Spatial Inefficiencies in Africa's Trade Network

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Motivation

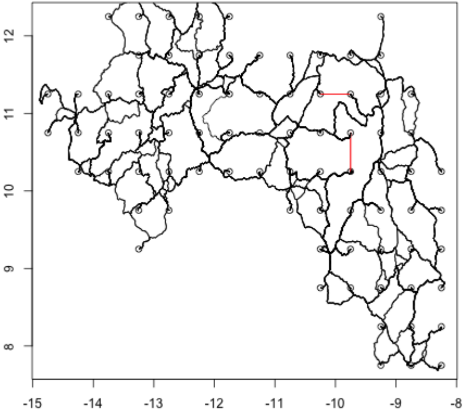
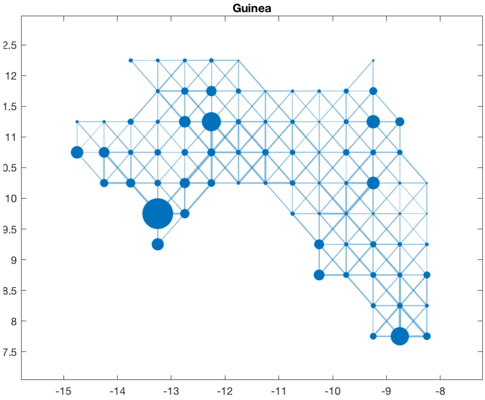


Figure: Road Network Guinea

Motivation



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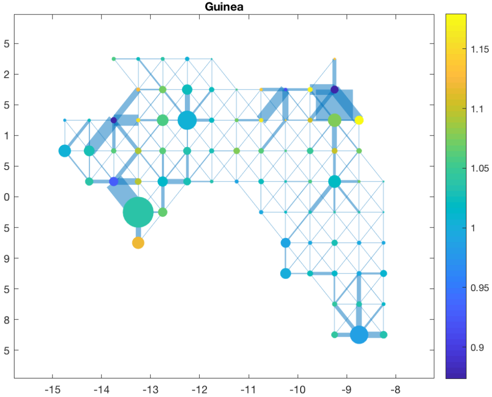

Figure: Optimal Road Network Guinea

Motivation

- Are African roads where they should be?
- Which country has the most efficient trade network?
- Do some regions have *too* many roads?

Motivation

Individual transport policies

$\Longleftrightarrow$

Overall network efficiency

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Individual transport policies

$\Longleftrightarrow$

Overall network efficiency

Steps

1. Network representation for all African countries
   - Nodes
   - Edges
2. Employ in simple trade model
3. Reshuffle roads to get optimal network
4. Analyse patterns of reshuffling

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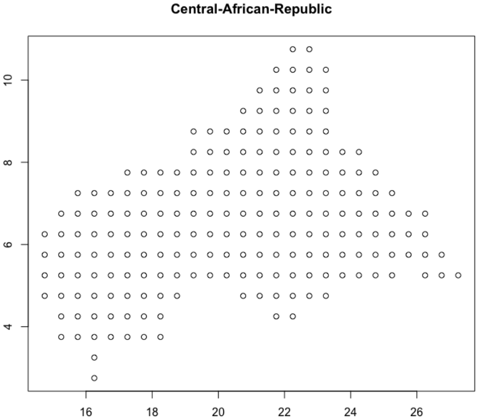
Network Nodes

Figure: 10,167 grid cells (0.5 x 0.5 degrees)

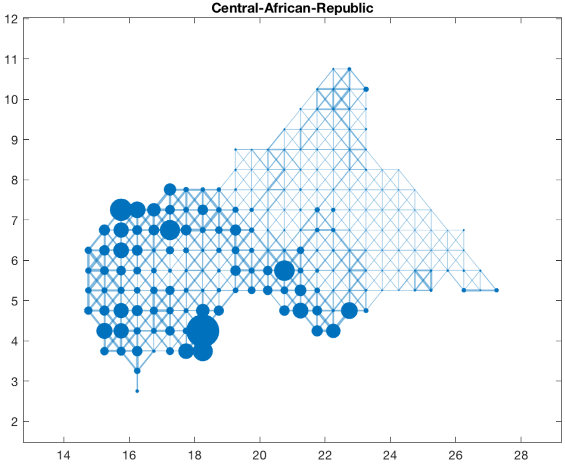
Network Nodes

- Population
- Output (night lights)
- Geography



Network Edges

- Average Speed
- Distance
- Topography



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Trade Model – see Fajgelbaum & Schaal (2017)

- Node i houses L_i and produces Y_i^n of good n
- Two varieties $n \in \{\text{urban}, \text{rural}\}$
- Consumers in i consume $C_i = \left(\sum_n (C_i^n)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$
- Derive utility $u_i = c_i^{\alpha}$, where $c_i = \frac{C_i}{L_i}$
- Can trade with neighbouring nodes $N(i)$
- Occur iceberg trade cost $\tau_{i,k}^n = \delta_{i,k}^{\tau} \frac{(Q_{i,k}^n)^{\beta}}{I_{i,k}^{\gamma}}$
  - costs fall with $I_{i,k}$ (*infrastructure*)
  - costs rise with $Q_{i,k}^n$ (*congestion*)

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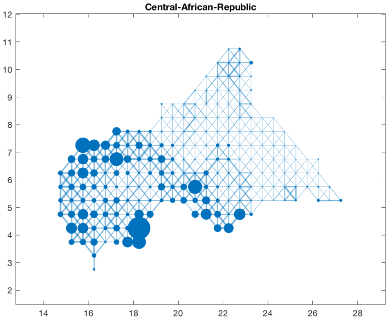
Trade Model – see Fajgelbaum & Schaal (2017)

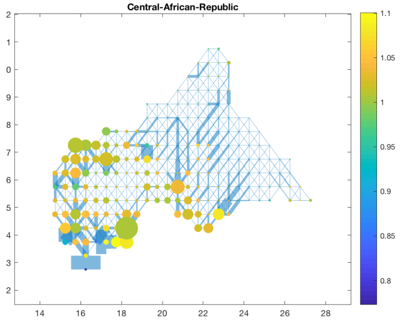
- Social planner can reallocate infrastructure $I_{i,k}$
- Keeping total infrastructure cost fixed
  - $\sum_i \sum_{k \in N(i)} \delta^I_{i,k} I_{i,k} \leq K$
  - where K = total cost of building the current network

Full Planner's Problem

Network Reallocation

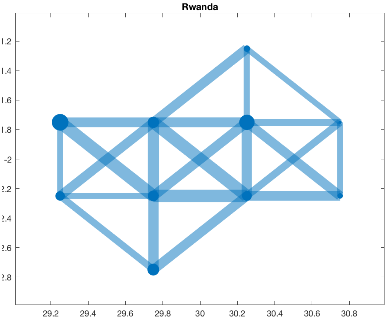


(a) pre reallocation

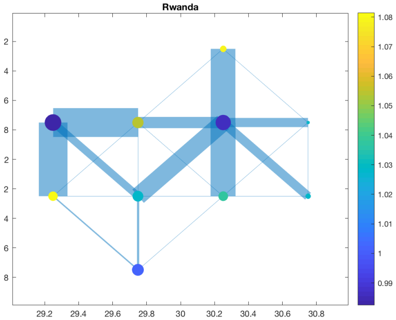


(b) post reallocation

Network Reallocation

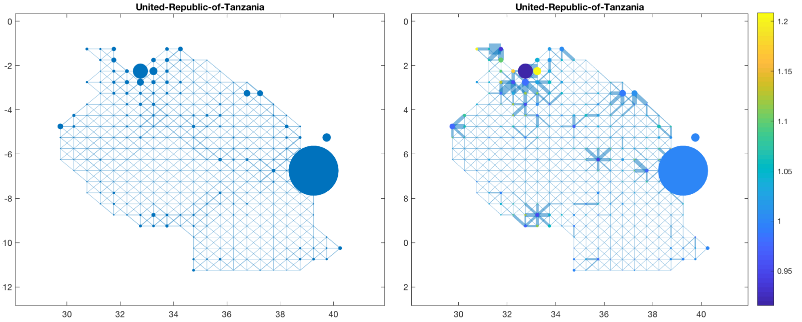


(a) pre reallocation



(b) post reallocation

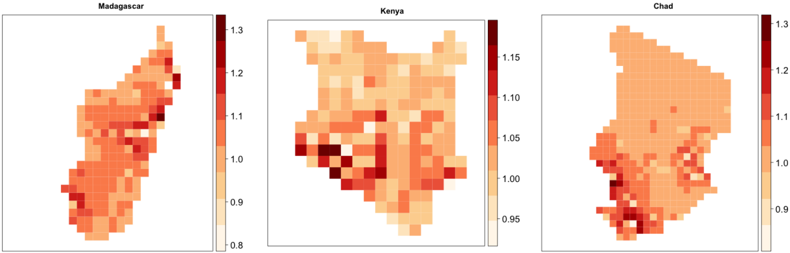
Network Reallocation



(a) pre reallocation **(b)** post reallocation

Λ_i for sample countries

Figure: Local Infrastructure Discrimination Index Λ_i



(a) Madagascar **(b)** Kenya **(c)** Chad

$$\Lambda_i = \frac{\text{Welfare under the optimal Infrastructure}_i}{\text{Welfare under the current Infrastructure}_i}$$

Λ_i for entire sample

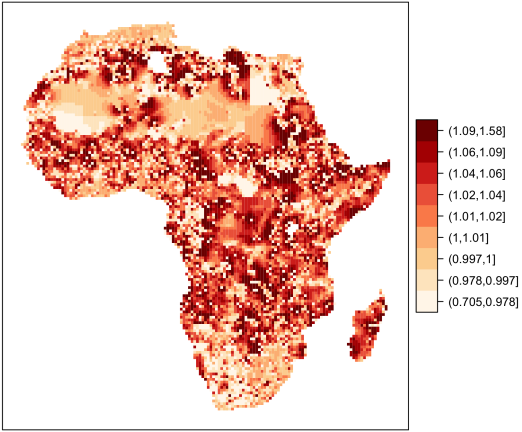


Figure: African grid cells by Λ_i

Country Map

Steps

1. Network representation for all African countries
   - Nodes
   - Edges
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Why do some areas have too few roads while others have too many?

Lasting impact of Colonial Railroads

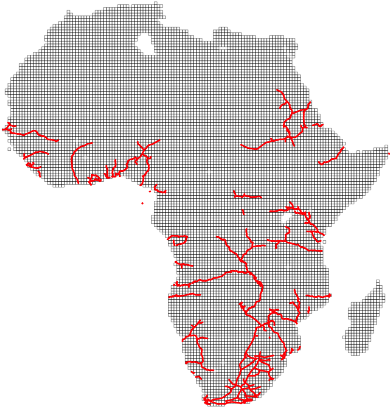

Figure: Colonial Railroads

Source: Jedwab & Moradi (2016) and own digitisations

Lasting impact of Colonial Railroads

	Dependent variable:							
	Local Infrastructure Discrimination Index Λ_i							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
KM of Colonial Railroads	−0.0002***	−0.0001***	−0.0002***	−0.0002***				
	(0.0001)	(0.0001)	(0.0001)	(0.0001)				
KM of Colonial Placebo Railroads					0.00004	−0.0002	−0.0003	−0.0003
					(0.0003)	(0.0003)	(0.0003)	(0.0003)
Country FE		Yes	Yes	Yes		Yes	Yes	Yes
Geographic controls			Yes	Yes			Yes	Yes
Simulation controls				Yes				Yes
Observations	10,158	10,158	10,158	10,158	10,158	10,158	10,158	10,158
R^2	0.001	0.099	0.112	0.114	0.00000	0.098	0.111	0.113
Note:								*p<0.1; **p<0.05; ***p<0.01

Columns (1)-(4) estimate the effect of colonial infrastructure investments on today's Local Infrastructure Discrimination Index. Starting with a simple univariate cross-section in (1), column (2) adds 49 country-fixed effects. Column (3) adds geographic controls, consisting of altitude, temperature, average land suitability, malaria prevalence, yearly growing days, average precipitation, the fourth-order polynomial of latitude and longitude, and an indicator of whether the grid cell lies on the border of a country's network. Simulation controls are added in column (4) and are comprised of population, night lights, ruggedness, and a dummy for whether a cell is classified as urban. These are indicators that went into the original infrastructure re-allocation simulation and are hence not orthogonal to Λ. Columns (5)-(8) repeat these calculations with railroads that were planned, but never built ("placebo railroads"). Results are robust to using only the subsample of 33 countries with any colonial infrastructure investment as reported by Jedwab & Moradi (2016), plus South Africa. Heteroskedasticity-robust standard errors are clustered on the 3x3 degree level and are shown in parantheses.

General Equilibrium Effects of Colonial Railroads

	Dependent variable:							
	Local Infrastructure Discrimination Index Λ_i							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$<$ 10 KM to Colonial Railroad	-0.013^{***}	-0.015^{***}	-0.017^{***}				-0.014^{***}	
	(0.003)	(0.004)	(0.004)				(0.004)	
10 $-$ 20 KM to Colonial Railroad	-0.013^{***}	-0.015^{***}	-0.017^{***}				-0.015^{***}	
	(0.005)	(0.005)	(0.005)				(0.005)	
20 $-$ 30 KM to Colonial Railroad	-0.002	-0.004	-0.005				-0.005	
	(0.004)	(0.004)	(0.004)				(0.004)	
30 $-$ 40 KM to Colonial Railroad	0.010^{**}	0.008^{*}	0.007				0.008	
	(0.005)	(0.005)	(0.005)				(0.005)	
$<$ 10 KM to Colonial Placebo Railroad				-0.005	-0.005	-0.006		-0.007^{*}
				(0.004)	(0.004)	(0.004)		(0.004)
10 $-$ 20 KM to Colonial Placebo Railroad				-0.003	-0.004	-0.004		-0.005
				(0.005)	(0.005)	(0.005)		(0.005)
20 $-$ 30 KM to Colonial Placebo Railroad				-0.001	-0.001	-0.001		-0.004
				(0.004)	(0.004)	(0.004)		(0.004)
30 $-$ 40 KM to Colonial Placebo Railroad				0.007	0.006	0.005		0.003
				(0.004)	(0.004)	(0.004)		(0.004)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic controls		Yes	Yes		Yes	Yes	Yes	Yes
Simulation controls			Yes			Yes	Yes	Yes
Observations	10,158	10,158	10,158	10,158	10,158	10,158	6,362	6,362
R^2	0.101	0.115	0.118	0.099	0.111	0.114	0.116	0.110
Note:						*p$<$0.1; **p$<$0.05; ***p$<$0.01		

Concerns

- Identification
- Non-linearity of model
- ...

Backup: full planner's problem

$$\max_{\substack{\left\{C_i^n, \{Q_{i,k}^n\}_{k\in N(i)}\right\}_n, \\ c_i, \left\{I_{i,k}\right\}_{k\in N(i)}}} \quad \sum_i L_i u(c_i)$$

subject to

$$L_i c_i \leq \left(\sum_{n=1}^{N} (C_i^n)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

$$C_i^n + \sum_{k\in N(i)} Q_{i,k}^n (1 + \tau_{i,k}^n(Q_{i,k}^n, I_{i,k})) \leq Y_i^n + \sum_{j\in N(i)} Q_{j,i}^n$$

$$\sum_i \sum_{k\in N(i)} \delta_{i,k}^i I_{i,k} \leq K$$

$$I_{i,k} = I_{k,i} \text{ for all } i \in \mathcal{I}, k \in N(i)$$

$$C_i^n, c_i, Q_{i,k}^n \geq 0 \text{ for all } i \in \mathcal{I}, n \in \mathcal{N}, k \in N(i).$$

Back

Backup: Λ for entire countries

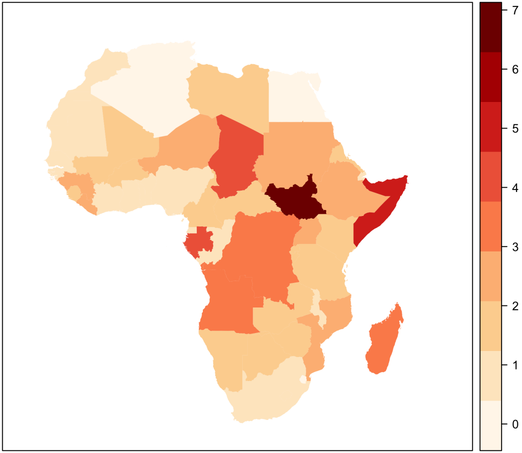

Figure: African countries by Λ_i

Back