Public Roads on Private Lands: Land Costs and Optimal Road Improvements in Urban Uganda

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NBER SI 2025 (Development)

Poor Road Infrastructure in African Cities

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Can low net returns explain low levels of investments in road infrastructure?

Widespread Beliefs of Large Benefits of Road Improvements

- *"Poor transportation infrastructure limits access to markets and public services."* (World Bank 2009)
- Road quality is associated with economic development (Akbar et al. 2023)

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Widespread Beliefs of Large Benefits of Road Improvements

$\uparrow$ road quality $\Rightarrow \uparrow$ speed $\Rightarrow \downarrow$ commuting time $\Rightarrow \Delta$ connectedness all over the city

Complex and Overlooked Costs of Road Improvements

$$\text{Costs} = \text{construction} + \underbrace{\text{acquisition of private land}}_{\text{market value + land ownership}}$$

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- 30% of WB-funded projects delayed because of land acquisition (WB 1996)

How do private land costs shape the net returns of road improvements?

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⇒ This paper: road improvements in Kampala, Uganda

The Independent Uganda

‘Private land ownership frustrating public projects’

Kampala, Uganda | THE INDEPENDENT | Private land ownership during implementation of public projects is frustrating plans to adopt physical...

Aug 18, 2023

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2. Citywide impacts, impact on optimal road placement & policy counterfactuals
   - **quantitative spatial model**

Results Overview

1. Evaluation of 180 km of realized improvements: concentrated in locations w/ Literature
   - low land payments: low market value & weak property rights
   - high benefits: $\underbrace{\text{+ 3.7 km/h local speed}}_{\text{reduced-form}}$; $\underbrace{\text{-4.9 \% avg commuting time}}_{\text{structural}}$

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     - realized improvements (\$8 vs \$166) & misallocation (\$67 vs \$217)
     - weak property rights have unintended positive consequences

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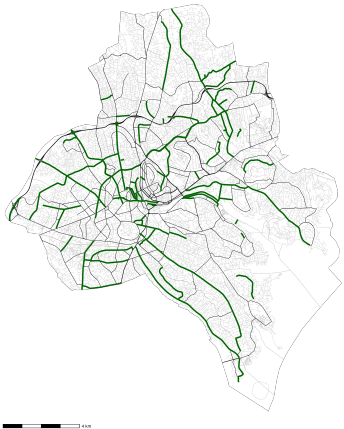
     - realized improvements (\$8 vs \$166) & misallocation (\$67 vs \$217)
     - weak property rights have unintended positive consequences
   - Restrictions on the use of external funds (e.g. WB, AfDB) lead to misallocation (\$67 vs \$281)

Outline

1. Context & Data
2. Reduced-Form Evidence
3. Model
4. Results & Counterfactuals

Context & Data

Road Improvements in Kampala



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  - avg traffic speed 24 km/h (25^{th} pctile world)

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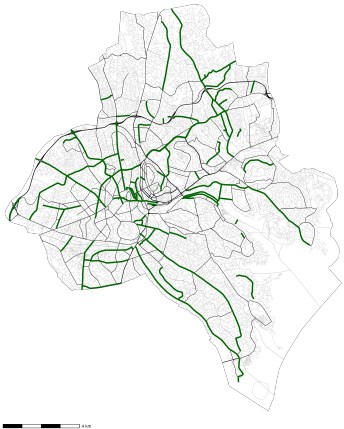

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  - staggered rollout since 2017

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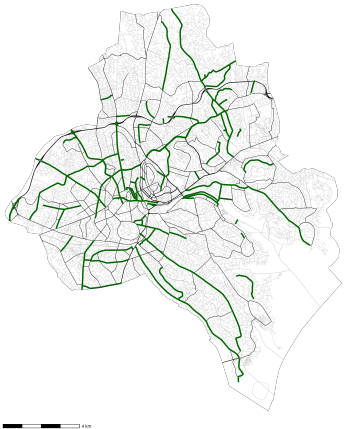

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  - avg traffic speed 24 km/h (25^{th} pctile world)
- 179 km of road improvements
  - 80%: construction funded: WB + AfDB
  - staggered rollout since 2017
- Paving + widening on private land
  - Legal: eminent domain w. compensation
  - In practice: not all get compensated

New Data to Study Road Improvements in Kampala

1. Land costs = market value $\times$ owners claiming the compensation
   - 1.1 Market value — Broker survey
   - 1.2 Share of owners claiming the compensation — Landowner survey
2. Benefits
   - 2.1 Local Property Values — Broker survey
   - 2.2 Road quality — Landowner survey
   - 2.3 Traffic speed — GoogleMaps queries
   - 2.4 Citywide impact (valuation of $\downarrow$ commuting time) — Ride-hailing data

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Novel Real Estate Broker Survey

377 (informal) real estate brokers all over the city

Novel Real Estate Broker Survey

1. standardized property appraisal exercise
   - vary characteristics one by one
2. $\approx 3,250$ past transactions
   - detailed characteristics
   - sales (2018-2024) and rental (2023-2024)
   - median sales price residential = $40,541
     - monthly rental =$108

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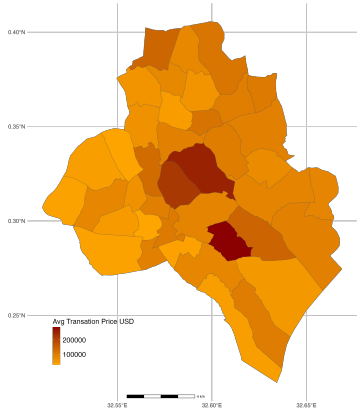

Average Transaction (Sale) Price by Neighborhood (2023-2024)

Comparison w/ Online

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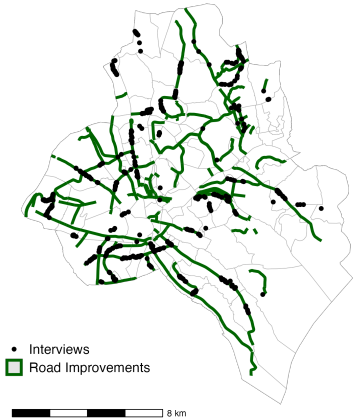
Novel Landowner Survey

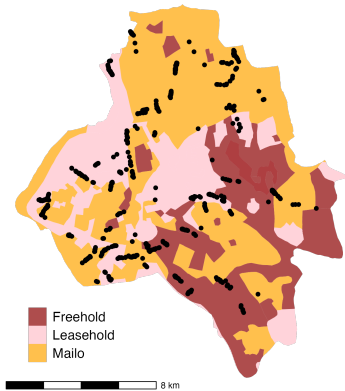
- 548 owners w/ affected property on upgraded roads
- Change in road quality
- Land acquisition process
  - amount + value of affected land
  - decision to claim the compensation
  - stated preferences + beliefs
- Avg land taken: 1.5 m (width)



Census | Sampling | Stated reasons claim | Stated reasons not to claim | Not pivotal | No strategic holdout

Novel Landowner Survey

- 548 owners w/ affected property on upgraded roads
- Change in road quality
- Land acquisition process
  - amount + value of affected land
  - decision to claim the compensation
  - stated preferences + beliefs
- Three property right regimes covered
  - leasehold most secure



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Traffic-Related Data

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   - 2.3 Traffic speed — GoogleMaps queries
     - road-level trips for representative sets of policy roads $\Rightarrow$ impact improvement on speed (03/2023 - 08/2024)
   - 2.4 Citywide impact (valuation of $\downarrow$ commuting time) — Ride-hailing data
     - random sample of weeks since 2019 ; 2.3 million trips & 330,000 unique users

Map

Census

Reduced-Form Evidence

Costs and Benefits of Road Improvements in Kampala

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Land Loss Can Be Substantial

Owner survey

- average owner looses 73 m^2 (786 ft^2)

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- average owner looses 73 m^2 (786 ft^2)
- property value after upgrade $<$ before upgrade for 26% of owners

Land Payments

$$\text{total land payment} = \sum_i \underbrace{\text{land taken}_i \times \text{market rate (pre)}_i}_{\text{legal(eminent domain)}} \times \underbrace{\text{share owners compensated}_i}_{\text{practice}}$$

Market Value is High and Spatially Heterogeneous

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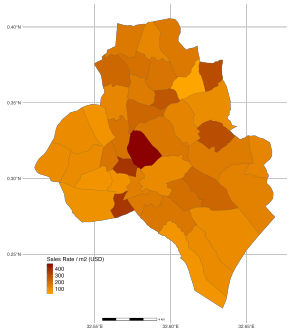
Broker survey:

- Market value of land taken = \$94 million
  - construction $\approx$ \$102 million
- Spatially heterogeneous



Residential Market Rate (pre)

Not all Owners Get Compensated

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Owner survey:

- 20% of interviewed owners claim the compensation

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Owner survey:

- 20% of interviewed owners claim the compensation
- Claim probability increasing in the compensation
  - 1 sd $\uparrow$ mv ($\$\,7,558$) $\Rightarrow \uparrow$ 27 pp claim proba

Large Costs of Claiming the Compensation

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  - copy ownership docs avg costs = $\$1,700$

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Heterogeneity Across Property Right Regimes

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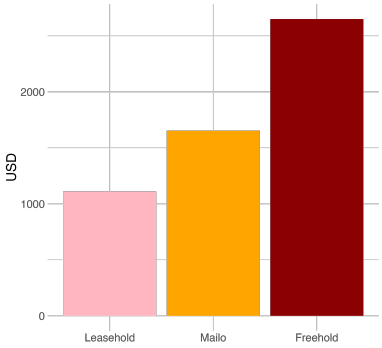
- Heterogeneity across property right regimes



Cost of Copy Ownership Documents

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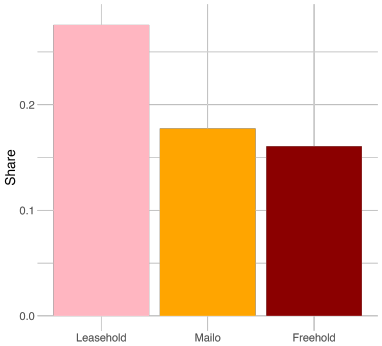
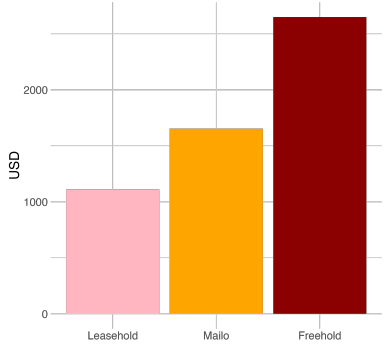


Share of claims



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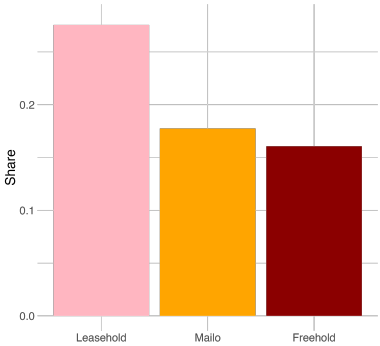

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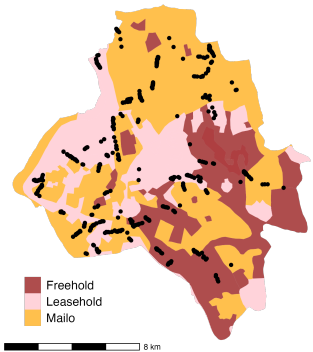

Costs and Benefits of Road Improvements in Kampala

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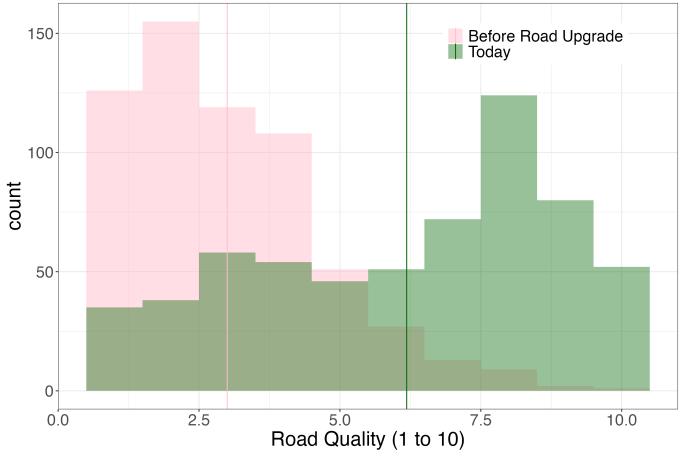
Impacts of Road Improvements on Road Quality



$\Rightarrow$ Improvement in road quality

(Owner Survey)

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Impacts of Road Improvements on Traffic Speed

$$s_{kl,t} = \alpha + \beta D_{kl,t} + X_{kl}'\gamma + \eta_t + e_{kl,t}$$

- **Data**: GoogleMaps queries (03/23-08/24)
- **Sample**: Policy roads Balance
- $s_{kl,t}$: speed on kl at time t
- $D_{kl,t}$: dummy variable if kl upgraded by t
- X_{kl} road controls: polynomial in lat/lon, class
- η_t: time fixed-effects

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Balance

Matching

	Dependent variable:			
	Traffic Speed (km/h)			
	(1)	(2)	(3)	(4)
Upgraded (dummy)	3.741***	3.753***	3.401***	3.289***
	(0.912)	(0.830)	(0.667)	(0.653)
Avg dep var	21.9	21.9	21.9	20.9
Time of Day	All	All	All	All
Hour + Day FE	Y	Y	Y	Y
Road char controls		Y	Y	Y
Geo controls			Y	
Match				Y
Observations	1,261	1,261	1,261	2,282
R^2	0.323	0.343	0.424	0.636
Note:				*p<0.1; **p<0.05; ***p<0.01

Rush / no rush

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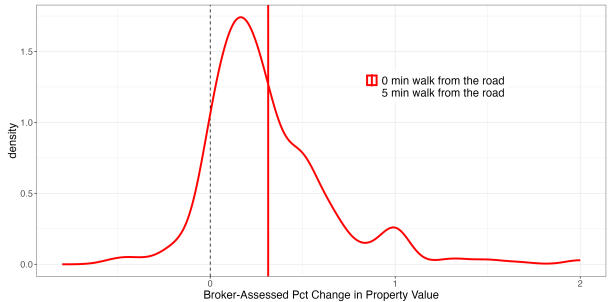
Increase in Local Property Values



- Broker survey:
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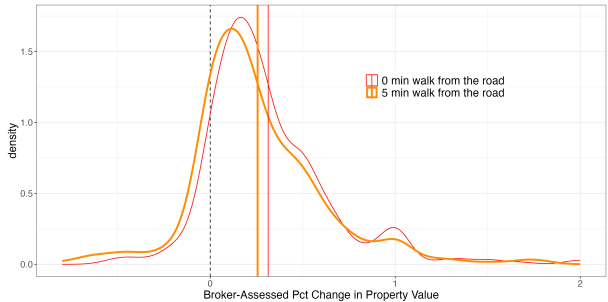
Evidence of Spatial Spillovers



- Broker survey:
  - average change in property value by upgraded roads = 30%
  - average change in property value 5 min walk from upgraded roads = 25%

Costs and Benefits of Road Improvements: Taking Stock

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$\Rightarrow$ quantitative spatial model

Model Overview

Model Overview - QSM

- Quantitative Spatial Model (Ahlfeldt et al. '15, Allen and Arkolakis '22) w. land use Full Model

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1. Freely tradable consumption good — Extension: Trading costs
2. Workers freely choose where to live, work and commute
   - Road improvement $\Rightarrow \uparrow$ local speed $\Rightarrow \downarrow$ commuting costs $\Rightarrow \Delta$ market access $\Rightarrow$ reallocation — Extension: Amenities

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- Quantitative Spatial Model (Ahlfeldt et al. '15, Allen and Arkolakis '22) w. land use [Full Model]

1. Freely tradable consumption good [Extension: Trading costs]
2. Workers freely choose where to live, work and commute
   - Road improvement $\Rightarrow \uparrow$ local speed $\Rightarrow \downarrow$ commuting costs $\Rightarrow \Delta$ market access $\Rightarrow$ reallocation [Extension: Amenities]
3. Land is split between roads and privately owned residential land
   - Opportunity cost: Road improvement $\Leftrightarrow$ road widening $\Rightarrow \downarrow$ residential land supply
   - Financial cost: land payment =f(rule, market value, owners' property rights) (model owners' decision to claim)

Model Overview - Government

- Government chooses road width R_{kl} to maximize the net welfare of its residents

$$\max_{\{R_{kl}\}} \quad \mathsf{W} = \sum_i \omega_i^o \times \underbrace{W_i^{\mathrm{o}}(\{R_{kl}\})}_{\text{welfare owner in } i} + \omega^w \times \underbrace{W^{\mathrm{w}}(\{R_{kl}\})}_{\text{expected welfare worker}} - \underbrace{\eta}_{\text{mcpf}\geq 1} \underbrace{\hat{C}}_{\text{land expenditures}}$$

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$$\hat{C} \equiv \sum_i \left(\sum_k \underbrace{\gamma_i\left(R_{ki}\right)}_{\text{share paid}} \times \underbrace{q_i^0}_{\text{market rate}} \underbrace{\frac{l_{ki}}{2}\left(R_{ki} - R_{ki}^0\right)}_{\text{land area taken}} \right)$$

- Today: fix maximum amount of road improvements to the observed level

Model Overview - Policy Parameters (1)

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- Payment rule: land payments depend on market value & heterogeneous property rights
  - alt: eminent domain: $\hat{C} = \sum_i \sum_k q_i^0 \frac{l_{ki}}{2} \left(R_{ki} - R_{ki}^0\right)$

Model Overview - Policy Parameters (2)

- Government chooses road width R_{kl} to maximize the net welfare of its residents

$$\max_{\{R_{kl}\}} \quad \mathsf{W} = \sum_i \omega_i^o \times \underbrace{W_i^o\left(\{R_{kl}\}\right)}_{\text{welfare owner in } i} + \omega^w \times \underbrace{W^w\left(\{R_{kl}\}\right)}_{\text{expected welfare worker}} - \underbrace{\eta}_{\text{mcpf}\geq 1} \underbrace{\hat{C}}_{\text{land expenditures}}$$

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- External funds cannot be used for land acquisition
  - alt: $\hat{C} = \sum_i \sum_k \gamma_i\left(R_{il}\right) \times \left(q_i^0 \frac{l_{ki}}{2}\left(R_{ki} - R_{ki}^0\right)\right) - \left(\underbrace{\bar{M}}_{\text{external funds}} - \underbrace{\bar{p} \sum_{ki}\left(R_{ki} - R_{ki}^0\right)}_{\text{construction costs}} \right)$

Main Model Parameters

Main model parameters estimated with my data: Full Table

- Land costs
  - Broker survey ⇒ property values
  - Owner survey ⇒ discrete choice model of owners' decision to claim the compensation Owner Model
- Googlemaps + upgrade rollout ⇒ elasticity of speed on road width $\hat{\xi} = 0.39$ ξ
  - Much higher than in HIC / MIC (Fajgelbaum and Schaal 22' = 0.1 ; Bordeu '24 = 0.13)
- Local ride hailing data ⇒ elasticity of location choice on commuting time $\hat{\theta\kappa} = 0.033$ $\theta\kappa$
  - Similar to HIC / MIC (Ahlfeldt et al. '15 = 0.07 ; Tsivanidis '23 = 0.028)

+ literature and census data to calibrate the other parameters and the model at baseline

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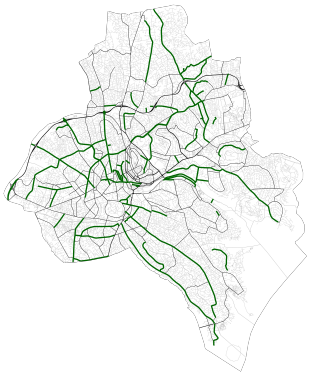
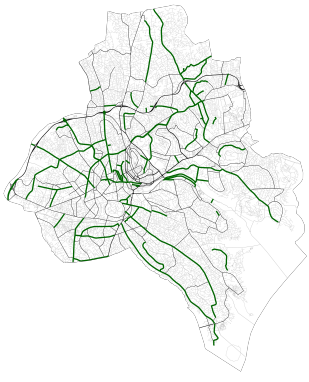
Welfare Impacts of Kampala Road Improvements



Upgraded Roads (dummy)

Welfare Impacts of Kampala Road Improvements



Upgraded Roads (dummy)

- Citywide benefits
  - avg commuting time: -4.9% (-6.9% fixing locations)
  - total property values: $+1.48\%$ ($+\$32$ million)

Graph MCPF

Table

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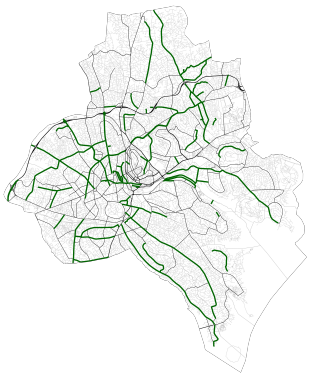

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  - construction: \$102 million
  - land: \$19 million (\$93 million eminent domain)

Graph MCPF

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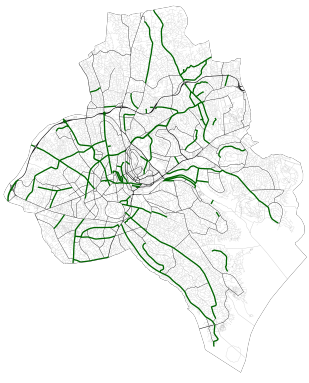

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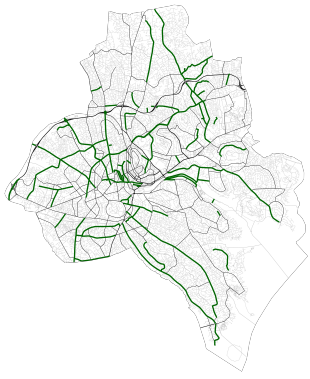

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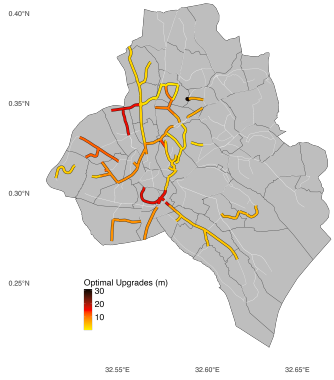
- Net welfare impact / resident: $+\$166$ (mcpf = 1.5)
  - eminent domain: \$8 (\$-170 with mcpf = 2.56)
- More upgrades where large net gains, large gross gains & low land costs
  - especially externally funded — Table

Policy Counterfactuals: Enforcing Land Payment Rule



Market Value
$67

Map Property Right Regimes | Property Right Regimes | Land use | Table

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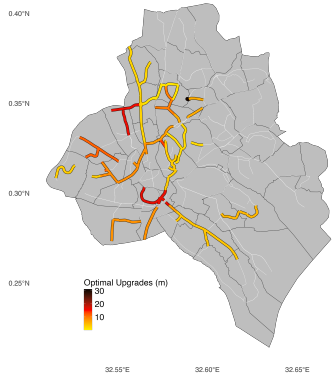

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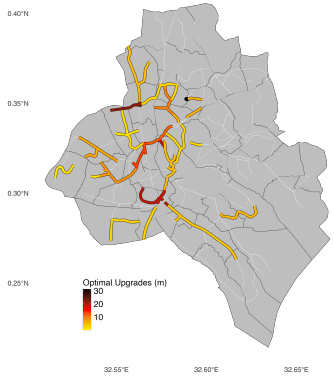

Status quo
$217

Map Property Right Regimes | Property Right Regimes | Land use | Table

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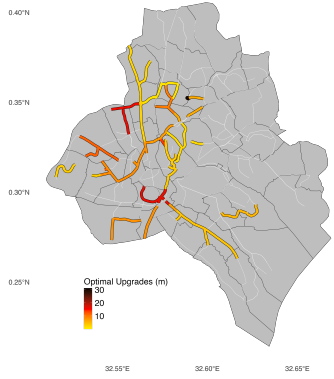

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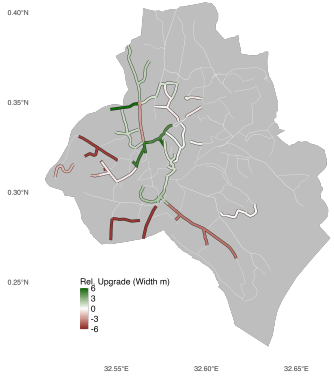

Status quo - market value (diff)
$217

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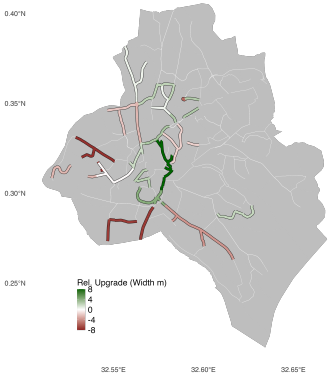
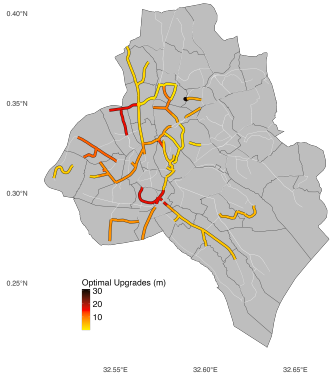
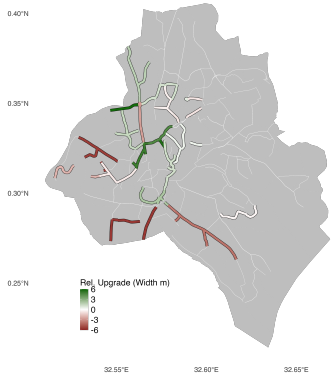


No payment - market value (diff)
$315



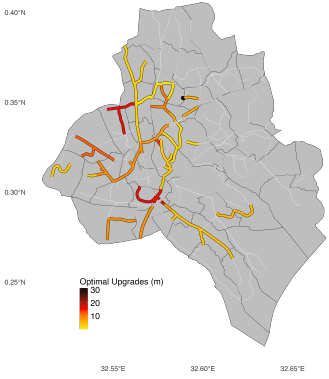
Market Value
$67



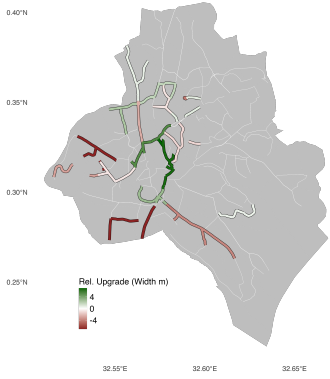
Status quo - market value (diff)
$217

Map Property Right Regimes | Property Right Regimes | Land use | Table

Policy Counterfactuals: No Restriction on the use of funds



Market Value - Status-quo restrictions
$67



Market value: no restrictions - restrictions (diff)
$281

Map Property Right Regimes | Property Right Regimes | Land use | Table

Conclusion

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  1. Large benefits: +3.7km/h speed ; -5% commuting time ; +1.5% citywide property values

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  1. Large benefits: +3.7km/h speed ; -5% commuting time ; +1.5% citywide property values
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- This paper: new data + QSM $\Rightarrow$ impacts of road improvements w/ land take
- Road improvements in Kampala: large benefits but threatened by land acquisition
  1. Large benefits: +3.7km/h speed ; -5% commuting time ; +1.5% citywide property values
  2. Land costs $\approx$ 13% of construction costs but $\approx$ 90% if legal regime enforced
- Policy implications:
  - Enforcing legal regimes may lead to misallocation of investments
  - Unintended positive consequences of weak property rights
  - External donors (WB, AfDB) should reconsider restrictions on the use of funds

Thank you!

jsorin@uchicago.edu

Appendix

Contributions to the Literature

1. Road improvements in LIC cities can have large net welfare gains, but these are mitigated by land costs

   - Large benefits of road improvements: local speed ↑, local property values ↑, city-level benefits
     Reduced-form: Gonzalez-Navarro '15, Duranton & Turner '11, Currier et al. '23, Akbar et al. '23
     QSM: Ahlfeldt et al. '15, Redding and Rossi Hansberg '17, Adao et al. '19, Allen & Arkolakis '20, Bryan et al. '20
     QSM for BRT in urban LIC & MIC: Majid et al. '18, Balboni et al. '21, Zarate '23, Tsivanidis '23

   - Welfare-maximizing improvements (QSM) also depend on heterogeneous & endogenous land costs
     Land costs USA: Mehrotra et al. '21, Brooks & Liscow '23
     Other costs LICs: Olken '07, Collier & Venables '16, Collier '19, Wolfram et al. '24
     Optimal QSM: Allen & Arkolakis '20, Fajgelbaum & Schaal '22, Bordeu '24

2. Strong property rights may distort public investments through land acquisition

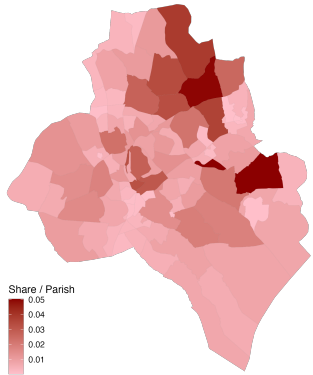
   - Strong private property rights conflict with public investments
     Property rights & private investments: North '90, Acemoglu et al. '01, Besley and Ghatsak '10, Bird and Venables '20
     Property rights & public goods: Acemoglu and Robinson '12, Posner and Weyl '17, Holland '23
     Eminent domain: Munch '76, Shavell '10, Jeong et al. '16

   - Land acquisition impacts are amplified by challenges to raise domestic funds

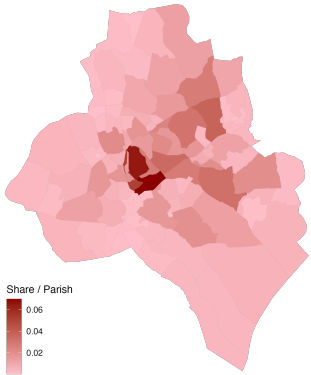
     Taxes LICs: Traxler '10, Besley and Persson '14, Knebelmann '19, Bergeron et al. '23, Brockmeyer et al. 23

Preview Results | Research Question

Commuting Flows



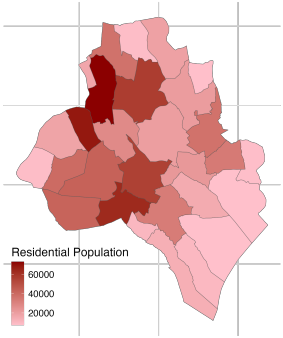
(a) Origin Parish



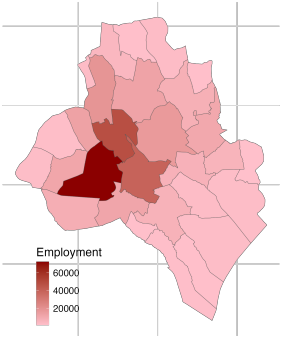
(b) Destination Parish

Main

Census Data



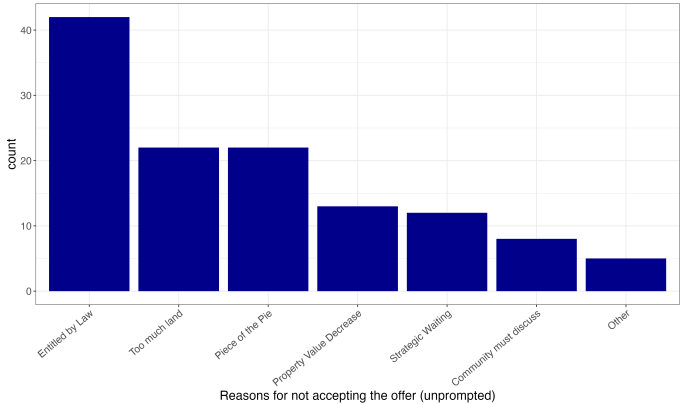
(c) Population



(d) Employment

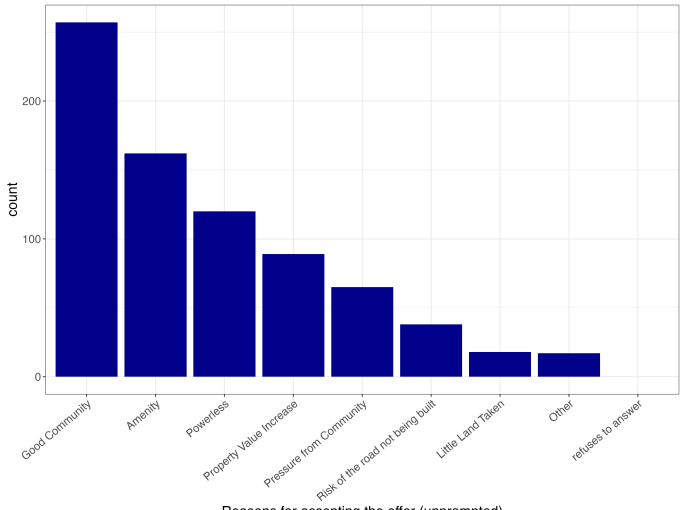
Main

Reasons to Claim the Compensation



Data | Reduced-form

Reasons to Not Claim the Compensation



Data | Reduced-form

Negotiation and Property Right Regimes

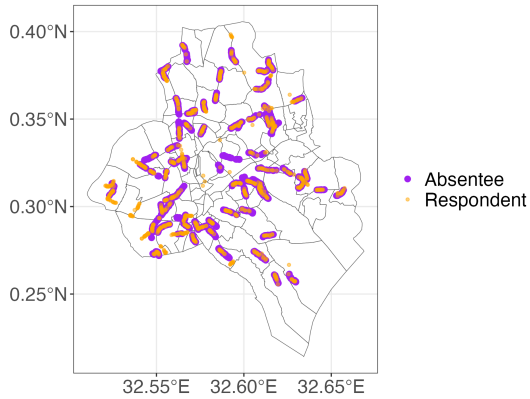
	Dependent variable:			
	Above Median Cost Ownership Doc	Nego ↓ Affected	Nego ↑ Money	Negotiate (d)
	(1)	(2)	(3)	(4)
Leasehold Property Rights	−0.200***	0.477***	0.398***	0.104**
	(0.056)	(0.151)	(0.148)	(0.042)
Division FE	Y	Y	Y	Y
Observations	459	517	501	532
R^2	0.073	0.180	0.075	0.013
Adjusted R^2	0.063	0.172	0.066	0.004

Notes: Standard errors are in parentheses, with *p<0.1; **p<0.05; ***p<0.01. In column 1, the dependent variable is a dummy = 1 if the self-reported cost of getting a copy of your ownership documents is above median. In column 2, the dependent variable is the answer to the question "*Do you think you could get a compensation of [amount] UGX for your affected land if you negotiated for at least 6 months? Please answer on a scale of 0 to 5, where 0 is very unlikely, and 5 is very likely*". In column 3, the dependent variable is the answer to the question "*Did you think that negotiations alone could remove your land from the design of the new road? Please answer on a scale of 1 to 5, where 1 is very unlikely, and 5 is very likely*." In column 4, the dependent variable is a dummy = 1 if the respondent did not negotiate for at least 6 months. The sample is the set of affected respondents in the owner survey.

Data Reduced-form

Owner Survey: Sampling

- Sampling unit: Road segment level Data Reduced-form
- Cross-randomization:
  - division
  - upgraded early vs late (in progress)
  - property right regime
- Randomized order all potential segments
  - 97 first valid selected
- Random starting point (intersection) + specified sampling area
- Census of non-surveyed properties



Owner Survey vs Census

	2014 Population Census	2019 UNPS	2019 UNPS (owners only)	Owner Survey
Panel A: Wealth Indicators				
Own TV (share)	0.68			0.97
Own Bicycle (share)	0.07	0.06	0.1	0.2
Own Car (share)		0.18	0.23	0.4
Own Computer (share)	0.18			0.3
Access to Electricity	0.84			0.97
Bank Account (share)	0.57			0.86
At least 2 meals per day (share)	0.14			1
Panel B: Education				
No formal education (share)	0.18			0.03
Some secondary education (share)	0.55			0.75
Panel C: Property				
Inherited Property (share)			0.31	0.58
Year Acquired			1994	1988
Parcel Area (m2)			2075	2218
Floor Tiles (share)		0.13	0.15	0.4
Floor Cement screed (share)		0.78	0.77	0.54

Notes: Census data from the 2014 Population Census and from the 2019 Uganda National Panel Survey restricted to Kampala. The share of population with secondary education in the Census data is for 13-18 y.o. residents, while it is for survey respondents in the survey data.

Data Reduced-form

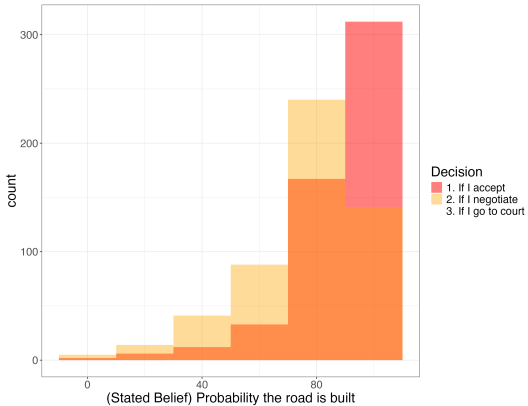
Mechanisms Behind The Impact of Land Tenure on Negotiation

	Dependent variable:			
	Beliefs Better Compensation	Beliefs Less Land	Cost Copy Ownership Docs Abv Median	Knowledge WB Compensation Rule
	(1)	(2)	(3)	(4)
Mailo Tenure (d)	−0.084***	−0.115***	0.190***	0.041
	(0.031)	(0.032)	(0.058)	(0.028)
Freehold Tenure (d)	−0.119**	−0.052	0.257**	−0.106**
	(0.057)	(0.059)	(0.103)	(0.054)
Tenure Ref	Leasehold	Leasehold	Leasehold	Leasehold
Division FE + Parish controls	Y	Y	Y	Y
Mean Dep Var	2.78	1.64	0.5	0.07
Observations	496	512	454	494
R^2	0.108	0.206	0.105	0.075
Adjusted R^2	0.088	0.189	0.083	0.054

⇒ the larger the transaction costs, the lower the odds of negotiating, the lower the cost for the government

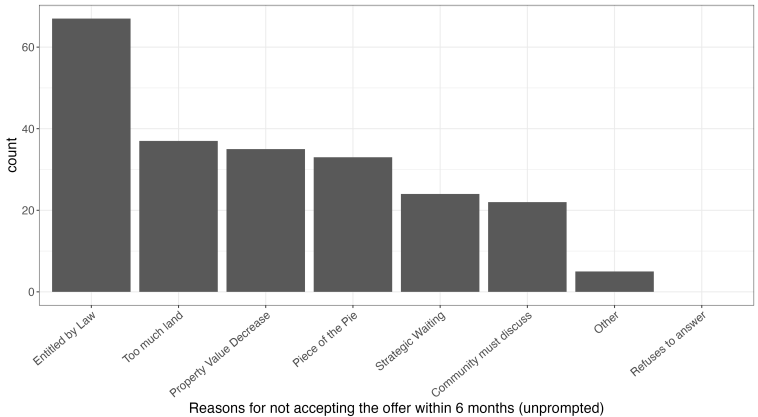
Data Reduced-form

Assumption: No individual pivotality



Data | Reduced-form

Assumption: No strategic holdout



Data | Reduced-form

Broker Survey vs Online Data

- Scrapped data from RealEstateDatabase.net
  - location (neighborhood)
  - property characteristics
  - posted date
- High-end properties: avg $\$332,694$
  - $\$70,472$ broker survey
- Check spatial correlation:

$$\ln p^b_{pt} = \alpha + \beta \times \ln p^o_{pt} + \gamma_t + \gamma_p + e_{pt}$$

	Dependent variable:				
	Log Parish-Level Mean Broker Survey Price (USD)				
	(1)	(2)	(3)	(4)	(5)
Log Parish-Level Mean Online Price (USD)	0.396***	0.400***	0.497**	0.494**	0.272***
	(0.099)	(0.100)	(0.194)	(0.198)	(0.080)
Year FE		Y		Y	
Parish FE			Y	Y	
Level of Observation	Parish-Year	Parish-Year	Parish-Year	Parish-Year	Parish
Observations	181	181	181	181	309
R^2	0.083	0.108	0.644	0.659	0.036
Adjusted R^2	0.078	0.077	0.433	0.431	0.033

Data

Early vs Late Road Upgrade Selection

	Dependent variable:	
	Early Wave	
	(1)	(2)
In central division (dummy)		−0.050
		(0.181)
Length road	−0.055	−0.062
	(0.113)	(0.117)
Road class: primary	0.238	0.239
	(0.253)	(0.256)
Road class: secondary	0.190	0.186
	(0.238)	(0.241)
Road class: tertiary	−0.105	−0.115
	(0.231)	(0.236)
Constant	0.347*	0.365*
	(0.201)	(0.213)
Reference road class: minor		
Observations	52	52
R^2	0.093	0.095
Adjusted R^2	0.016	−0.004
Residual Std. Error	0.487 (df = 47)	0.492 (df = 46)
Note:		*p<0.1; **p<0.05; ***p<0.01

Reduced-Form ξ Estimation

Impact on Traffic Speed - by Hour

$$s_{kl,t} = \alpha + \beta D_{kl,t} + X'_{kl}\gamma + \eta_t + e_{kl,t}$$

	Dependent variable:							
	Traffic Speed (km/h)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Upgraded (dummy)	4.194***	4.080***	3.574***	3.265***	2.824***	2.938***	2.762***	3.417***
	(1.068)	(0.998)	(0.780)	(0.774)	(0.841)	(0.777)	(0.678)	(1.245)
Avg dep var	22.9	22.9	22.9	22.3	19.9	19.9	19.9	18.9
Time of Day	Non-rush	Non-rush	Non-rush	Non-rush	Rush	Rush	Rush	Rush
Hour + Day FE	Y	Y	Y	Y	Y	Y	Y	Y
Road char controls		Y	Y	Y		Y	Y	Y
Geo controls			Y				Y	
Match				Y				Y
Observations	838	838	838	1,869	423	423	423	1,901
R^2	0.310	0.325	0.440	0.589	0.185	0.275	0.305	0.606

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Main

Road Matching (SUTVA)

- Goal: estimating the impact of road improvements on traffic speed

$$s_{kl,t} = \alpha + \beta D_{kl,t} + \mathbf{X}'_{\mathbf{kl}}\gamma + \eta_t + e_{kl,t}$$

- Concern: SUTVA violation
  - traffic flows on control roads affected because complements / substitutes to treated roads
- Solution: match each treated road to control unlikely to be affected by treated
- Matching Protocol: for each treated road query $\{D_1, t\}$:
  - Find all the parish-to-parish trips on which road D_1 is ever taken
    - from GoogleMaps parish-to-parish queries + match path to road network
  - Among all potential controls on day t: find road that has the smallest trip overlap with $\{D_1, t\}$
    - If substitutes: likely to replace D_1 on some instances
    - If complement: likely to be present on the same trips as D_1

Main

Environment: Land is Used for Residential and Road Purposes

- **Static GE model** of a city w/ locations $i, j \in \mathscr{J}$ & fixed nb workers $\bar{L}$
- **Heterogeneous locations**: residential amenities B_i, productive amenities A_i, landowner property rights Z_i

Extension

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- **Fixed amount of land per location** H_i imply an **opportunity cost of land**

$$H_i = \underbrace{H_i^r}_{\text{residential}} + \underbrace{H_i^p}_{\text{road}}$$

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  - **Residential land** H_i^r is owned by N_i^o **local immobile representative landowners**

$$\underbrace{W_i^o}_{\text{owner welfare}} = B^o \underbrace{(C_i^o)^\beta}_{\text{freely tradeable good}} \qquad C_i^o = \underbrace{\frac{H_i^r q_i (1-\phi) + T_i}{N_i^o}}_{\text{owner o's post tax rental income + transfer}}$$

Overview

Mobile Workers Choose Where to Live, Work, Commute

- **Production:** Perfectly competitive firms + freely tradeable good + labor only $\Rightarrow w_j = A_j$ Extension

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Extension

- **Preferences: mobile workers** choose where to live i, where to work j, commuting route r

$$\max_{i,j,r,C_{ij},H_{ij}} U_{ij}^w = \underbrace{B_i}_{\text{amenity}} \underbrace{C_{ij}^{\beta}}_{\text{consum}} \left(\underbrace{H_{ij}}_{\text{housing}} \right)^{1-\beta} \varepsilon_{ij}^w \qquad \text{s.t.} \underbrace{\frac{w_j}{\tau_{ij}} = C_{ij} + H_{ij} q_i}_{\text{budget constraint}}$$

- preference shock $\varepsilon_{ij}^w \sim$ Frechet $(1, \theta) \Rightarrow$ expected workers' welfare equalized over space
- θ = elasticity of commuting flows on commuting costs

$$W^{\mathrm{w}} \propto \left(\sum_{ij} \left(\frac{B_i \, w_j}{\tau_{ij} \, {q_i}^{1-\beta}} \right)^{\theta} \right)^{\frac{1}{\theta}}$$

Overview

Benefits: Commuting Costs Decrease In Road Infrastructure

- Average commuting costs τ_{ij}
  - ρ : elasticity of average τ_{ij} on route-level $\tau_{ij,r} \Rightarrow$ large $\rho \approx$ shortest-path

$$\tau_{ij} \equiv \left[\sum_r \left(\tau_{ij,r} \right)^{-\rho} \right]^{-\frac{1}{\rho}} \qquad \tau_{ij,r} = \prod_{kl \in r} d_{kl}$$

- Commuting costs on link d_{kl}

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  - increasing in time t_{kl} at rate $\kappa \equiv$ elasticity of commuting cost on time

$$d_{kl} = \exp\left(\kappa \times t_{kl} \right)$$

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  - increasing in time t_{kl} at rate $\kappa \equiv$ elasticity of commuting cost on time

$$d_{kl} = \exp\left(\kappa \times t_{kl} \right)$$

- Commuting time on link t_{kl}
  - decreasing in road width R_{kl} at rate $\xi \equiv$ elasticity of commuting time on road infrastructure

$$t_{kl} = \frac{\bar{t_{kl}}}{\left(R_{kl} \right)^{\xi}}$$

Marginal Land Costs Depend on Landowners Claiming the Compensation

$$\underbrace{p_k^1}_{\text{marginal cost land}} = \underbrace{q_k^0}_{\text{baseline property rate}} \times \underbrace{\gamma_k^N}_{\text{share of owners claiming compensation}}$$

$$\gamma_k^N = \mathbb{P}\left(a \times \underbrace{q_k^0 \Delta H_i^r}_{\text{potential compensation}} > \underbrace{f(Z_k) + c_k}_{\text{fixed cost}} \right)$$

- $f(Z_k)$ = owner's fixed costs as a function of property rights & obs. char. Z_k

Overview

- idiosyncratic fixed cost $c_k \sim Logistic(0,1)$
- q_k^0 : property rate evaluated at baseline (prior to the policy)
- no holding out

Reasons Not Claim Reasons Claim Not pivotal

Government Problem

- Government chooses road width R_{kl} to maximize the net welfare of its residents

$$\max_{\{R_{kl}\}} \quad \mathsf{W} = \sum_i \omega_i^o \times \underbrace{W_i^{\mathrm{o}}\left(\{R_{kl}\},\phi\right)}_{\text{welfare owner in } i} + \omega^w \times \underbrace{W^{\mathrm{w}}\left(\{R_{kl}\},\phi\right)}_{\text{expected welfare worker}} - \underbrace{\eta}_{\text{mcpf}\geq 1} \underbrace{\hat{C}}_{\text{land expenditures}}$$

$$\hat{C} \equiv \sum_i \left(\sum_k \underbrace{\gamma_i\left(R_{ki}\right)}_{\text{share paid}} \times \underbrace{q_i^0}_{\text{market rate}} \underbrace{\frac{l_{ki}}{2}\left(R_{ki} - R_{ki}^0\right)}_{\text{land area taken}} \right)$$

$$\bar{M} \geq \sum_i \bar{P} \frac{l_{ki}}{2}\left(R_{ki} - R_{ki}^0\right)$$

Overview

Equilibrium

Equilibrium: Given the model's parameters $\{B^o, \beta, \theta, \kappa, \xi, a, f(.), \omega_i^o, \omega^w, \eta, \bar{L}, \bar{M}, \bar{p}\}$, location and link characteristics $\{B_i\}, \{A_i\}, \{H_i\}, \{Z_i\}, \{\bar{t}_{kl}\}$, baseline infrastructure $\{R_{kl}^0\}$, the equilibrium of the model is the set of prices $\{q_i\}, \{p_i^1\}, \phi$ and quantities $\{L_{ij}\}$, $\{\gamma_i^N\}$, $\{H_{ij}\}$, $\{C_{ij}\}$, $\{R_{kl}\}$ such that

- the government chooses $\{R_{kl}\}$ and the tax rate ϕ to maximize workers and owners' welfare s.t. budget constraints
- workers choose $\{i, j, r, C_{ij}, H_{ij}\}$ to maximize their utility
- owners consume all their income on the tradeable good and choose to claim the compensation with probability γ_i^N
- residential land markets clear $\sum_j H_{ij} = H_i^r \ \forall i$
- the good market clears

Overview

Non-Freely Traded Good

- **Empirically**: prices of goods vary within the city and may be affected by road improvements (Vitali '24, Bassi et al. '24)
- **Current model:** firms produce a (i) single (ii) freely traded good
  - **Implication**: benefits of road improvements biased downwards

- **Potential model extension**
  - perfectly competitive firms in each location produce a unique variety, CES demand w/ elasticity σ

$$\text{output price: } p_j = \underbrace{\frac{w_j}{A_j}}_{\text{marginal cost}} \times \underbrace{\tau_{ij}^F}_{\text{transport costs}}$$

$$\text{good-by-good market clearing: } p_j^{-\sigma} \cdot Y = A_j \sum_i \frac{L_{ij}}{\bar{L}}$$

  - road improvement $\Rightarrow$ ambiguous impact on p_j but positive welfare effect through $\uparrow w_j$
    - $\uparrow L_{ij} \Rightarrow \downarrow p_j$ (supply curve out)
    - $\downarrow$ trade costs $\tau_{ij}^F \Rightarrow \uparrow$ demand for j goods $\Rightarrow \uparrow p_j$ (demand curve out)

Amenities

- **Empirically**: road upgrades ↑ local amenities: ↓ flood risk, ↓ dust, ↓ accidents...
- **Current model:** exogenous amenities B_i
  - **Implication:** benefits of road improvements biased downwards
- **Potential model extension**
  - residential amenities B_i depend on local road quality in location i

$$B_i = \bar{B}_i \cdot f(\{R_{il}\}_{\forall l \in \mathscr{C}_i})$$

- **Estimation: past transactions from broker survey**
  - impact on local amenities ≈ residual impact on local property values controlling for Δ market access

$$\log P_{i,t} = \alpha + \beta_1 \log \underbrace{MA_{i,t}}_{\text{structural}} + \beta_2 \underbrace{\bar{R}_i}_{\text{avg road quality}} + X_i' \mu + \gamma_t + e_{i,t}$$

Parameters and Data Overview

Parameter		Source	Value
$\gamma_i(R_{il})$	owner compensation claim model	Owner survey	
ξ	elasticity of time$_{kl}$ on road width R_{kl}	GoogleMaps + upgrade rollout	0.39
θ	elasticity of location choice on commuting costs	Local ride hailing app	3.3
κ	elasticity of commuting costs on time	Ahlfeldt et al. (2015)	0.01
β	share of worker's expenditure on consumption	UNPS (2019)	0.76
ρ	elasticity of route-choice on route-cost	$\approx$ shortest path	50
$\{\omega_i^o\}, \omega^w$	welfare weights on owners and workers	Utilitarian	
η	marginal cost of public funds	Lit, Manwaring & Regan 2023	1.0-2.56

- Data on: $L_i^R, L_i^F, q_i^R, l_{kl}, R_{kl}, \bar{t_{kl}}$; A_i, B_i by inverting the model

Main

Estimating Owners' Costs of Claiming the Compensation

- Empirical proba that owner o in i claims the compensation ($\equiv$ does not consent for $\geq$ 6 months)

$$\gamma_{oi}^{N} = \mathbf{P}\left(\underbrace{a_1\, q_i \Delta H_{oi}^{r}}_{\text{MV affected land}} - \underbrace{a_0\, P_{oi}^{0}}_{\text{initial offer (d)}} \geq \underbrace{\mu\, \mathbf{Z}_i' + \nu\, \mathbf{X}_{\mathbf{o}}' + c_{oi}}_{\text{compensation claim fixed cost}} \right)$$

  - $\mathbf{X_o} \in \{$**property right regime**, wealth index, social integration index$\}$
  - $\mathbf{Z_i} \in$ parish-level geo + socio-economic characteristics

- **Estimation**: assume that $c_{oi} \sim$ logistic distribution $(0,1) \Rightarrow$ estimate a_1, a_0, μ, ν through MLE

No Pivotality | No Strategic Waiting | All Parameters | Stylized | Sampling | Data

Estimating Owner Fixed Costs

Odds of claiming the compensation

- ↑ in affected value
- ↑ in property rights
  - ref = leasehold (strong)
  - ↓ in mailo
  - ↓ in freehold

	Propensity to Negotiate		
	(1)	(2)	(3)
Market Value Affected Land (std)	0.284**	0.286**	0.376***
	(0.113)	(0.114)	(0.125)
Tenure Mailo (d)	-0.72***	-0.723***	-0.765**
	(0.253)	(0.259)	(0.352)
Tenure Freehold (d)	-0.741**	-1.291***	-1.26**
	(0.331)	(0.402)	(0.599)
Observations	544	544	544
Ref Tenure	Leasehold	Leasehold	Leasehold
Geo FE			Grid
Parish Geo Controls		Y	Y
Parish SocioEcon Controls		Y	Y

⇒ leasehold clearest rights: cost copy ownership doc 33% lower than mailo and 58% lower than freehold

No Pivotality | No Strategic Waiting | All Parameters | Stylized | Sampling | Data | Mechanisms | Robustness

Elasticity of Commuting Flows on Commuting Times

$$\log L_{ij,ym} = \alpha + \gamma_{i,y} + \gamma_{j,y} + \gamma_m - \theta\kappa \times \text{time}_{ij,ym} + \mu \times X_{ij} + \xi_{ij,ym}$$

- **Data** on L_{ijym}, time_{ijym} from **local ride-hailing company**

  Params

  - Sampled periods in 2019, 2023 and 2024
  - DoW rush-hour to capture work-related trips
  - Avg by user × month × year × origin-destination
- Standard errors are clustered by origin-destination pair
- **Id assumption:** $\Delta\text{time}_{ij} \perp \xi_{ij,ym}$.
- **Limitations**: drop if no trip & potential selection
- $\hat{\theta\kappa} = 0.033 \Rightarrow \{\kappa, \theta\} = \{\mathbf{0.01}, \mathbf{3.3}\}$

	Dependent variable:	
	(1)	(2)
Time (in Min)	-0.033^{***}	-0.023^{***}
	(0.001)	(0.001)
Period Def	Month	Month
Sample	All	Evening
Fixed Effects		
- origin x year	Y	Y
- destination x year	Y	Y
- month	Y	Y
SE Clustered	o-d	o-d
Observations	59,300	45,077
R^2	0.437	0.687

Literature $\hat{\theta\kappa} \in [\underbrace{0.028}_{\text{Tsivanidis '23}}, ..., \underbrace{0.0706}_{\text{Ahlfeldt et al. '15}}]$

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Estimating ξ

- ξ = elasticity of infrastructure on local speed

$$t_{kl,t} \equiv \frac{\bar{t_{kl}}}{R_{kl,t}^{\xi}}$$

$$\Rightarrow \log t_{kl,t} = X_{kl}^{'} - \xi \log R_{kl,t}$$

- Corresponding empirical specification

$$\log s_{kl,t} = \alpha - \xi \log R_{kl,t} + X_{kl}^{'}\gamma + \eta_t + e_{kl,t}$$

- Data: GoogleMaps queries (03/23-08/24)
- Sample: Policy roads
- $s_{kl,t}$: speed on kl at time t
- $R_{kl,t}$: road width pre-upgrade (KCCA) + 3.2 m if upgraded
- η_t: time fixed-effects
- **Identifying** variation: early vs late upgrades Balance
  - Robustness: road FE (subset roads)
- Standard errors clustered at the road + day level

Parameters

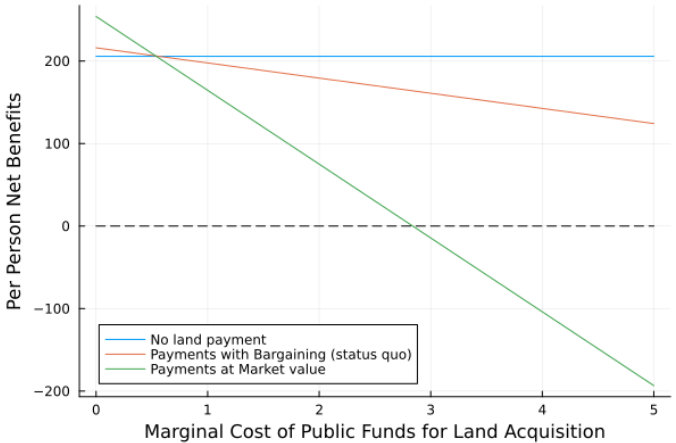
Estimation ξ

	Dependent variable:					
	Log Traffic Speed (km/h)					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Road Infrastructure (width m)	0.386***	0.344***	0.422***	0.390***	0.314***	0.253***
	(0.093)	(0.082)	(0.112)	(0.096)	(0.089)	(0.075)
Sample	All	All	Non-Rush	Non-Rush	Rush	Rush
Mean Speed Control (km/h)	19.9	19.9	20.5	20.5	18.9	18.9
Mean Road Width Control (m)	6.3	6.3	6.3	6.3	6.3	6.3
Road Controls	Y	Y	Y	Y	Y	Y
Road Geo Controls		Y		Y		Y
Day + Hour FE	Y	Y	Y	Y	Y	Y
SE Clustered	road+day	road+day	road+day	road+day	road+day	road+day
Observations	1,021	1,021	632	632	389	389
R^2	0.323	0.417	0.312	0.465	0.318	0.348

- Literature $\hat{\xi} \in$
  - $[0.1, 0.13]$ Fajgelbaum and Schaal 22'
  - $[0.13]$ Bordeu 24'

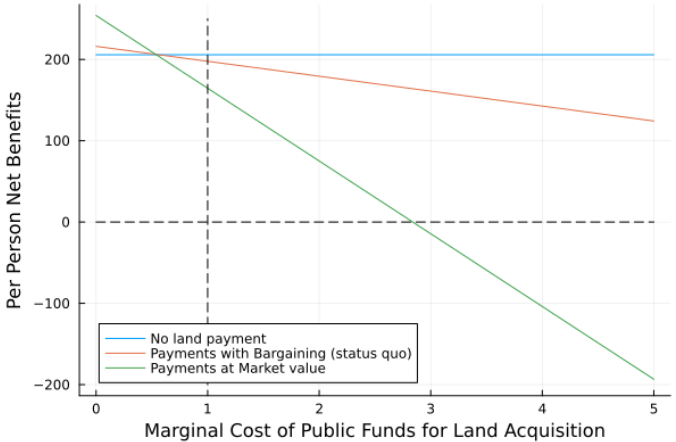
Parameters Balance

Welfare Impacts of Kampala Road Improvements



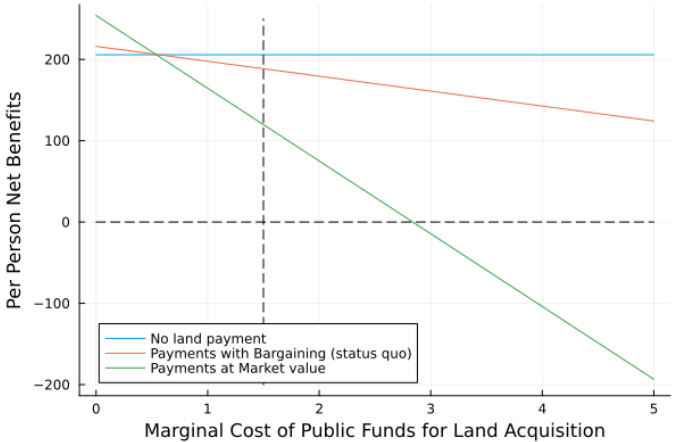
Main

Welfare Impacts of Kampala Road Improvements



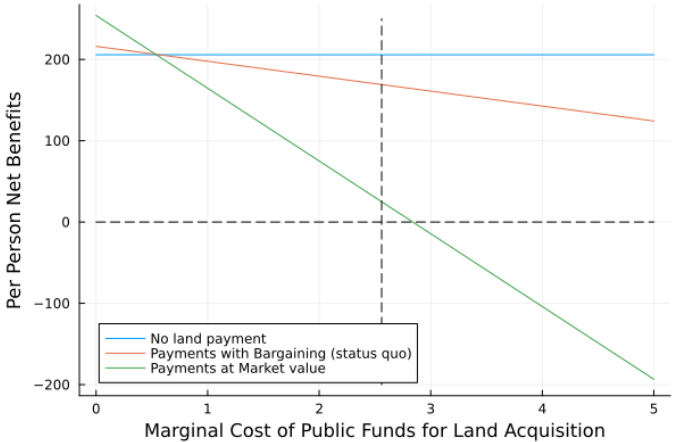
Main

Welfare Impacts of Kampala Road Improvements



Main

Welfare Impacts of Kampala Road Improvements



Main

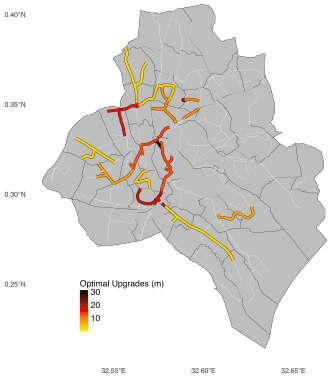
More Upgrades Around Low Costs, High Benefits Links

	Dependent variable:							
	Log Length of Upgraded Roads (m)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Final Net Welfare	0.410***				0.565**			
	(0.132)				(0.260)			
Log Final Worker Welfare		0.413	0.413**	0.504		0.569	0.569***	0.906***
		(0.342)	(0.162)	(0.304)		(0.343)	(0.130)	(0.316)
Log Land Costs (Bargaining)		−0.875	−0.875			−2.185***	−2.185***	
		(0.721)	(0.825)			(0.724)	(0.683)	
Log Land Costs (Market Value)				−0.664				−2.437***
				(0.730)				(0.578)
Observation level: link between parish								
Road Upgrades	All	All	All	All	Ext. funds	Ext. funds	Ext. funds	Ext. funds
Control for road length	Y	Y	Y	Y	Y	Y	Y	Y
Control for division	Y		Y	Y	Y		Y	Y
Observations	94	94	94	94	94	94	94	94
R^2	0.001	0.017	0.017	0.006	0.007	0.098	0.098	0.071

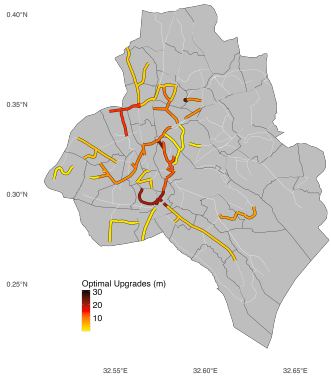
Note: *p<0.1; **p<0.05; ***p<0.01

Main

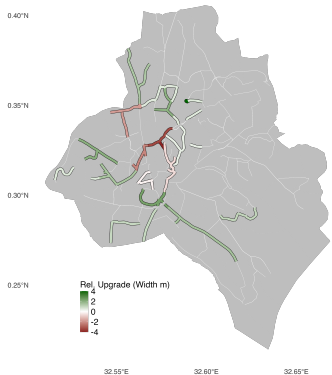
Counterfactuals: Accounting for Land Use



No land Use
$376



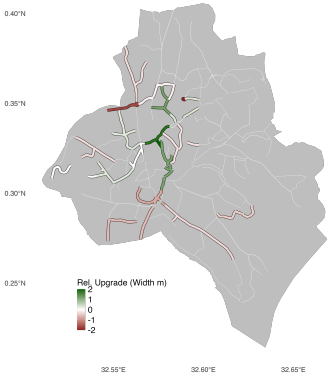
Land Use
$315



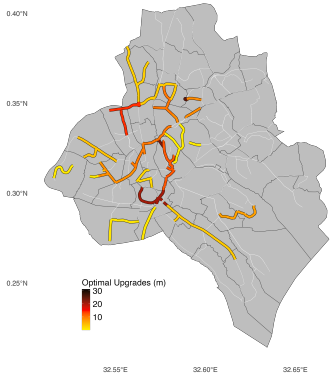
Difference (use - no use)

Counterfactual Payment

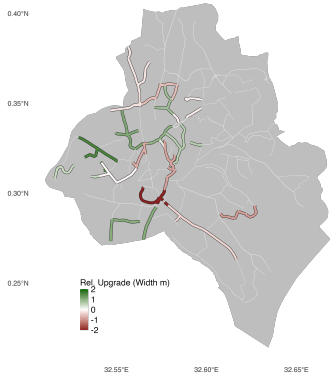
Counterfactuals: Enforcing Different Property Right Regimes



All freehold (diff)
$242



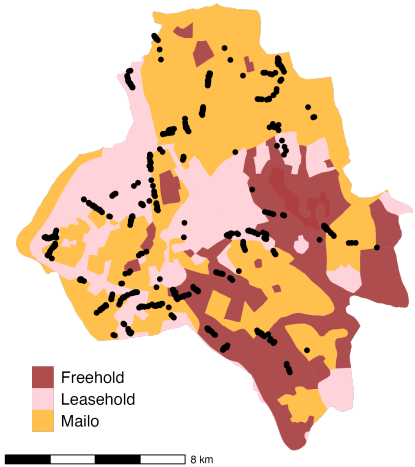
Status-quo
$ 217



All leasehold (diff)
$ 190

Counterfactual Payment

Property Right Regimes



Results and Counterfactuals

	Avg Change (%)		Land Costs	Net Welfare Gains	
	Commuting Time	Property Values	(USD) (million)	Per Resident	Total (million)
Panel A. Realized Road Improvements - Main					
A1. Status-quo payments	-4.9	1.5	19.2	165.5	173
A2. Market value	-4.9	1.5	93.6	7.9	8
A3. No payment	-4.9	1.5	0	206.7	216
Panel B. Optimal Road Improvements - Existing Restrictions on the Use of Funds					
B1. Status-quo payments	-7.0	2.51	41.2	217.0	227
B2. Market value	-6.1	2.27	100.0	66.7	69.8
B3. No payment	-6.6	2.62	0	315.3	330
Panel C. Optimal Road Improvements - Alternative Property Right Regimes					
C1.1. Status-quo payments - All Leasehold	-6.57	2.51	51.6	190.9	200
C1.2. Status-quo payments - All Freehold	-6.65	2.57	31.3	242.3	254
Panel D. Optimal Road Improvements - Alternative MCPF					
D2.1. Market value - MCPF = 1.0	-6.46	2.48	110.4	162.9	170
D2.2. Market value - MCPF = 2.6	-2.56	0.88	29.3	-66.4	-70

Main Realized | Main Optimal | Full Counterfactuals