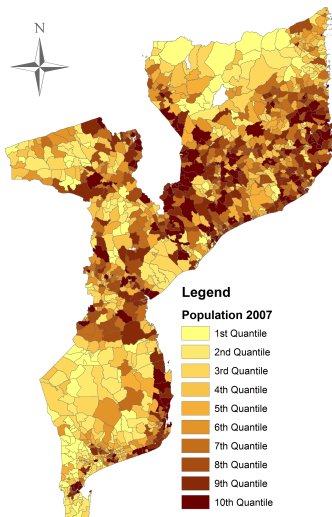
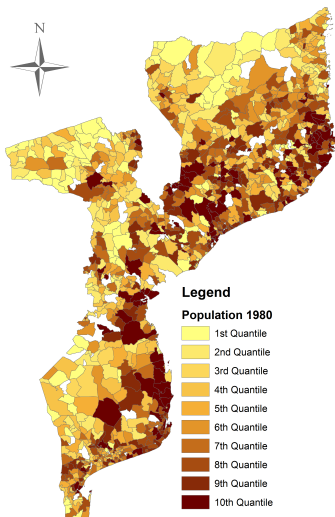
## Infrastructure in 1973 and 2013 - Central



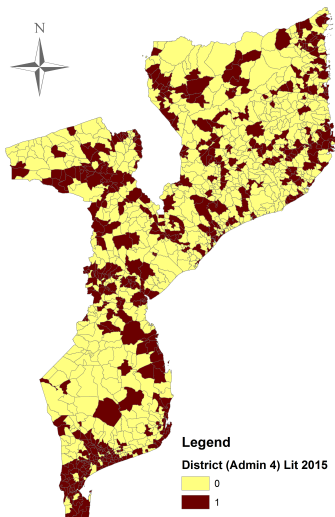
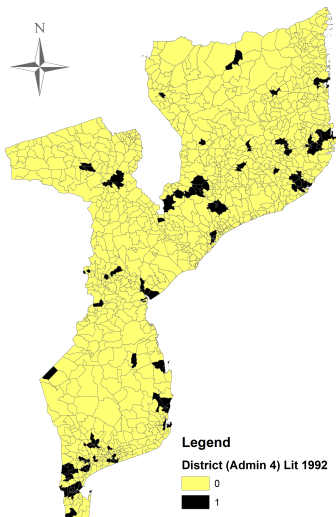
# Population

- ▶ Population 1980 [Census, National Institute of Statistics]
- ▶ Population 1997 [Census, National Institute of Statistics]
- ▶ Population 2007 [Census, National Institute of Statistics]

## Population in 1980 and 2007



## Luminosity in 1992 and 2015



## Preliminary Evidence

- ▶ Descriptive Statistics
- ▶ Correlates of Minefield and UXOs Spatial Distribution
- ▶ Correlates of Timing of Intervention



# Summary Statistics across Localidades (Admin-4 Level)

	Observations	Full Sample			
		Mean	Standard Deviation	Median	Min Max
Share of Contaminated					
localities in 1992	1187	0.720	0.449	0	1
Number of Threats in 1992	1187	6.253	14.164	0	238
Lit 1992	1187	0.098	0.297	0	1
Lit 1999	1187	0.177	0.382	0	1
Lit 2007	1187	0.227	0.419	0	1
Lit 2015	1187	0.422	0.494	0	1
Log Luminosity 1992	1187	-10.579	2.924	-11.5	2.51
Log Luminosity 1999	1187	-9.858	3.736	-11.5	2.83
Log Luminosity 2007	1187	-9.344	4.197	-11.5	3.11
Log Luminosity 2015	1187	-7.633	4.800	-11.5	3.15
Paved Road 1973 (dummy)	1187	0.171	0.377	0	1
Unpaved Road 1973 (dummy)	1187	0.021	0.144	0	1
Trail 1973 (dummy)	1187	0.660	0.474	0	1
Railway 1992 (dummy)	1187	0.130	0.336	0	1
Navigable River (dummy)	1187	0.228	0.420	0	1
Cantinas (dummy)	1187	0.584	0.493	0	1
Civil War (dummy)	1187	0.158	0.365	0	1
Log MA Light 1992	1187	-15.767	3.127	-22.3	-5.54
Log MA Light 1999	1187	-14.104	3.274	-20.9	-4.49
Log MA Light 2007	1187	-12.809	3.190	-20.9	-1.75
Log MA Light 2015	1187	-10.214	2.409	-16	-.765
Log Average Cost 1992	1187	8.903	0.220	8.54	9.68
Log Average Cost 1999	1187	8.729	0.239	8.34	9.59
Log Average Cost 2007	1187	8.367	0.392	7.66	9.51
Log Average Cost 2015	1187	7.911	0.175	7.52	8.52

## Number of Localities cleared per period

Descriptive Statistics	
Period	# of Locality Cleared
1992-1999	39
2000-2007	403
2008-2015	413

## Summary. Correlates of Minefields

- ▶ Distance to Zimbabwe (early stage of civil war) and Tanzania (independence war)
- ▶ Presence of roads (all types)
- ▶ Civil war
- ▶ Log population density
  
- ▶ No link with geographic features (elevation, ruggedness, malaria, etc)
- ▶ No link with lit/unlit in 1992
- ▶ No link with commercial villages/cities

## Summary of Timing of Removal (at the admin-4 level)

The average time to fully clear a locality is 7 years (median 6)

### ► First Intervention

- Distance to Zimbabwe (ADP) and Malawi (HALO)
- Civil War
- Population (weak)

### ► Last Intervention

- Distance to Zimbabwe and Tanzania (HALO)
- Population density
- No link transportation network or geography

### ► Distribution of Timing of Intervention

## Local Effects of Demining Activities

- ▶ **Average Effect** No Causality [Spillovers]
  - Panel Estimates (yearly frequency & three-period)
  - Differenced Specifications
- ▶ **Heterogeneity** of Local Average Effect [Important for Policy]
  - Province
  - Population density
  - Rural-Urban
  - Type of Minefield (roads, railroads, borders, farms, etc)
  - Spatial Spillover

## Empirical Specification

$$y_{i,t} = \beta Threat_{i,t} + \mu_i + \mu_{tp} + \eta_{i,t}$$

where

- $y_{i,t}$ : luminosity in district  $i$  in year  $t$ .
- $Threat_{i,t}$ : number or dummy of landmine and UXO threats removed in locality  $i$  in each period
- $\mu_i$ : locality fixed effects
- $\mu_{tp}$ : time x province fixed effects

► Demining by Province

## Land Mine Removal and Local Development

	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cleared Threats	0.329*** (0.073) [0.071]		0.037*** (0.007) [0.080]		0.469*** (0.098) [0.107]		0.058*** (0.011) [0.129]	
Cleared (dummy)		0.373*** (0.109) [0.037]		0.038*** (0.011) [0.038]		0.755*** (0.182) [0.082]		0.083*** (0.020) [0.088]
Number of Localities	1,187	1,187	1,187	1,187	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.168	.166	.124	.121	.241	.238	.224	.22
Observations	27,301	27,301	27,301	27,301	4,748	4,748	4,748	4,748

**Note:** Being lit increases years of schooling by 1.8 years in Mozambique (DHS).

[1.1 in rural and 2.9 in urban] ▶ Lights Education DHS

## Land Mine Removal and Local Development. Long-run Differences

	Log Luminosity				Lit			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta$ Cleared Threats	0.787*** (0.165) [0.189]		0.753*** (0.127) [0.181]		0.102*** (0.018) [0.223]		0.094*** (0.014) [0.205]	
Cleared (dummy)		0.968*** (0.328) [0.093]		0.777*** (0.281) [0.075]		0.123*** (0.035) [0.107]		0.089*** (0.030) [0.078]
Network Elements	No	No	Yes	Yes	No	No	Yes	Yes
Civil War (dummy)	No	No	Yes	Yes	No	No	Yes	Yes
Log - Population Density 1980	No	No	Yes	Yes	No	No	Yes	Yes
Log - Luminosity	No	No	Yes	Yes	No	No	No	No
Lit (dummy)	No	No	No	No	No	No	Yes	Yes
Log - Land	No	No	Yes	Yes	No	No	Yes	Yes
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.0686	.047	.433	.416	.0704	.0397	.352	.329
Observations	1,077	1,077	1,077	1,077	1,077	1,077	1,077	1,077



# Sensitivity Checks. Summary. Part 1

## Evolution of Luminosity ▸ Graph

## Alternative Outcomes

- ▶ Population as Outcome ▸ Population
- ▶ New Roads and Old Network Improvement ▸ Roads as Outcome

## Sensitivity Checks. Summary. Part 2

### Robustness Checks

- ▶ Controlling for New Roads and Improvements on Old Road Network  
▶ Roads as Controls
- ▶ Maputo province outlier (in opposite direction). ▶ Maputo
- ▶ Dropping Big Cities. ▶ Big Cities
- ▶ Effect larger in the North (reduce error-in-variables) ▶ North
- ▶ Stopping in 2013 (same luminosity data) ▶ 2013
- ▶ Dynamic Panel ▶ Dynamic
- ▶ Intermediate Period ▶ First and Last
- ▶ Only Contaminated Locality ▶ Affected
- ▶ Hazard Level evidence ▶ Hazard
- ▶ Admin-3 Level ▶ Admin 3
- ▶ CHAs vs SHAs ▶ CHAs and SHAs

## Heterogeneity on Locality Characteristics. Summary

- ▶ Connected vs Non-Connected to the Transportation Network.

▶ Transportation Network

- ▶ Population (population density). Strong.

▶ Population Density 1980

- Effect increases in population density;
- cutoff around median/mean (7,000-12,000);
- effect present when we drop top decile/quartile

## Heterogeneity on Landmines Characteristics.

We classify each landmine based on its proximity to the following non-mutually exclusive categories:

- ▶ Roads and Railways: 100m
- ▶ Border: 10000m
- ▶ Villages with Cantinas: 1000m
- ▶ Civil War Event: 1000m
- ▶ River: 100m
- ▶ Villages with Cantinas: 1000m
- ▶ Electricity Grid (Pylons): 100m
- ▶ Rural (residual category)

# Heterogeneity on Landmines Characteristics. Results

	Yearly		4 Years (1992, 1999, 2007, 2015)	
	Log Luminosity (1)	Lit (2)	Log Luminosity (3)	Lit (4)
Log Number of Accumulated Cleared Threats:				
- Road and Railway (100m)	0.323** (0.144) [0.036]	0.038** (0.016) [0.043]	0.381** (0.191) [0.045]	0.054** (0.022) [0.063]
- Border (10000m)	-0.559*** (0.194) [-0.040]	-0.048** (0.021) [-0.035]	-0.388 (0.267) [-0.029]	-0.027 (0.031) [-0.020]
- Cantinas (1000m)	0.284 (0.208) [0.023]	0.034* (0.020) [0.028]	0.580** (0.259) [0.050]	0.063** (0.027) [0.053]
- Civil War (1000m)	0.672** (0.260) [0.043]	0.043* (0.026) [0.027]	0.558 (0.357) [0.037]	0.030 (0.037) [0.019]
- River (100m)	0.068 (0.880) [0.001]	0.003 (0.104) [0.001]	0.090 (1.126) [0.002]	0.048 (0.136) [0.010]
- Village (1000m)	0.594*** (0.148) [0.063]	0.049*** (0.015) [0.052]	0.785*** (0.189) [0.087]	0.061*** (0.020) [0.067]
- Electricity Grid (100m)	0.585* (0.342) [0.025]	0.055 (0.036) [0.023]	0.350 (0.283) [0.017]	0.021 (0.030) [0.010]
- Residual	-0.068 (0.071) [-0.012]	0.001 (0.007) [0.002]	-0.078 (0.097) [-0.015]	0.008 (0.011) [0.015]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.184	.133	.26	.235
Observations	27,301	27,301	4,748	4,748

## Summary of Heterogeneity on Landmines Characteristics

- ▶ Positive and large effect of demining roads and railways
- ▶ Clearance of villages and cantinas has positive effect
- ▶ Negative effect of clearing borders
- ▶ No effect from demining electricity pylons (Placebo)

# General Equilibrium

- ▶ By affecting the transportation network, land mines increase market fragmentation and isolation
- ▶ Demining activities will *indirectly* affect districts that were not directly contaminated by landmines
- ▶ “Market Access” approach.  
(Donaldson and Hornbeck, 2016; Arkolakis, Costinot, and Rodriguez-Clare, 2012; Alder, 2016; Perez-Cervantes, 2014)

## Model Structure

- ▶ Ricardian spatial general equilibrium models of inter-district trade and spatial development (Eaton and Kortum, 2002)
  - Many regions
  - Differential technology
  - Efficiency varies across commodities and regions
  - Regions inputs are mobile within region
  - Geographic barriers to trade [Transportation Costs]

▶ Model



## Market Access

- ▶ Reduced-form relationship between aggregate change in welfare and improvement in district's Market Access

$$MA_o \approx \sum_{d=1}^D \tau_{o,d}^{-\theta} N_d(Y_d)$$

where

- $\tau_{o,d}$  reflects a district's cost of transportation via the available network to all the other districts, d.
- $\theta$  is the trade elasticity (inversely related to the comparative advantage of each district)
- $N_d$  and  $Y_d$  reflect total population and total output of all but the origin district.

# Computing $\tau$

## Need to build the transportation network

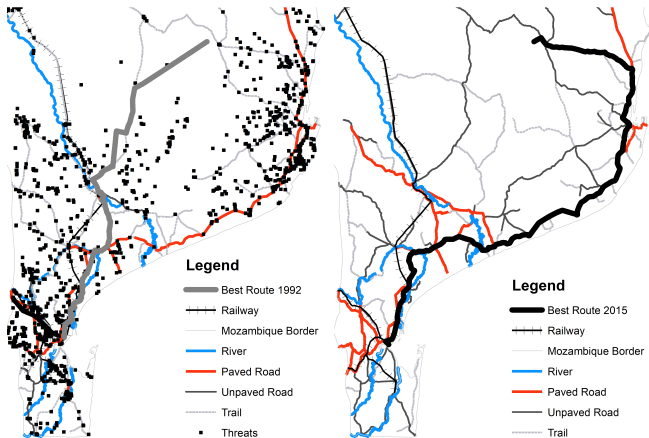
- Network components: Railways, Paved Roads, Unpaved Roads, Trails, and Rivers
- Connect each district (centroid) to transportation network
- Impose relative cost parameters for each mode of transportation

► Parametrization

Using Dijkstra's algorithm, we compute the lowest-cost route between every pair of districts centroids

- Optimal Routes in 1992
- Optimal Routes in 1999
- Optimal Routes in 2007
- Optimal Routes in 2015

## Example of Change in Optimal Route - Maputo to Funhalouro (600km) (40h in 1992 - 8h in 2015)



## Market Access Measures - Transportation Costs

Land mines placed on a road make that road unusable.

Changes in  $\tau$  are due to demining activities:

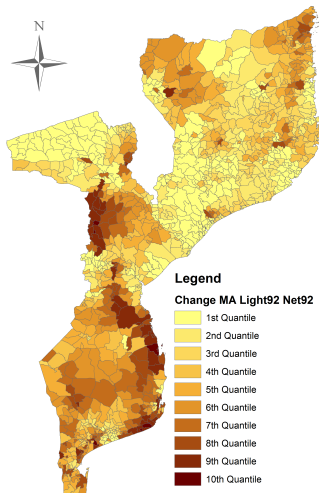
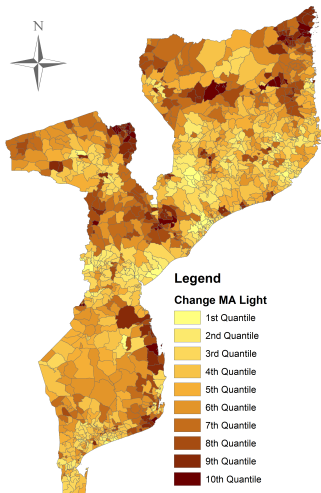
- ▶ clearing roads 1973
- ▶ building new roads after demining

**Note:** We are able to isolate both effects.

## Market Access Measures - $\theta$ is 3.88 (Donaldson, 2015)

- ▶ **Market Access - Light:** we proxy aggregate demand in the destination district with the sum of lights (Alder 2016)
- ▶ **Market Access - Population:** aggregate demand in the destination district proxied with population. (Effectively assuming income per capita is the same in all districts)

## Changes in Market Access



## Empirical Specification

$$Y_{d,t} = \lambda \ln(MA_{d,t}) + \mu_d + \mu_{p,t} + \varepsilon_d.$$

where:

- ▶  $Y_{d,t}$  is luminosity over the corresponding period  $t$
- ▶  $\ln(MA_{d,t})$  is the locality's “market access” in period  $t$
- ▶  $\mu_d$  is a locality fixed effect
- ▶  $\mu_{p,t}$  is a province-year fixed effect

## Results - Panel

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Direct Effect			
	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.296*** (0.064) [0.262]	0.032*** (0.007) [0.278]			0.274*** (0.064) [0.242]	0.029*** (0.007) [0.254]		
Log Market Access, Population			0.248*** (0.069) [0.150]	0.025*** (0.008) [0.148]			0.187*** (0.067) [0.113]	0.017** (0.007) [0.101]
Cleared Threats					0.393*** (0.094) [0.090]	0.049*** (0.010) [0.111]	0.375*** (0.108) [0.086]	0.049*** (0.012) [0.110]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.248	.229	.249	.228	.254	.235	.254	.234
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

**Note:** Being lit increases years of schooling by 1.8 years in Mozambique (DHS).

[1.1 in rural and 2.9 in urban] ▶ Lights Education DHS



## Results - Magnitude

- ▶ 10% increase in the luminosity market access increases average luminosity (lit) by around 3% (0.3%).
- ▶ Beta coefficient of the luminosity market access is three times larger than the beta coefficient of the local effect
- ▶ Being lit increases:
  - years of schooling by 1.8 years in Mozambique (DHS). [1.1 in rural and 2.9 in urban]
  - DHS wealth index by 1.5. [0.32 in rural and 2 in urban]
- ▶ Luminosity-market access elasticity is comparable to the one in Alder (2016) for India [Golden Quadrilateral]

## Robustness Checks

- ▶ Alternative  $\theta$  ▶ Alternative  $\theta$
- ▶ Average Transportation Cost ▶ Average  $\tau$
- ▶ Market Potential ▶ Market Potential
- ▶ Inflating Luminosity of Maputo, Beira, Nacala ▶ Inflate Light
- ▶ Alternative network elements parametrization ▶ Jedwab and Storeygard
- ▶ Removing Railways ▶ No Railways
- ▶ Relaxing land mines blocking assumption ▶ Passable Obstacle
- ▶ Accounting for Local MA ▶ Neighbors
- ▶ Long-Run Differences ▶ Long-Run

## Isolating the Indirect effect

We focus on the sample of not affected localities:

- ▶ estimating the indirect effect more precisely
- ▶ issues of endogeneity of demining interventions are absent

## Results - Non Affected

Demining-Phase Estimation (1992, 1999, 2007, 2015)				
	Contemporaneous Log Luminosity		Lit	
	(1)	(2)	(3)	(4)
Log Market Access, Light	0.270*** (0.099) [0.279]	0.032*** (0.011) [0.318]		
Log Market Access, Population			0.297** (0.135) [0.208]	0.033** (0.015) [0.223]
Number of Localities	332	332	291	291
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.189	.167	.205	.173
Observations	1,328	1,328	1,164	1,164

## Isolating the Effect of Demining

**Concern:** Market access can change because of:

- demining activities
- building new roads/infrastructures
- changes in population and real income

We shut down these last two effect focusing on the predetermined components of market access

- network 1973
- development at the end of the war in 1992

# Results Fixing Initial Conditions

Accounting For:	Demining-Phase Estimation (1992, 1999, 2007, 2015)							
	Direct Effect				Direct Effect, New Road, and Old Road Improvement			
	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light (Initial)	0.260** (0.113) [0.199]	0.025** (0.012) [0.186]			0.261** (0.114) [0.200]	0.025** (0.012) [0.188]		
Log Market Access, Population (Initial)			0.663*** (0.178) [0.358]	0.054*** (0.019) [0.285]			0.665*** (0.178) [0.359]	0.055*** (0.019) [0.288]
Cleared Threats	0.424*** (0.092) [0.097]	0.053*** (0.010) [0.119]	0.334*** (0.106) [0.077]	0.046*** (0.012) [0.104]	0.387*** (0.091) [0.089]	0.049*** (0.010) [0.110]	0.303*** (0.104) [0.070]	0.043*** (0.011) [0.096]
New Road (dummy)					0.014 (0.206) [0.002]	0.018 (0.023) [0.019]	-0.083 (0.215) [-0.009]	0.006 (0.024) [0.006]
Old Network Improved (dummy)					0.451** (0.183) [0.052]	0.044** (0.020) [0.050]	0.448** (0.178) [0.051]	0.042** (0.020) [0.047]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.243	.226	.259	.236	.245	.227	.261	.237
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

# Counterfactual

- ▶ We build policies counter-factual to evaluate welfare gain/losses  
(e.g. Donaldson and Hornbeck, 2016; Alder, 2017)
  1. Quantify the welfare loss without demining activities
  2. We construct alternative measures of market access under different demining strategies

## Mozambique without Demining

- ▶ We want to evaluate how much lower luminosity would be without demining.
- ▶ We compute market access in 2015 (2007) assuming land mines were still on the ground
- ▶ We use the calculated decline in market access and estimated impact of market access on luminosity to predict the decrease in luminosity



## Mozambique without Demining

	Percent Decline MA without Demining Activities	Percent Decline in Luminosity without Demining Activities
Market Access, Light	2007 (obs=1187)	
No demining activities	58	30.2 (1.7)
No demining activities & Assuming the Luminosity Distribution in 1992	62.3	41.9 (1.7)
Market Access, Light	2015 (obs=1187)	
No demining activities	59.4	58.7 (2.4)
No demining activities & Assuming the Luminosity Distribution in 1992	75.3	70.4 (1.7)

## Mozambique without Demining

- ▶ Luminosity in 2015 would have declined by 70%
- ▶ Estimated elasticity between GPD and luminosity is 0.3, GDP would have decrease by 15-25% in 2015

# Policy Experiment Simulation: Targeting Transportation Network

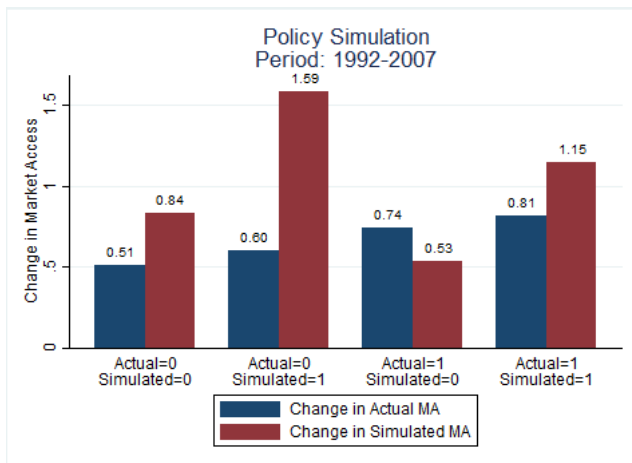
- ▶ Period 1: 3 main corridors starting from Maputo, Beira and Nampula ▶ Period 1
- ▶ Period 2: N1 highway and other paved roads ▶ Period 2
- ▶ Period 3: Unpaved roads

We match the number of simulated cleared localidades to the actual cleared ones in each period

## Policy Experiment Simulation - Results

Dependent Variable	$\Delta$ Market Access Network and Luminosity (Initial)			
	Mean	Median	Observations	# of Affected used in Simulation
<i>Period: 1992-2015</i>				
Actual (log)	1.21	0.83	1187	855
Simulated (log)	1.21	0.83	1187	855
<i>Period: 1992-1999</i>				
Actual (log)	0.11	0.00	1187	39
Simulated (log)	0.13	0.01	1187	39
<i>Period: 1992-2007</i>				
Actual (log)	0.63	0.31	1187	442
Simulated (log)	0.99	0.56	1187	442

## Policy Experiment Simulation - Period 2



## Conclusion

- ▶ *“Land mines keep poor people poor, decades after the conflict”*
- ▶ First attempt to shed lights on the effect of land mines removal on development
- ▶ Small to Moderate effect on Local Development
- ▶ Large General Equilibrium Effects
- ▶ Policy Simulation showing cost of not coordination and prioritization

# Suggestions for Practitioners

- ▶ Prioritize targeting regions with the largest externalities
- ▶ Fully clear a contaminated district as compared to partial clearing
  - Important as land mine clearance is ongoing in several countries
  - Funding for demining is fizzling
- ▶ Co-ordination and centralization among stakeholders and demining actors

Thank you!



## “Extensive” versus “Intensive” Margin [▶ Back](#)

### Examples:

- 8 AP mines were found in Mahnica Valley in Maputo Province preventing the return of 20000 people to their village
- 26642 AP and AT land mines were found at Cahora Bassa Dam (second biggest in Africa) between 2009 and 2014

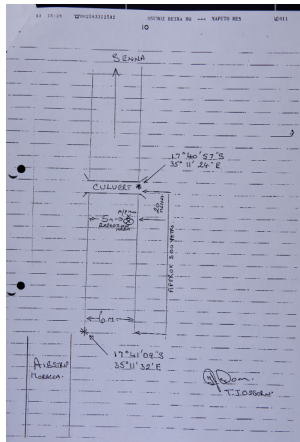
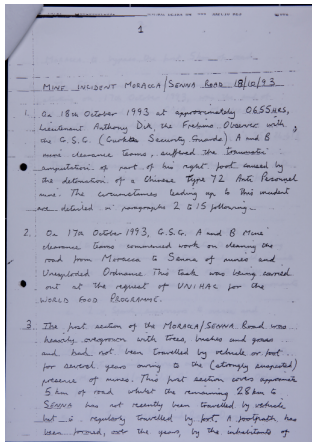
# Appendix

# Data Description

- ▶ Example from IMSMA Dataset
- ▶ Example of original report from ADP in 2000
- ▶ Example of original report from NPA in 2014
- ▶ Example of map digitization from Ronco (USAID) 1994

Machanissa village - Inhambane Province [▶ Back](#)

# Original Report. Example from GSG 1993

[▶ Back](#)


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Página 1 de 2

## Original Report. Example from NPA 2014

Back



Ajuda Popular da Noruega – APN  
Programa Humanitário de Desarmamento / Moçambique

## Relatório de Conclusão da Tarefa

## 1 Informação Geral

1.1 MSMA ID: Chiba-Nova-87	1.12 Tamanho total da área libertada: 214 m²
1.2 Nome da área: Antiga Escola Mutungwenheque	1.13 Área classificada por (Manual): 214 m²
1.3 ID de Redução da área(s):	1.14 Área Pesquisada (Manual): m²
1.4 Nome da Organização: APN	1.15 Área Cancelada (PNT): m²
1.5 Data início da tarefa: 10 / 11 / 2014	1.16 Área Clarificada (MOD): m²
1.6 Estado: Concluído	1.17 Área Clarificada por (MOD): m²
1.8 Dados introduzidos por:	1.18 Número de sapadores usados: 63
1.9 Profundidade da clarificação: 20 cm	1.19 Tipo de detector usado: MINE LAB
1.10 Total de horas de trabalho: 23 hrs	1.20 Supervisor da tarefa: Jose Omar Nhembe
1.11 Data do fim da tarefa: 13 de Novembro de 2014	1.21 Número de beneficiários:
1.22 A conclusão é baseada no processo de: <input checked="" type="checkbox"/> Clarificação <input type="checkbox"/> Pesquisa técnica <input type="checkbox"/> PNT <input type="checkbox"/> EOD <input type="checkbox"/> BAC	
Selecione apenas um processo	
1.23 Objecto: <input type="checkbox"/> Habitação <input type="checkbox"/> Indústria <input type="checkbox"/> Terreno agrícola <input type="checkbox"/> Estrada <input type="checkbox"/> Área da fronteira	
1.24 Métodos e tecnologias usados?: <input checked="" type="checkbox"/> Manual <input type="checkbox"/> Mecânica <input type="checkbox"/> Cães <input type="checkbox"/> Ratos <input type="checkbox"/> Combinado	
1.25 Acidente/incidente ocorreu durante a Operação?: <input type="checkbox"/> Sim <input checked="" type="checkbox"/> Não ID do acidente:	
1.26 Área restante não clarificada: <input type="checkbox"/> Sim <input checked="" type="checkbox"/> Não	
1.27 Marcação da área não clarificada: <input type="checkbox"/> Sinais locais <input type="checkbox"/> Sinais oficiais <input type="checkbox"/> Vedado <input type="checkbox"/> Vários <input checked="" type="checkbox"/> Nenhum	
1.28 Descrição da área não clarificada:	

Não existe área restante

## 1.29 Informação adicional:

É um antigo caminho que passa da antiga escola de Mutungwenheque para as residências de Manguja que foi minado no tempo de conflito armado tendo causado acidente humano no ano de 1981 envolvendo o Sr. Manhunge Kowoye

A dimensão do troço clarificado é de 45 metro de comprimento e 5 metros de largura que era considerada como suspeita de estar minada.

A porção designada está demarcada com marcos nos 4 contornos da área clarificada

1.30 Controlo e Comentário da qualidade efectuado por (nome & organização): Sr. Tembo do IND

1.31 Método de controlo de qualidade: ☒ Manual ☐ Cães ☐ Mecânica ☐ Combinado

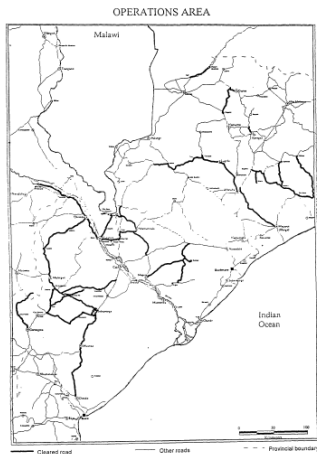
## 2 Localização

2.1 Província: Sofala	2.4 Sistema Coord.: WGS84 DD MM SS.SS	2.7 Nome do Map:
2.2 Distrito: Chibabava	2.5 X/E Long.: 033° 53' 15,6" E	2.8 Série do Map:
2.3 Posto Administrativo: Muxungue	2.6 Y/N Lat.: 20° 15' 21,1" S	2.9 Edição do Map:
2.4 Localidade: Panja	2.7 MGRS Coord.:	2.10 Folha Map:
	2.8 Coord. fix por: <input type="checkbox"/> DGPS <input checked="" type="checkbox"/> GPS or <input type="checkbox"/> Map.com <input type="checkbox"/> <30m or <input type="checkbox"/> >30 m Precisão	2.11 Escala do Map:1 :

# Ronco Demining Activities 1994/1995.

## Original Map Digitized

► Back





## Correlates of Minefield

- ▶ Intervention level
  - Distribution of land mines
- ▶ Admin 4 level
  - Linear Probability Model
  - Ordered Probit
  - Negative Binomial Maximum Likelihood

## Correlates of Minefields (at the Admin-4 Level)

$$\begin{aligned} Threat_i = & \exp(a + \beta_0 Area + \beta_1 Geo_i + \beta_2 Border_i + \beta_3 CW_i \\ & + \beta_4 Dist_i + \beta_5 Transport_i + \beta_6 Cantinas_i + \beta_7 Lit_i \\ & + \beta_8 PopDens_{1980,i} + \varepsilon_i) \end{aligned}$$

where:

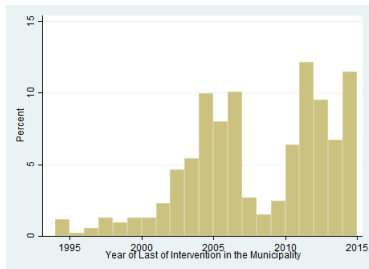
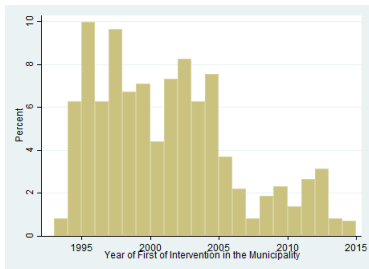
- $Threat_{i,p}$ : dummy or number for land mines or UXOs;
- $Area$ : log land area of district  $i$ ;
- $Geo_{i,p}$ : vector of geographical characteristics;
- $Border_{i,p}$ : vector of (log) distance to each of the national borders;
- $Dist_{i,p}$ : vector of (log) distance to the closest big cities (Maputo, Beira, Nacala) and to the coast;
- $Transport_{i,p}$ : vector of indicator for rail, paved road, unpaved road, trail, and navigable river;
- $CW_i$ : indicator for civil war event;
- $Catinas_{i,p}$ : indicator for cantinas in 1965;
- $Lit_{i,p}$ : indicator for lit in 1992;
- $PopDens_{1980,i,p}$ : (log) population density in 1980.

# Correlates of Minefields [▶ Back](#)

Dependent Variable	Minefields and UXOs Threat (dummy)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Distance South Africa Border	0.032 (0.053)							0.038 (0.063)
Log - Distance Zimbabwe Border	-0.086*** (0.026)							-0.096*** (0.027)
Log - Distance Malawi Border	-0.052** (0.026)							-0.048 (0.030)
Log - Distance Tanzania Border	-0.093** (0.046)							-0.119** (0.046)
Log - Distance Zambia Border	0.181*** (0.035)							0.176*** (0.042)
Log - Distance Swaziland Border	-0.116** (0.058)							-0.148** (0.066)
Elevation		-0.093 (0.109)						0.102 (0.121)
Malaria Ecology		-0.001 (0.008)						0.016* (0.008)
Suitability of Agriculture		-0.136 (0.105)						-0.191* (0.106)
Log - Distance Closest Big City		-0.088*** (0.030)						-0.030 (0.035)
Log - Distance Coast		0.051 (0.037)						0.038 (0.047)
Paved Road 1973 (dummy)			0.081*** (0.019)					0.051** (0.022)
Unpaved Road 1973 (dummy)			0.099** (0.044)					0.001 (0.062)
Trail 1973 (dummy)			0.054*** (0.010)					0.035*** (0.009)
Railway (dummy)			-0.010 (0.061)					-0.066 (0.059)
Navigable River (dummy)			0.002 (0.006)					-0.004 (0.004)
Civil War (dummy)				0.249*** (0.031)				0.141*** (0.028)
Cantina 1965 (dummy)					0.114*** (0.030)			0.058** (0.028)
Lit (dummy)						0.122** (0.056)		0.010 (0.055)
Log - Population Density 1980							0.056*** (0.015)	0.027* (0.015)
Log - Land Area	0.102*** (0.014)	0.083*** (0.014)	0.089*** (0.015)	0.095*** (0.014)	0.085*** (0.015)	0.095*** (0.014)	0.144*** (0.019)	0.100*** (0.017)
Observations	1195	1190	1195	1195	1195	1195	1099	1094
Adjusted R-squared	0.095	0.068	0.094	0.097	0.072	0.063	0.067	0.157
Province FE	N	N	N	N	N	N	N	N

## First Year and Last Year of Intervention at admin-4 level

► Back



## Correlates of Minefields - Probit

▶ Back

Dependent Variable	Minefields and UXOs Threat (dummy)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Distance South Africa Border	0.086 (0.220)							0.024 (0.269)
Log - Distance Zimbabwe Border	-0.285*** (0.098)							-0.336*** (0.108)
Log - Distance Malawi Border	-0.154* (0.080)							-0.146 (0.099)
Log - Distance Tanzania Border	-0.314** (0.162)							-0.422** (0.182)
Log - Distance Zambia Border	0.555*** (0.108)							0.518*** (0.143)
Log - Distance Swaziland Border	-0.371 (0.243)							-0.395 (0.274)
Elevation		-0.312 (0.332)						0.341 (0.419)
Malaria Ecology		-0.006 (0.023)						0.047 (0.029)
Suitability of Agriculture		-0.413 (0.321)						-0.585 (0.369)
Log - Distance Closest Big City	-0.271*** (0.096)							-0.140 (0.126)
Log - Distance Coast	0.152 (0.109)							0.092 (0.158)
Paved Road 1973 (dummy)			0.424*** (0.130)					0.270** (0.130)
Unpaved Road 1973 (dummy)			0.709 (0.525)					0.199 (0.556)
Trail 1973 (dummy)			0.227*** (0.053)					0.154*** (0.049)
Railway (dummy)			0.149 (0.387)					-0.130 (0.399)
Navigable River (dummy)			0.009 (0.026)					-0.005 (0.017)
Civil War (dummy)				1.049*** (0.180)				0.724*** (0.183)
Cantina 1965 (dummy)					0.359*** (0.092)			0.175* (0.091)
Lit (dummy)						0.398** (0.201)		0.024 (0.211)
Log - Population Density 1980							0.182*** (0.051)	0.114** (0.052)
Log - Land Area	0.324*** (0.041)	0.258*** (0.042)	0.292*** (0.045)	0.318*** (0.047)	0.264*** (0.044)	0.291*** (0.040)	0.456*** (0.061)	0.395*** (0.064)
Obs	1195	1190	1195	1195	1195	1195	1099	1094
PseudoR2	0.088	0.062	0.098	0.095	0.064	0.055	0.060	0.170
Province FE	N	N	N	N	N	N	N	N

# Correlates of Minefields - Negative Binomial Maximum Likelihood

Back

Dependent Variable	Number of Minefields and UXOs Threats (count)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Distance South Africa Border	0.107 (0.211)							0.110 (0.242)
Log - Distance Zimbabwe Border	-0.435*** (0.141)							-0.550*** (0.180)
Log - Distance Malawi Border	-0.194 (0.138)							-0.139 (0.136)
Log - Distance Tanzania Border	-0.232* (0.141)							-0.381** (0.156)
Log - Distance Zambia Border	0.706** (0.341)							0.784*** (0.235)
Log - Distance Swaziland Border	-0.632*** (0.212)							-0.692*** (0.264)
Elevation		-1.299*** (0.430)						0.231 (0.547)
Malaria Ecology		-0.099*** (0.029)						0.024 (0.037)
Suitability of Agriculture		0.214 (0.409)						-0.012 (0.355)
Log - Distance Closest Big City		-0.343** (0.145)						-0.069 (0.156)
Log - Distance Coast		0.204 (0.142)						0.149 (0.170)
Paved Road 1973 (dummy)			0.457*** (0.106)					0.235*** (0.083)
Unpaved Road 1973 (dummy)			0.733** (0.324)					-0.173 (0.185)
Trail 1973 (dummy)			0.081** (0.039)					0.083*** (0.032)
Railway (dummy)			0.265 (0.174)					-0.241 (0.192)
Navigable River (dummy)			0.014 (0.020)					0.001 (0.017)
Civil War (dummy)				1.068*** (0.196)				0.512*** (0.178)
Cantina 1965 (dummy)					0.274* (0.147)			-0.066 (0.109)
Lit (dummy)						0.630*** (0.228)		0.072 (0.319)
Log - Population Density 1980							0.286*** (0.072)	0.255*** (0.073)
Log - Land Area	0.375*** (0.063)	0.365*** (0.065)	0.331*** (0.059)	0.378*** (0.061)	0.314*** (0.056)	0.353*** (0.051)	0.582*** (0.070)	0.607*** (0.065)
Province FE	N	N	N	N	N	N	N	N
Observations	1195	1190	1195	1195	1195	1195	1099	1094

# Timing of Intervention

- ▶ Interventions by province and period
- ▶ Timing of first intervention
- ▶ Timing of first intervention

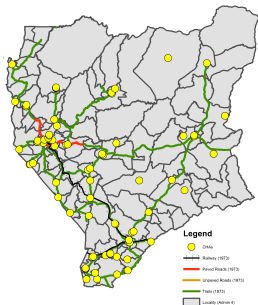
▶ Back



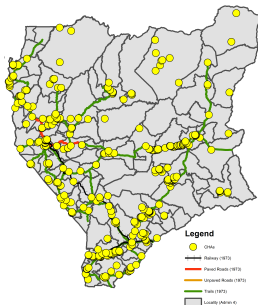
# Demining Activities Niassa (Intervention Level)

► Back

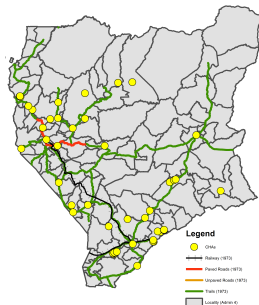
Clearance of CHAs in Niassa 1993-1999



Clearance of CHAs in Niassa 2000-2007



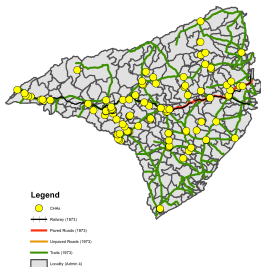
Clearance of CHAs in Niassa 2008-2015



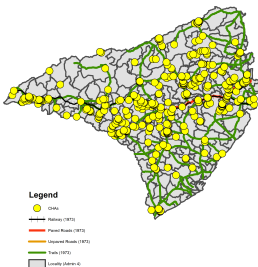
# Demining Activities Nampula (Intervention Level)

► Back

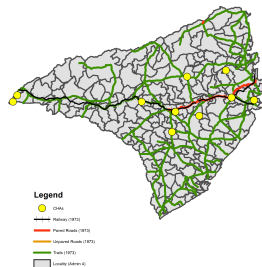
Clearance of CHAs in Nampula 1993-1999



Clearance of CHAs in Nampula 2000-2007



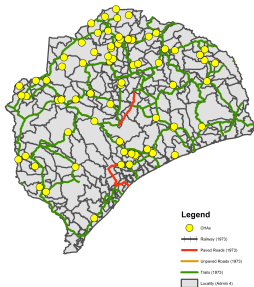
Clearance of CHAs in Nampula 2008-2015



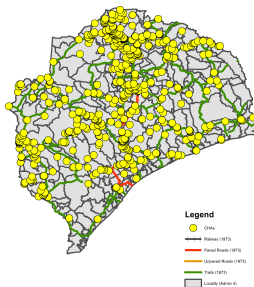
# Demining Activities Zambezia (Intervention Level)

► Back

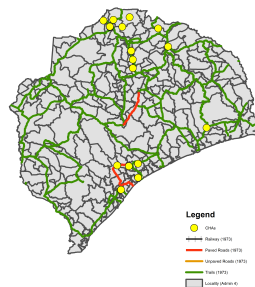
Clearance of CHAs in Zambezia 1993-1999



Clearance of CHAs in Zambezia 2000-2007



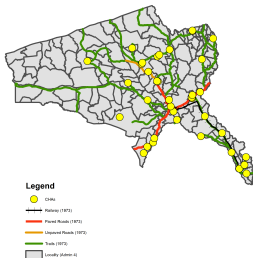
Clearance of CHAs in Zambezia 2008-2015



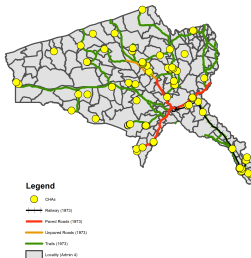
# Demining Activities Tete (Intervention Level)

► Back

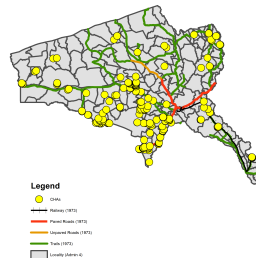
Clearance of CHAs in Tete 1993-1999



Clearance of CHAs in Tete 2000-2007



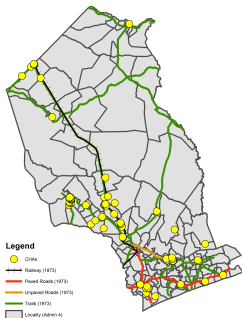
Clearance of CHAs in Tete 2008-2015



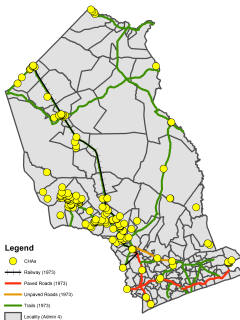
## Demining Activities Gaza (Intervention Level)

► Back

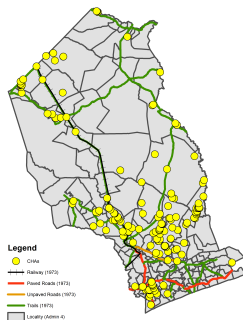
Clearance of CHAs in Gaza 1993-1999



Clearance of CHAs in Gaza 2000-2007



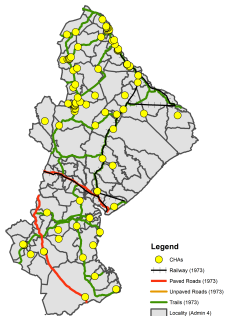
Clearance of CHAs in Gaza 2008-2015



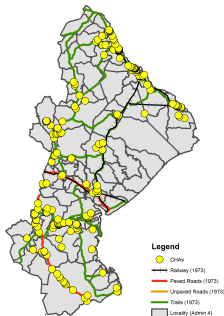
# Demining Activities Sofala (Intervention Level)

► Back

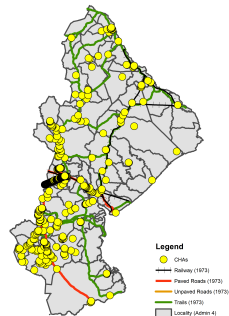
Clearance of CHAs in Sofala 1993-1999



Clearance of CHAs in Sofala 2000-2007



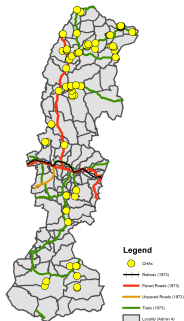
Clearance of CHAs in Sofala 2008-2015



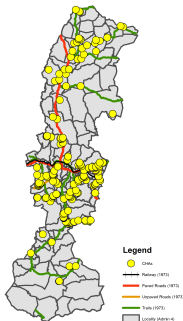
# Demining Activities Manica (Intervention Level)

► Back

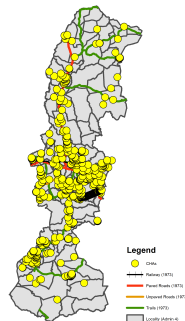
Clearance of CHAs in Manica 1993-1999



Clearance of CHAs in Manica 2000-2007



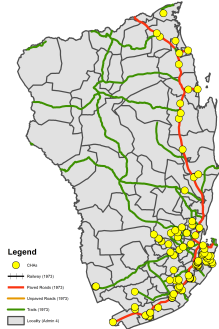
Clearance of CHAs in Manica 2008-2015



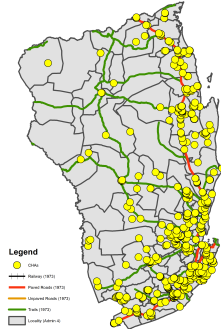
# Demining Activities Inhambane (Intervention Level)

▶ Back

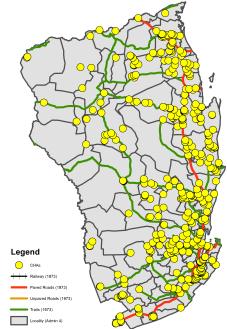
Clearance of CHAs in Inhambane 1993-1999



Clearance of CHAs in Inhambane 2000-2007



Clearance of CHAs in Inhambane 2008-2015

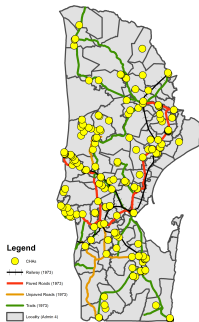




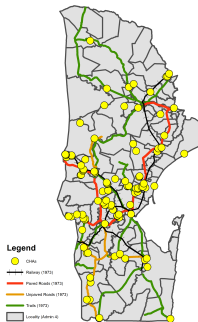
# Demining Activities Maputo (Intervention Level)

▶ Back

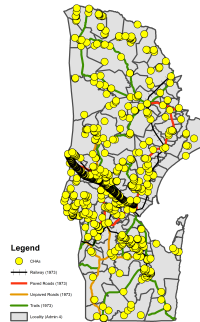
Clearance of CHAs in Maputo 1993-1999



Clearance of CHAs in Maputo 2000-2007



Clearance of CHAs in Maputo 2008-2015



# First Year Province FE [▶ Back](#)

	Number of Years until First Intervention							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log - Distance South Africa Border	0.142** (0.065)							0.133* (0.070)
Log - Distance Zimbabwe Border	-0.203*** (0.051)							-0.185*** (0.047)
Log - Distance Malawi Border	0.205*** (0.044)							0.199*** (0.045)
Log - Distance Tanzania Border	-0.034 (0.033)							-0.014 (0.036)
Log - Distance Zambia Border	-0.132* (0.076)							-0.018 (0.083)
Log - Distance Swaziland Border	0.019 (0.076)							0.026 (0.083)
Elevation		-0.054 (0.173)						0.084 (0.174)
Malaria Ecology		-0.015 (0.011)						-0.014 (0.012)
Suitability of Agriculture		-0.236* (0.138)						-0.015 (0.122)
Log - Number of Villages		-0.053 (0.034)						0.007 (0.032)
Log - Distance Coast		0.015 (0.051)						0.013 (0.054)
Paved Road 1973 (dummy)			-0.086 (0.058)					-0.059 (0.056)
Unpaved Road 1973 (dummy)			-0.190 (0.123)					-0.205* (0.114)
Trail 1973 (dummy)			-0.115*** (0.043)					-0.063 (0.042)
Railway Colonial (dummy)			-0.114 (0.093)					-0.041 (0.066)
Navigable River (dummy)			-0.020 (0.061)					0.004 (0.051)
Civil War (dummy)				-0.267*** (0.053)				-0.243*** (0.056)
Cantina 1965 (dummy)					-0.098** (0.040)			-0.010 (0.038)
Lit						-0.065 (0.056)		0.043 (0.053)
Log - Population Density 1980							-0.077*** (0.022)	-0.034* (0.021)
Log - Land	-0.054*** (0.017)	-0.018 (0.021)	-0.034* (0.018)	-0.039** (0.017)	-0.027 (0.018)	-0.032* (0.018)	-0.107*** (0.023)	-0.092*** (0.030)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	786	786	786	786	786	786
Log Likelihood	-2331	-2385	-2378	-2365	-2392	-2398	-2383	-2280
R2 Fitted	.175	.125	.134	.139	.112	.106	.126	.235

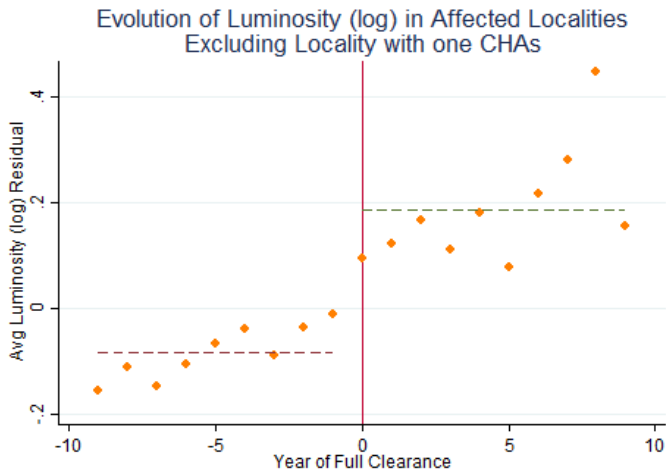
# Last Year Province FE [▶ Back](#)

	Number of Years until Last Intervention							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Adjacent South Africa (dummy)	0.035 (0.038)							0.025 (0.038)
Adjacent Zimbabwe (dummy)	0.122*** (0.043)							0.125*** (0.047)
Adjacent Malawi (dummy)	-0.016 (0.053)							-0.033 (0.052)
Adjacent Tanzania (dummy)	0.062 (0.057)							0.120** (0.059)
Adjacent Zambia (dummy)	-0.067 (0.109)							-0.083 (0.105)
Adjacent Swaziland (dummy)	0.061** (0.027)							0.064* (0.037)
Elevation		0.058 (0.088)						0.036 (0.091)
Malaria Ecology		-0.003 (0.007)						-0.001 (0.007)
Suitability of Agriculture		-0.042 (0.061)						-0.046 (0.062)
Log - Number of Villages		0.023 (0.017)						0.018 (0.017)
Log - Distance Coast		-0.001 (0.023)						0.011 (0.024)
Paved Road 1973 (dummy)			0.037 (0.027)					0.037 (0.031)
Unpaved Road 1973 (dummy)			0.015 (0.038)					0.010 (0.037)
Trail 1973 (dummy)			0.021 (0.020)					0.016 (0.019)
Railway Colonial (dummy)			-0.007 (0.037)					-0.001 (0.035)
Navigable River (dummy)			-0.029 (0.023)					-0.034 (0.023)
Civil War (dummy)				0.023 (0.021)				0.003 (0.023)
Cantina 1965 (dummy)					0.033 (0.020)			0.022 (0.020)
Lit						0.002 (0.030)		-0.017 (0.033)
Log - Population Density 1980							0.020* (0.011)	0.014 (0.012)
Log - Land	0.026*** (0.009)	0.024** (0.011)	0.032*** (0.009)	0.030*** (0.009)	0.029*** (0.009)	0.030*** (0.009)	0.049*** (0.014)	0.034* (0.018)
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	786	786	786	786	786	786
Log Likelihood	-2174	-2175	-2176	-2178	-2177	-2179	-2177	-2166
R2 Fitted	.329	.331	.324	.321	.322	.32	.32	.339

# Land Mine and Local Development

- ▶ Evolution of Luminosity
- ▶ Alternative Outcomes
- ▶ Sensitivity Checks
- ▶ Heterogeneity on Locality Characteristics
- ▶ Heterogeneity on Landmines Characteristics

## Evolution of Luminosity - Before and After [▶ Back](#)



# Land Mine Removal and Local Development. Population as Outcome

▶ Back

	$\Delta \text{ Log Pop}$	$\Delta \text{ Log Pop}$	$\Delta \text{ Log Pop}$	$\Delta \text{ Log Pop}$
	(1)	(2)	(3)	(4)
$\Delta \text{ Cleared Threats}$	0.063*** (0.021) [0.077]		0.081*** (0.025) [0.099]	
Cleared (dummy)		0.076 (0.054) [0.046]		0.021 (0.048) [0.013]
Network Elements	No	No	Yes	Yes
No	No	Yes	Yes	
Civil War (dummy)	No	No	Yes	Yes
No	No	Yes	Yes	
Log - Population Density 1980	No	No	Yes	Yes
No	No	Yes	Yes	
Log - Luminosity	No	No	Yes	Yes
No	No	No	No	
Lit (dummy)	No	No	No	No
No	No	Yes	Yes	
Log - Land	No	No	Yes	Yes
No	No	Yes	Yes	
Province FE	Yes	Yes	Yes	Yes
R-squared	.124	.12	.417	.41
Observations	1,077	1,077	1,077	1,077

## Land Mine Removal and Local Development. Roads as Outcome

	4 Years (1992, 1999, 2007, 2015)			
	New Road (dummy)		Old Net Improvement (dummy)	
	(1)	(2)	(3)	(4)
Cleared Threats	0.039*** (0.010) [0.084]		0.080*** (0.011) [0.159]	
Cleared (dummy)		-0.001 (0.018) [-0.001]		0.069*** (0.019) [0.065]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.351	.346	.441	.432
Observations	4,748	4,748	4,748	4,748

# Land Mine Removal and Local Development. Roads as Controls

► Back

	4 Years (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit	
	(1)	(2)	(3)	(4)
Cleared Threats	0.433*** (0.097) [0.099]		0.053*** (0.011) [0.119]	
Cleared (dummy)		0.719*** (0.180) [0.079]		0.079*** (0.020) [0.084]
New Road (dummy)	0.003 (0.204) [0.000]	0.080 (0.204) [0.009]	0.017 (0.023) [0.017]	0.026 (0.023) [0.027]
Old Network Improved (dummy)	0.448** (0.184) [0.052]	0.521*** (0.182) [0.060]	0.044** (0.020) [0.050]	0.054*** (0.020) [0.060]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.242	.241	.225	.222
Observations	4,748	4,748	4,748	4,748



# Land Mine Removal and Local Development. Roads as Controls

► Back

	4 Years (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit	
	(1)	(2)	(3)	(4)
Cleared Threats	0.433*** (0.097) [0.099]		0.053*** (0.011) [0.119]	
Cleared (dummy)		0.719*** (0.180) [0.079]		0.079*** (0.020) [0.084]
New Road (dummy)	0.003 (0.204) [0.000]	0.080 (0.204) [0.009]	0.017 (0.023) [0.017]	0.026 (0.023) [0.027]
Old Network Improved (dummy)	0.448** (0.184) [0.052]	0.521*** (0.182) [0.060]	0.044** (0.020) [0.050]	0.054*** (0.020) [0.060]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.242	.241	.225	.222
Observations	4,748	4,748	4,748	4,748

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	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cleared Threats	0.358*** (0.075) [0.080]		0.042*** (0.007) [0.092]		0.512*** (0.104) [0.121]		0.064*** (0.011) [0.146]	
Cleared (dummy)		0.386*** (0.114) [0.041]		0.039*** (0.011) [0.041]		0.756*** (0.187) [0.088]		0.084*** (0.021) [0.093]
Number of Localities	1,109	1,109	1,109	1,109	1,109	1,109	1,109	1,109
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.162	.159	.124	.12	.237	.233	.226	.22
Observations	25,507	25,507	25,507	25,507	4,436	4,436	4,436	4,436

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## Fixed Effect Estimates of Demining - Stopping in 2013

	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2013)			
	Log Luminosity (1)	Log Luminosity (2)	Lit (3)	Lit (4)	Log Luminosity (5)	Log Luminosity (6)	Lit (7)	Lit (8)
Cleared Threats	0.291*** (0.073) [0.062]		0.031*** (0.007) [0.067]		0.360*** (0.098) [0.080]		0.038*** (0.011) [0.088]	
Cleared (dummy)		0.306*** (0.111) [0.029]		0.029*** (0.011) [0.028]		0.349** (0.176) [0.037]		0.031* (0.018) [0.033]
Number of Localities	1,187	1,187	1,187	1,187	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.157	.154	.105	.103	.221	.217	.176	.172
Observations	26,114	26,114	26,114	26,114	4,748	4,748	4,748	4,748

## Fixed Effect Estimates of Demining - Dynamic [▶ Back](#)

	Yearly			
	Log Luminosity		Lit	
	(1)	(2)	(3)	(4)
Cleared Threats	0.156*** (0.037) [0.033]		0.019*** (0.004) [0.042]	
Cleared (dummy)		0.163*** (0.058) [0.016]		0.018*** (0.007) [0.018]
Log - Luminosity First Lag	0.504*** (0.019) [0.491]	0.505*** (0.019) [0.492]		
Lit (dummy) First Lag			0.387*** (0.018) [0.380]	0.389*** (0.018) [0.381]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.362	.361	.229	.228
Observations	24,927	24,927	24,927	24,927

# Land Mine Removal and Local Development. Intermediate Period

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	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
First Intervention (dummy)	-0.103 (0.084) [-0.012]	-0.010 (0.009) [-0.012]	-0.351** (0.149) [-0.042]	-0.039** (0.018) [-0.045]
Cleared (dummy)	0.421*** (0.118) [0.042]	0.043*** (0.012) [0.043]	0.972*** (0.197) [0.106]	0.107*** (0.023) [0.114]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.166	.121	.239	.22
Observations	27,301	27,301	4,748	4,748

Land Mine Removal and Local Development. Affected Only [▶ Back](#)

	Yearly				Demining-Phase Estimation (1992, 1999, 2007, 2015)			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cleared Threats	0.337*** (0.089) [0.074]		0.038*** (0.009) [0.084]		0.511*** (0.116) [0.120]		0.062*** (0.013) [0.143]	
Cleared (dummy)		0.246* (0.133) [0.026]		0.024* (0.013) [0.025]		0.747*** (0.229) [0.086]		0.067** (0.026) [0.075]
Number of Localities	855	855	855	855	855	855	855	855
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.178	.175	.133	.13	.264	.259	.248	.241
Observations	19,665	19,665	19,665	19,665	3,420	3,420	3,420	3,420



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	Yearly		4 Years (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Cleared Threats	0.398*** (0.108) [0.101]	0.041*** (0.012) [0.104]	0.532*** (0.147) [0.144]	0.057*** (0.017) [0.151]
Number of Postos	417	417	417	417
Posto FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.24	.167	.381	.339
Observations	9,591	9,591	1,668	1,668

## Land Mine Removal and Local Development. CHAs versus SHAs

	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Cleared Threats	0.336*** (0.076) [0.072]	0.036*** (0.007) [0.077]	0.506*** (0.109) [0.116]	0.057*** (0.012) [0.128]
Cancelled Threats	-0.045 (0.112) [-0.007]	0.008 (0.011) [0.012]	-0.163 (0.147) [-0.024]	0.002 (0.016) [0.003]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.168	.124	.241	.224
Observations	27,301	27,301	4,748	4,748

# Fixed Effect Estimates of Demining - Heterogeneity on Locality Characteristics

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	Transportation Network			Population Density 1980					Survey	
	Connected Lit (1)	Non Connected Lit (2)	Connected Lit (3)	1st Q Lit (4)	2nd Q Lit (5)	3rd Q Lit (6)	4th Q Lit (7)	5th Q Lit (8)	Survey Lit (9)	No Survey Lit (10)
Cleared (dummy)	0.036*** (0.013) [0.035]	0.005 (0.016) [0.006]		0.020 (0.013) [0.030]	0.042* (0.023) [0.053]	0.039 (0.025) [0.040]	0.046** (0.022) [0.044]	0.064* (0.032) [0.050]	0.041*** (0.014) [0.043]	0.032* (0.017) [0.030]
Cleared (dummy) × Paved 1973 (dummy)			0.062** (0.028) [0.030]							
Cleared (dummy) × Unpaved 1973 (dummy)			0.049 (0.069) [0.008]							
Cleared (dummy) × Trail 1973 (dummy)			-0.000 (0.014) [-0.000]							
Cleared (dummy) × Rail (dummy)			0.062** (0.031) [0.028]							
Number of Localities	888	299	888	216	215	216	215	215	659	528
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year × Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.14	.0623	.142	.0715	.131	.13	.153	.197	.135	.104
Observations	20,424	6,877	20,424	4,968	4,945	4,968	4,945	4,945	15,157	12,144

# Fixed Effect Estimates of Demining - Heterogeneity. GIS

## Alternative Thresholds

[▶ Back](#)

	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Cleared Threats:				
- Road and Railway (200m)	0.313** (0.136) [0.041]	0.033** (0.015) [0.044]	0.398** (0.187) [0.055]	0.049** (0.022) [0.066]
- Border (20000m)	-0.651*** (0.173) [-0.057]	-0.057*** (0.018) [-0.050]	-0.656*** (0.216) [-0.061]	-0.052** (0.025) [-0.047]
- Cantinas (2000m)	0.322* (0.175) [0.035]	0.043** (0.017) [0.047]	0.586*** (0.200) [0.067]	0.069*** (0.022) [0.076]
- Civil War (2000m)	0.589*** (0.222) [0.051]	0.030 (0.021) [0.026]	0.749** (0.296) [0.068]	0.041 (0.029) [0.036]
- River (200m)	0.262 (0.537) [0.008]	0.026 (0.058) [0.008]	0.030 (0.614) [0.001]	0.011 (0.068) [0.004]
- Village (2000m)	0.427*** (0.114) [0.065]	0.038*** (0.012) [0.058]	0.534*** (0.144) [0.085]	0.048*** (0.016) [0.075]
- Electricity Grid (200m)	0.420 (0.286) [0.021]	0.036 (0.029) [0.018]	0.332 (0.286) [0.018]	0.020 (0.032) [0.011]
- Residual	-0.255*** (0.084) [-0.038]	-0.014 (0.009) [-0.021]	-0.316*** (0.108) [-0.051]	-0.014 (0.012) [-0.022]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.189	.136	.271	.242
Observations	27,301	27,301	4,748	4,748

# Fixed Effect Estimates of Demining - Heterogeneity Reports Based Classification

[Back](#)

	Yearly		Demining-Phase Estimation (1992, 1999, 2007, 2015)	
	Log Luminosity	Lit	Log Luminosity	Lit
Cleared Threats:				
- Road, Railway, Bridges	-0.036 (0.162) [-0.003]	0.010 (0.017) [0.009]	-0.360 (0.234) [-0.014]	0.001 (0.026) [0.001]
- Military	0.459** (0.219) [0.035]	0.048** (0.023) [0.038]	0.375 (0.243) [0.030]	0.036 (0.028) [0.020]
- Protection Ring & Residential	0.107 (0.125) [0.012]	0.008 (0.014) [0.009]	0.329** (0.141) [0.039]	0.031* (0.016) [0.036]
- Forest & Bush	-0.046 (0.214) [-0.002]	0.011 (0.022) [0.005]	-0.020 (0.313) [-0.001]	0.013 (0.037) [0.007]
- Footpath	-0.270* (0.158) [-0.023]	-0.007 (0.017) [-0.006]	-0.432** (0.206) [-0.040]	-0.027 (0.023) [-0.024]
- Farm	0.155 (0.180) [0.012]	0.015 (0.018) [0.012]	0.253 (0.218) [0.021]	0.035 (0.025) [0.028]
- Water Supply	-0.508 (0.426) [-0.020]	-0.054 (0.043) [-0.021]	-0.745 (0.480) [-0.030]	-0.089 (0.054) [-0.035]
- Electricity Pylons	0.291 (0.207) [0.012]	0.012 (0.019) [0.005]	0.108 (0.199) [0.006]	-0.002 (0.022) [-0.001]
- Public Infrastructure	0.436* (0.261) [0.031]	0.033 (0.026) [0.024]	0.710** (0.309) [0.053]	0.079** (0.032) [0.057]
- River	0.184 (0.276) [0.009]	0.015 (0.027) [0.007]	0.544* (0.319) [0.027]	0.047 (0.034) [0.023]
- Border	-1.175* (0.709) [-0.020]	-0.120 (0.077) [-0.021]	-0.452 (0.884) [-0.009]	-0.037 (0.114) [-0.007]
- Not Classified	0.256** (0.109) [0.040]	0.025** (0.010) [0.039]	0.351** (0.154) [0.058]	0.039** (0.016) [0.044]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	173	127	248	23
Observations	27,301	27,301	4,748	4,748

# Own Categories vs Report Based Categories [▶ Back](#)

Matching Report-Based and GIS-Based Categories														
	Military	Protective Ring	Forest & Bush	Footpath	Farm	Water Supply	Electricity Pylons	Residential	Public Infrastructure	River	Border	Road, Railway, Bridge	Not Classified	Total GIS
GIS Road (100m)	76	33	34	85	78	14	8	32	73	18	4	212	411	1078
GIS Railway (100m)	1	0	3	2	3	0	1	1	1	0	0	15	5	32
GIS Border (10000m)	5	2	6	5	8	0	2	3	5	2	20	5	46	109
GIS Cantinas (1000m)	12	4	3	10	11	3	1	4	12	3	0	13	38	114
GIS Civil War (1000m)	3	0	2	0	0	0	0	0	4	1	0	2	11	23
GIS River (100m)	0	5	2	2	3	0	0	1	1	2	0	6	17	39
GIS Village (1000m)	25	12	9	48	23	7	5	22	34	11	1	52	173	422
GIS Electricity Grid (100m)	8	2	7	1	6	1	240	5	12	8	0	9	46	345
GIS Rural	307	99	188	477	474	40	646	195	237	101	8	480	1748	5000
Total Report-Based	437	157	254	630	606	65	903	263	379	146	33	794	2495	7162

## Gravity Equation [▶ Back](#)

$$\ln X_{o,d} = A_o(X, \tau) + B_d(X, \tau) - \theta \tau_{o,d}.$$

- $X_{o,d}$ : total bilateral trade from origin to destination district.
- $\theta$ : "trade elasticity". Region's productivity for a given good (variety) is drawn from Frechét distribution with parameter  $\theta$
- $A_o(X, \tau)$ : origin's productivity and factor costs
- $B_d(X, \tau)$ : destination's productivity and factor costs



## Consumer Market Access [▶ Back](#)

- ▶ With expenditure shares as Eaton and Kortum (2002) and total expenditure equals to income ( $X_d = Y_d$ ):

$$X_{o,d} = k_1 A_o(q_0^\alpha w_o^\gamma)) - \theta \tau_{o,d}^{-\theta} Y_d CMA_d^{-1}.$$

- $X_{o,d}$ : total bilateral trade from origin to destination district.
- $\theta$ : "trade elasticity". Region's productivity for a given good (variety) is drawn from Frechét distribution with parameter  $\theta$
- $A_o(q_0^\alpha w_o^\gamma)$ : origin's productivity and factor costs
- $\tau_{o,d}$ : destination's cost
- $Y_d$ : destination's income
- $CMA_d$ : destination's consumer market access

## Firm Market Access [▶ Back](#)

- ▶ Sum over all destinations to get total output of  $o$ :

$$Y_o = \sum_o X_o d = k_1 A_o (q_0^\alpha w_o^\gamma) - \theta \sum_o \underbrace{\frac{\tau_{o,d}^{-\theta} Y_d}{CMA_d}}_{\equiv FMA_o}$$

- $FMA_o$ : origin's firm market access



# Aggregate Development

- ▶ Network element parametrization
- ▶ Sensitivity checks
  - Alternative  $\theta$  value
  - Inflating lumonsity of Maputo, Beira, Nacala
  - Alternative Network Parametrization
  - Relaxing the assumption of impassable landmines

## Parametrization of Transportation Costs [▶ Back](#)

- ▶ We classified network elements based on their efficiency  
(Jedwab and Storeygard (2015) and Donaldson (2017))
  - **Railways.** Cost per km = 1
  - **Paved Road.** Cost per km = 2
  - **Unpaved Road.** Cost per km = 4
  - **Trail.** Cost per km = 10
  - **Walking.** Cost per km = 20
- ▶ **Cost Calculation** =  $[length\ in\ kilometers \times Cost\ parameter]$

## Results - Alternative $\theta$ Values (Simonovska and Waugh (2014))

	Demining-Phase Estimation (1992, 1999, 2007, 2015)							
	Panel A: $\theta = 2.7$							
	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.370*** (0.104) [0.236]	0.040*** (0.011) [0.246]			0.385** (0.173) [0.206]	0.039** (0.018) [0.204]		
Log Market Access, Population			0.241** (0.107) [0.104]	0.024** (0.012) [0.102]			0.963*** (0.247) [0.353]	0.089*** (0.026) [0.317]
Cleared Threats	0.408*** (0.093) [0.093]	0.051*** (0.010) [0.114]	0.388*** (0.106) [0.089]	0.050*** (0.011) [0.112]	0.425*** (0.092) [0.097]	0.053*** (0.010) [0.119]	0.334*** (0.105) [0.077]	0.045*** (0.011) [0.102]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.25	.232	.253	.234	.243	.226	.259	.237
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

## Results - Alternative $\theta$ Values (Simonovska and Waugh (2014))

	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.201*** (0.044) [0.234]	0.022*** (0.005) [0.247]			0.204** (0.083) [0.206]	0.018** (0.009) [0.183]		
Log Market Access, Population			0.152*** (0.046) [0.124]	0.013*** (0.005) [0.107]			0.490*** (0.132) [0.361]	0.038*** (0.014) [0.271]
Cleared Threats	0.385*** (0.094) [0.088]	0.049*** (0.010) [0.109]	0.368*** (0.108) [0.084]	0.049*** (0.012) [0.109]	0.420*** (0.093) [0.096]	0.053*** (0.010) [0.119]	0.338*** (0.107) [0.077]	0.047*** (0.012) [0.106]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.254	.236	.255	.234	.243	.226	.259	.236
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

## Results - Alternative $\theta$ Values [▶ Back](#)

(Simonovska and Waugh (2014))

	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.129*** (0.027) [0.218]	0.014*** (0.003) [0.230]				0.024** (0.012) [0.184]		
Log Market Access, Population			0.095*** (0.028) [0.120]	0.052*** (0.018) [0.284]	0.052*** (0.018) [0.284]		0.643*** (0.173) [0.359]	0.052*** (0.018) [0.284]
Cleared Threats	0.375*** (0.094) [0.086]	0.047*** (0.010) [0.106]	0.374*** (0.107) [0.086]	0.047*** (0.012) [0.104]	0.047*** (0.012) [0.104]	0.053*** (0.010) [0.119]	0.334*** (0.106) [0.077]	0.047*** (0.012) [0.104]
Number of Localities	1,187	1,187	1,077	1,077	1,077	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.253	.235	.255	.236	.236	.226	.259	.236
Observations	4,748	4,748	4,308	4,308	4,308	4,748	4,308	4,308



## Results - Average $\tau$ [▶ Back](#)

Demining-Phase Estimation (1992, 1999, 2007, 2015)				
	Contemporaneous		Initial Conditions	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Log Average $\tau$	-3.507*** (0.518) [-0.397]	-0.333*** (0.059) [-0.368]	-3.652*** (0.542) [-0.333]	-0.368*** (0.054) [-0.328]
Cleared Threats	0.437*** (0.095) [0.100]	0.055*** (0.010) [0.122]	0.405*** (0.093) [0.093]	0.051*** (0.010) [0.114]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.251	.231	.257	.236
Observations	4,748	4,748	4,748	4,748

## Results - Market Potential [▶ Back](#)

Demining-Phase Estimation (1992, 1999, 2007, 2015)				
	Contemporaneous		Initial Conditions	
	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)
Log Market Potential	1.432*** (0.401) [0.306]	0.162*** (0.044) [0.337]	3.986*** (0.504) [0.570]	0.402*** (0.052) [0.561]
Cleared Threats	0.420*** (0.093) [0.096]	0.052*** (0.010) [0.117]	0.355*** (0.093) [0.081]	0.046*** (0.010) [0.103]
Number of Localities	1,187	1,187	1,187	1,187
Locality FE	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes
R-squared	.244	.228	.26	.239
Observations	4,748	4,748	4,748	4,748

## Results - Inflating Luminosity of Maputo, Beira and Nacal

▶ Back

	Demining-Phase Estimation (1992, 1999, 2007, 2015)							
	Contemporaneous				Initial Conditions			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.263*** (0.061) [0.235]	0.028*** (0.006) [0.245]			0.272** (0.108) [0.213]	0.026** (0.011) [0.197]		
Log Market Access, Population			0.170** (0.068) [0.104]	0.016** (0.007) [0.093]			0.617*** (0.176) [0.336]	0.052*** (0.018) [0.273]
Cleared Threats	0.398*** (0.094) [0.091]	0.050*** (0.010) [0.112]	0.381*** (0.107) [0.087]	0.050*** (0.012) [0.111]	0.421*** (0.093) [0.096]	0.053*** (0.010) [0.119]	0.340*** (0.105) [0.078]	0.047*** (0.011) [0.105]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.253	.235	.253	.234	.244	.226	.258	.236
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

## Results - Alternative Network Parametrization (Jedwab and Storeygard (2018))

	Demining-Phase Estimation (1992, 1999, 2007, 2015)							
	Contemporaneous				Initial Conditions			
	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.235*** (0.058) [0.213]	0.025*** (0.006) [0.226]			0.259** (0.103) [0.199]	0.024** (0.011) [0.177]		
Log Market Access, Population			0.120* (0.061) [0.075]	0.011 (0.007) [0.066]			0.615*** (0.166) [0.332]	0.048*** (0.018) [0.252]
Cleared Threats	0.395*** (0.093) [0.090]	0.050*** (0.010) [0.111]	0.393*** (0.107) [0.090]	0.051*** (0.012) [0.114]	0.422*** (0.092) [0.097]	0.053*** (0.010) [0.119]	0.337*** (0.105) [0.077]	0.047*** (0.011) [0.105]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.251	.234	.253	.233	.243	.226	.259	.236
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

## Results - Dropping Railways [▶ Back](#)

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Initial			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.277*** (0.063) [0.245]	0.030*** (0.007) [0.257]			0.295*** (0.110) [0.228]	0.029** (0.012) [0.216]		
Log Market Access, Population			0.190*** (0.067) [0.115]	0.017** (0.007) [0.103]			0.691*** (0.178) [0.374]	0.057*** (0.019) [0.302]
Cleared Threats	0.391*** (0.094) [0.090]	0.049*** (0.010) [0.110]	0.374*** (0.108) [0.086]	0.049*** (0.012) [0.110]	0.420*** (0.093) [0.096]	0.053*** (0.010) [0.118]	0.331*** (0.107) [0.076]	0.046*** (0.012) [0.103]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.254	.236	.254	.234	.244	.226	.259	.237
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

## Results - Land mines as passable obstacles [▶ Back](#)

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Initial			
	Log Luminosity		Lit		Log Luminosity		Lit	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.276*** (0.073) [0.224]	0.030*** (0.007) [0.236]			0.681*** (0.180) [0.501]	0.073*** (0.021) [0.526]		
Log Market Access, Population			0.069 (0.073) [0.041]	0.008 (0.008) [0.049]			0.761** (0.324) [0.412]	0.085*** (0.031) [0.447]
Cleared Threats	0.430*** (0.095) [0.098]	0.053*** (0.010) [0.119]	0.421*** (0.109) [0.097]	0.053*** (0.012) [0.119]	0.408*** (0.098) [0.093]	0.051*** (0.011) [0.114]	0.384*** (0.111) [0.088]	0.049*** (0.012) [0.110]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.25	.232	.252	.233	.245	.228	.253	.234
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

## Results - Excluding Adjacent Neighbors [▶ Back](#)

Demining-Phase Estimation (1992, 1999, 2007, 2015)								
	Contemporaneous				Initial			
	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit	Log Luminosity	Lit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Market Access, Light	0.136** (0.054) [0.115]	0.012* (0.006) [0.097]			0.272** (0.109) [0.191]	0.024** (0.012) [0.167]		
Log Market Access, Population			0.208*** (0.072) [0.131]	0.021*** (0.008) [0.132]			0.571*** (0.129) [0.304]	0.052*** (0.014) [0.273]
Cleared Threats	0.436*** (0.093) [0.100]	0.055*** (0.010) [0.122]	0.379*** (0.105) [0.087]	0.049*** (0.011) [0.109]	0.429*** (0.092) [0.098]	0.054*** (0.010) [0.121]	0.345*** (0.104) [0.079]	0.046*** (0.011) [0.104]
Number of Localities	1,187	1,187	1,077	1,077	1,187	1,187	1,077	1,077
Locality FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year x Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	.243	.225	.254	.235	.244	.226	.26	.238
Observations	4,748	4,748	4,308	4,308	4,748	4,748	4,308	4,308

## Results - Long-Run Difference [▶ Back](#)

[illegible]



▶ Back

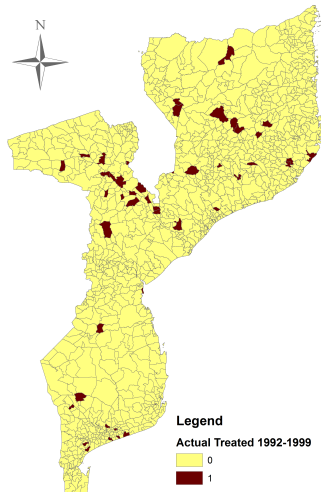
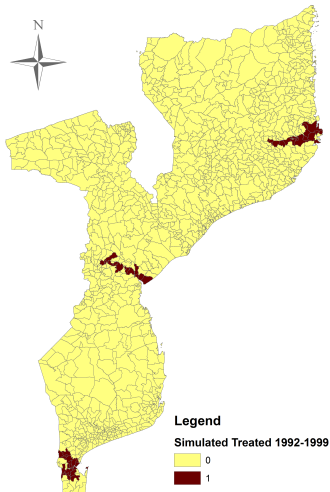
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## Policy Experiment

- ▶ Maps of simulated treated versus actual treated 1992-1999
- ▶ Maps of simulated treated versus actual treated 1992-2007

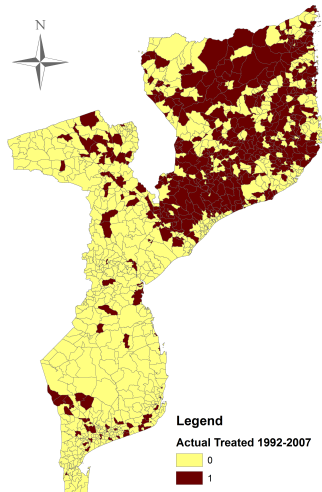
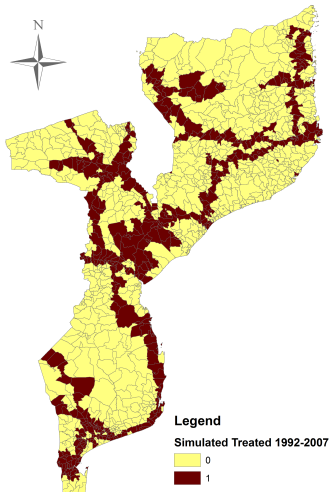
## Simulated vs Actual Treated 1992-1999

▶ Back



## Simulated vs Actual Treated 1992-2007

▶ Back



# Validating Luminosity as development proxy

- ▶ Luminosity - Income/Education Mapping (DHS)
  - Regression estimates results
  - Graph Luminosity - Income at Admin 3
  - Graph Luminosity - Education at Admin 3

## Luminosity Income/Education Mapping (DHS)

### Mozambique Administrative Level 4 Evidence

The numbers are the coefficient estimates of different regressions on the effect of being lit on years of schooling and wealth.

**Education:** Mean (median) years of schooling 4.67 (5); 21391 obs

- 1.8 (unconditional); 1.5 with province fixed-effects (391 obs)
- 1.1 in rural and 2.9 in urban (unconditional)

**Wealth:** Mean (median) composite wealth index (range 1-5). 3.21 (3)

- 1.5 (unconditional); 0.91 with province fixed-effects (391 obs)
- 0.32 in rural and 2 in urban (unconditional)

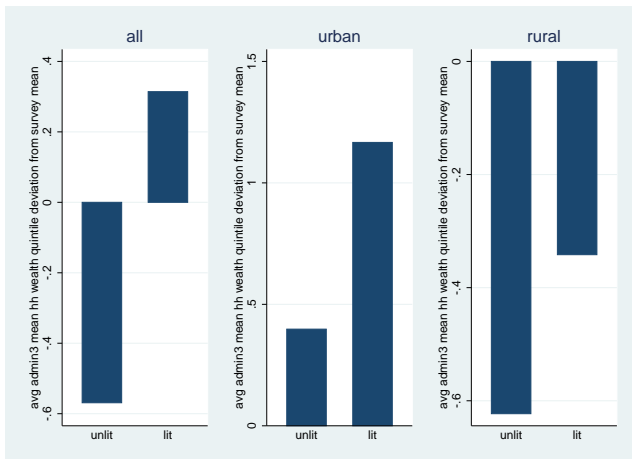
Stronger results at the DHS Household level.

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## Luminosity Income Mapping (DHS) [▶ Back DID](#) [▶ Back MA](#)

### Africa Administrative Level 3 Evidence (21 Countries - 74 Surveys)



## Luminosity Education Mapping (DHS)

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### Africa Administrative Level 3 Evidence (21 Countries - 74 Surveys)

