

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

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Poor Road Infrastructure in African Cities



- ▶ 30% roads in African cities are paved

(Kumar et al. 2008)

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

Widespread Beliefs of Large Benefits



- ▶ “Poor transportation infrastructure limits access to markets and public services.” (World Bank 2009)
- ▶ Urban road quality is associated with economic development (Akbar et al. 2023)

Overlooked Costs of Road Improvements



Costs = construction + acquisition of private land

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Costs = construction + **acquisition of private land**

- ▶ 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**

Outline

- 1. Framework**
- 2. Data & Reduced-Form Evidence**
- 3. Results & Counterfactuals**

Context: Road Improvements in Kampala

- ▶ 45% Kampala's major roads are paved

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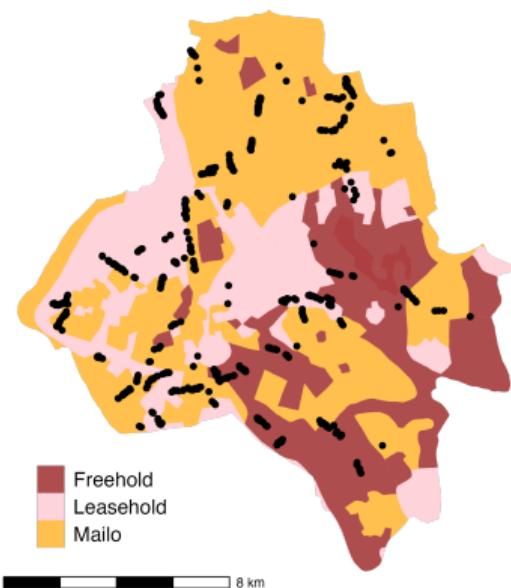
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 - ▶ staggered rollout since 2017
- ▶ Paving + widening on private land
 - ▶ Avg width affected per owner = 1.5 meter
 - ▶ Legal: eminent domain w. compensation
 - ▶ In practice: not all get compensated

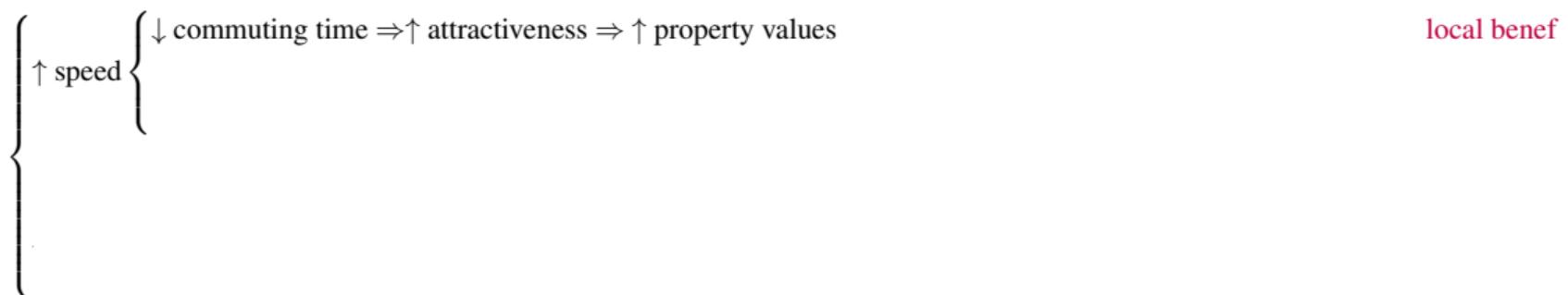
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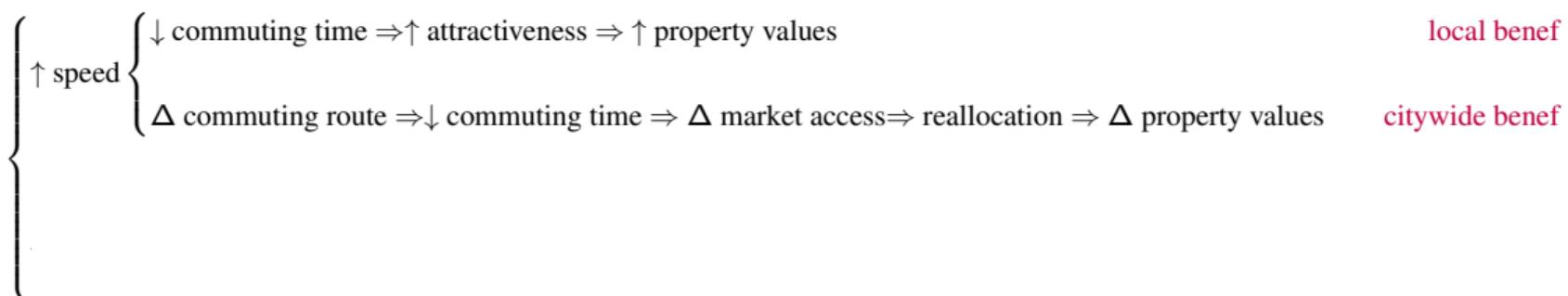
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- ▶ **local** benefits \Rightarrow reduced-form variation (policy)

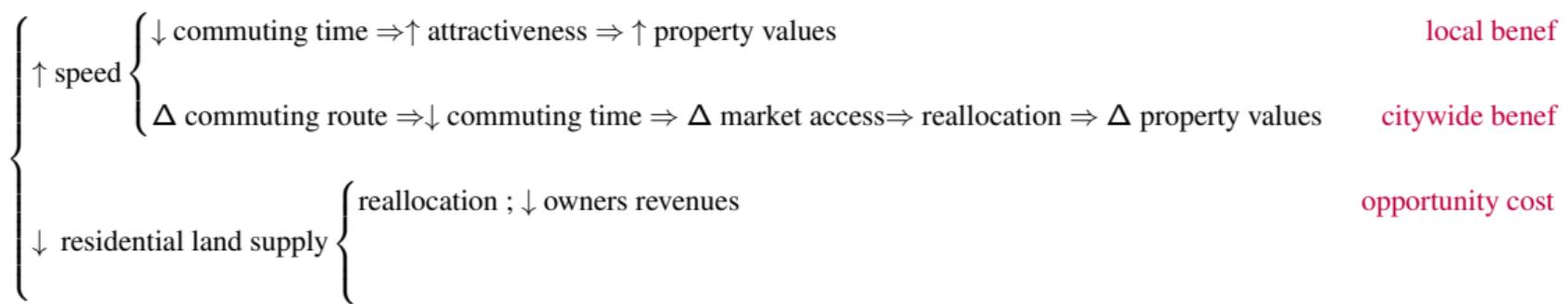
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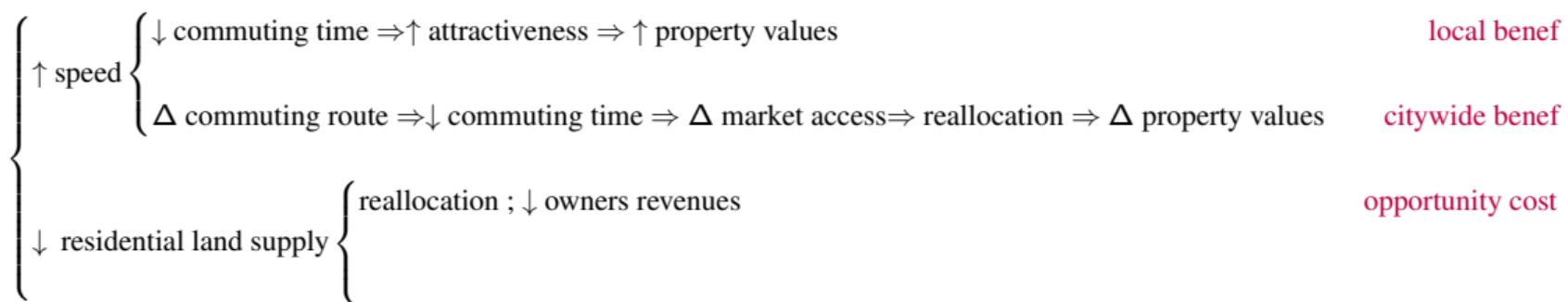
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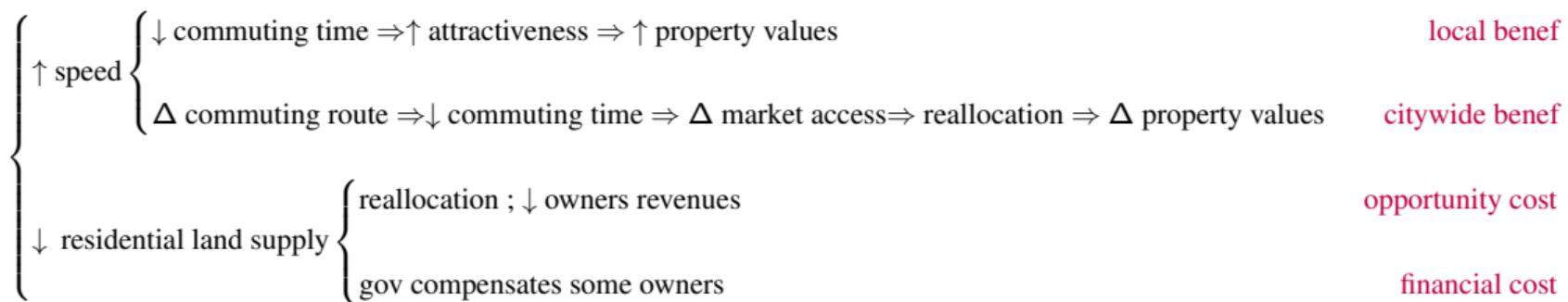
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- ▶ **citywide** impacts \Rightarrow quantitative spatial model (Ahlfeldt et al. '15, Allen and Arkolakis '22) Model
- ▶ Freely tradable consumption good ; workers freely choose where to live, work and commute
- ▶ Land split between (privately owned) residential use and (publicly owned) roads
- ▶ key model elasticities: ξ (local speed on road width) & $\theta \kappa$ (commuting flows on commuting time)

Measuring the Net Returns from Road Improvements (1)

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- **compensation** \Rightarrow owner survey + discrete choice model

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► Central government problem

Model

- External funds: road construction ($\approx 180\text{km}$)
- Objective: residents' eq welfare minus (domestically funded) land acquisition expenditures
 - residents' equilibrium location choices (OC land)
 - complementary effects of road improvements

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- External funds: road construction ($\approx 180\text{km}$)
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- Financial cost depends on marginal cost of public funds ($\eta \geq 1$)
 - $\eta > 1 \Rightarrow$ land expenditures are costly

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- Financial cost depends on marginal cost of public funds ($\eta \geq 1$)
- Uneven enforcement of the eminent domain w/ market value compensation
 - depends on property rights regime

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

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 - ▶ the cost of land payments ⇒ allowing external funds for land acquisition

Data & Empirical Facts

Novel Real Estate Broker Survey

- ▶ Database of 3000+ past transactions

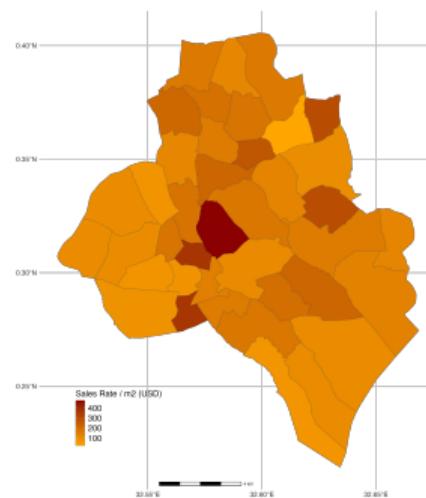


Comparison w/ Online

377 (informal) real estate brokers all over the city

Spatially Heterogeneous Market Rate

- ▶ Database of 3000+ past transactions
- ▶ Spatially heterogeneous
- ▶ Market value of land taken = \$94 million
 - ▶ construction \approx \$102 million



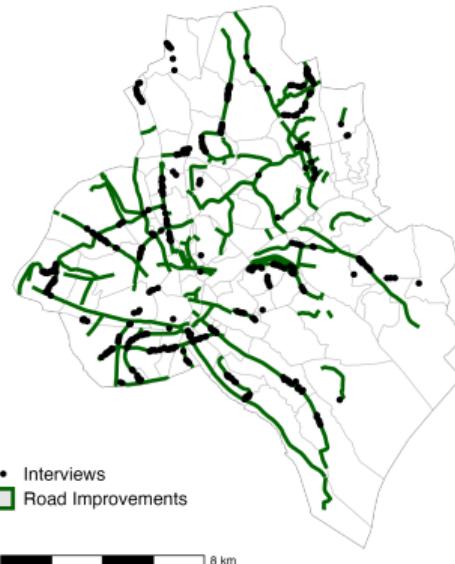
Residential Market Rate (pre)

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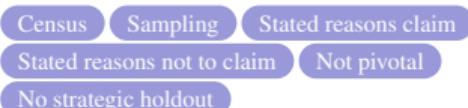
Who Claims the Compensation: Novel Landowner Survey

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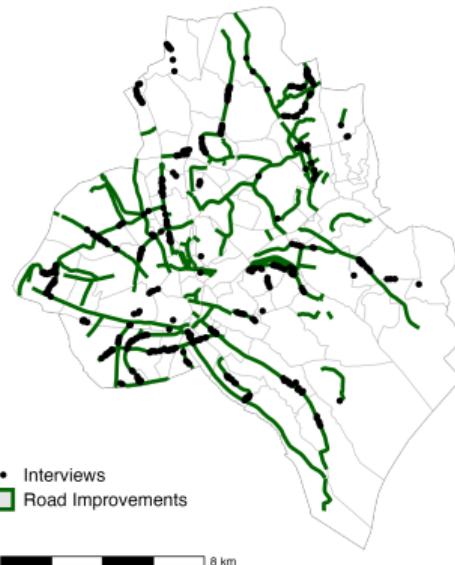
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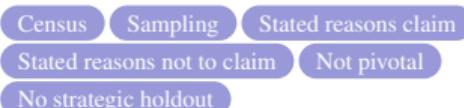
- ▶ 548 owners w/ affected property on upgraded roads



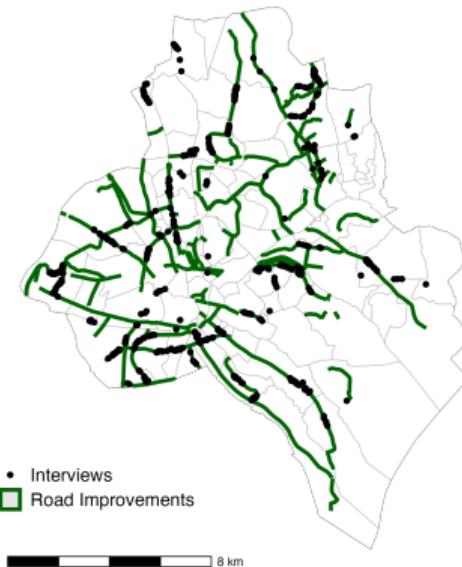
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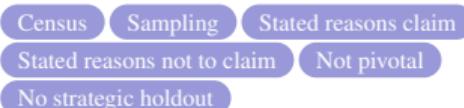
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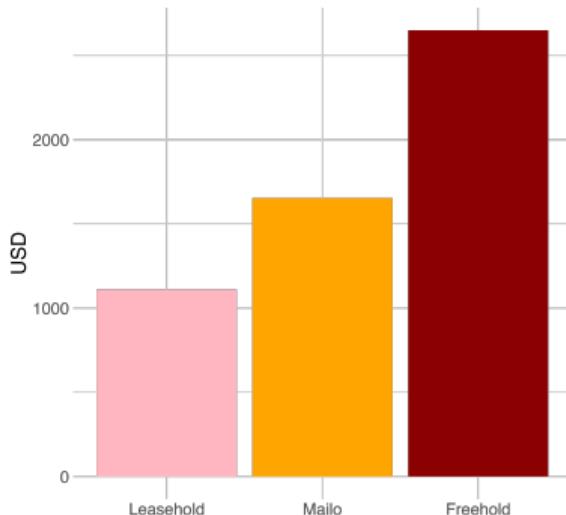
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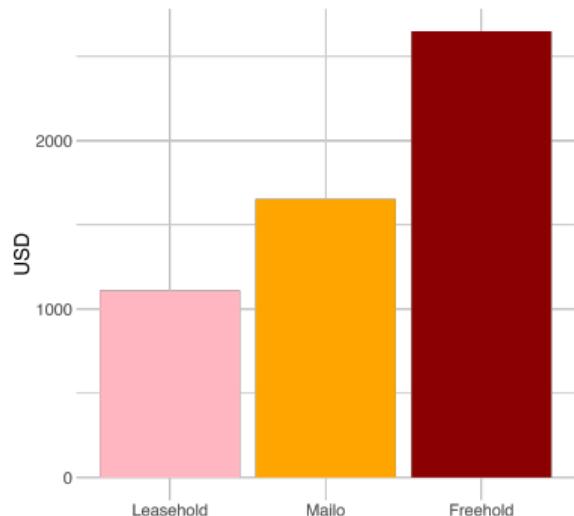
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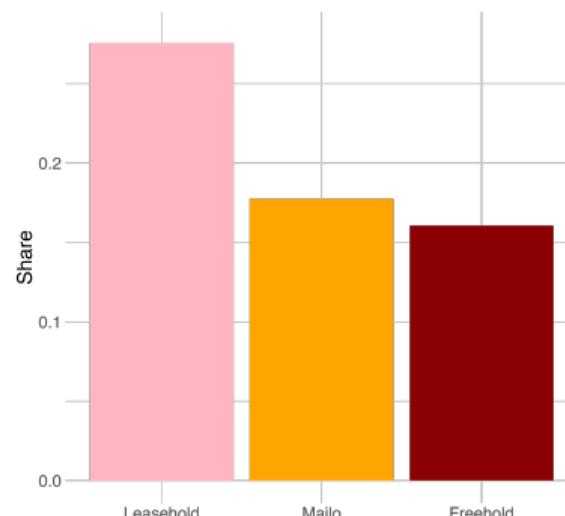
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 - ▶ heterogeneous across the property right regimes

Cost of Copy Ownership Documents

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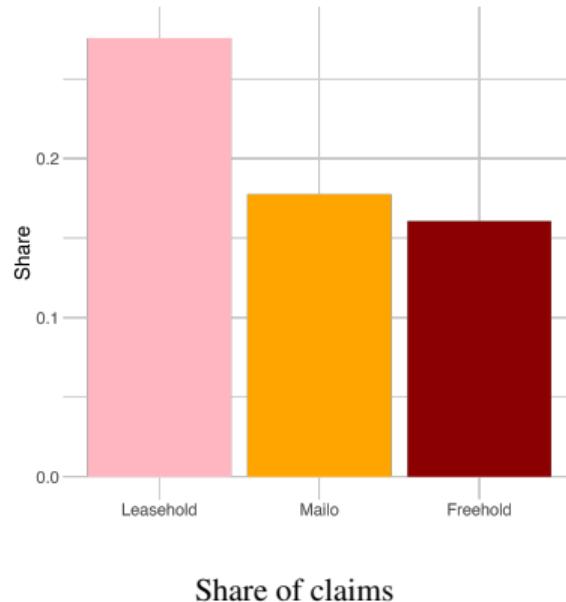
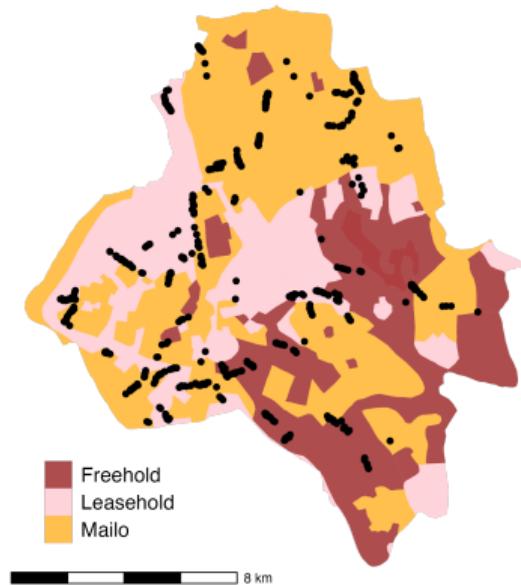


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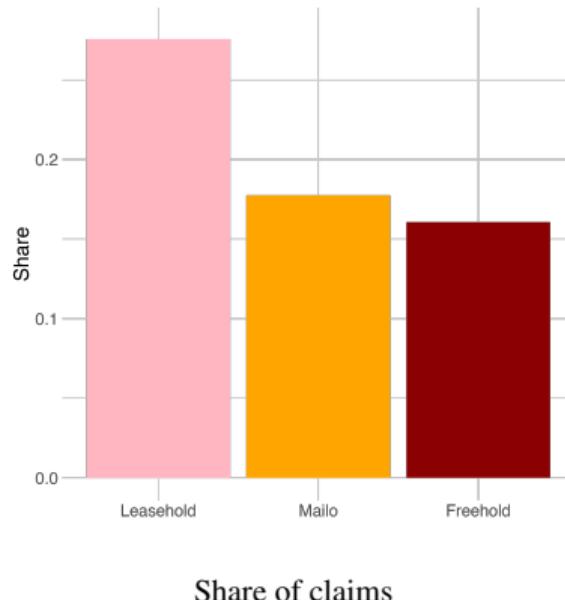
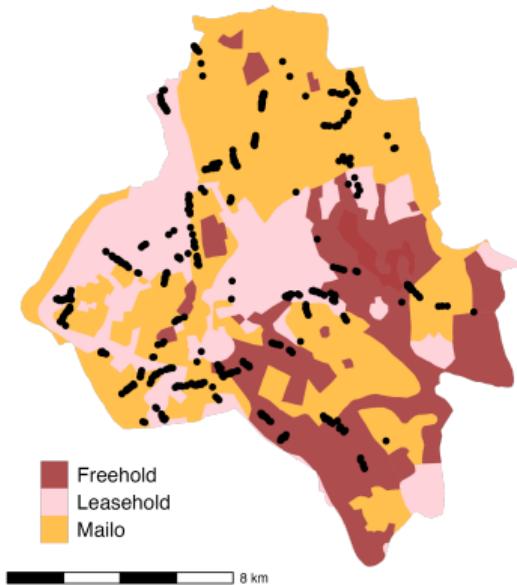


Share of claims

Who Claims the Compensation: Novel Landowner Survey



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Owner survey \Rightarrow discrete choice model of owners' decision to claim the compensation

Owner Model

Benefits of Road Improvements in Kampala

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► Change in speed (Googlemaps on policy roads + upgrade rollout)

► road upgrade $\Rightarrow 3.7 \text{ km/h} \uparrow \text{traffic speed}$

► elasticity of speed on road width $\hat{\xi} = 0.39$

Much higher than in HIC / MIC (Fajgelbaum and Schaal 22' = 0.1 ; Bordeu '24 = 0.13)

RF

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► Citywide benefits: model (spillovers: commuting and reallocation)

Full Table

Census

► Distaste for commuting (**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)

Results & Counterfactuals

Welfare Impacts of Kampala Road Improvements



Upgraded Roads (dummy)

Welfare Impacts of Kampala Road Improvements

► Citywide benefits

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



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Graph MCPF

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



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- ▶ More upgrades where large net gains, large gross gains & low land costs

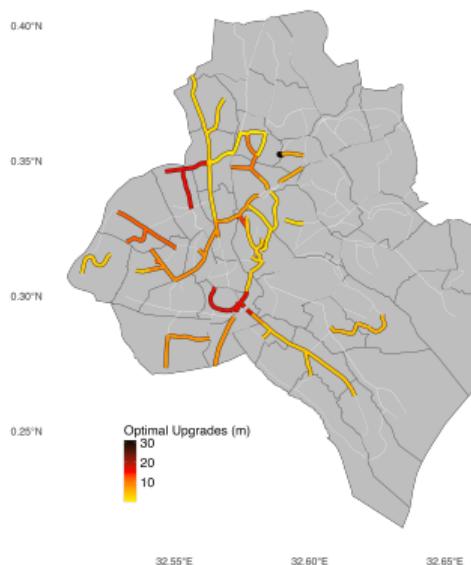
- ▶ especially externally funded



Upgraded Roads (dummy)

Table

Policy Counterfactuals: Enforcing Land Payment Rule



Market Value
\$67

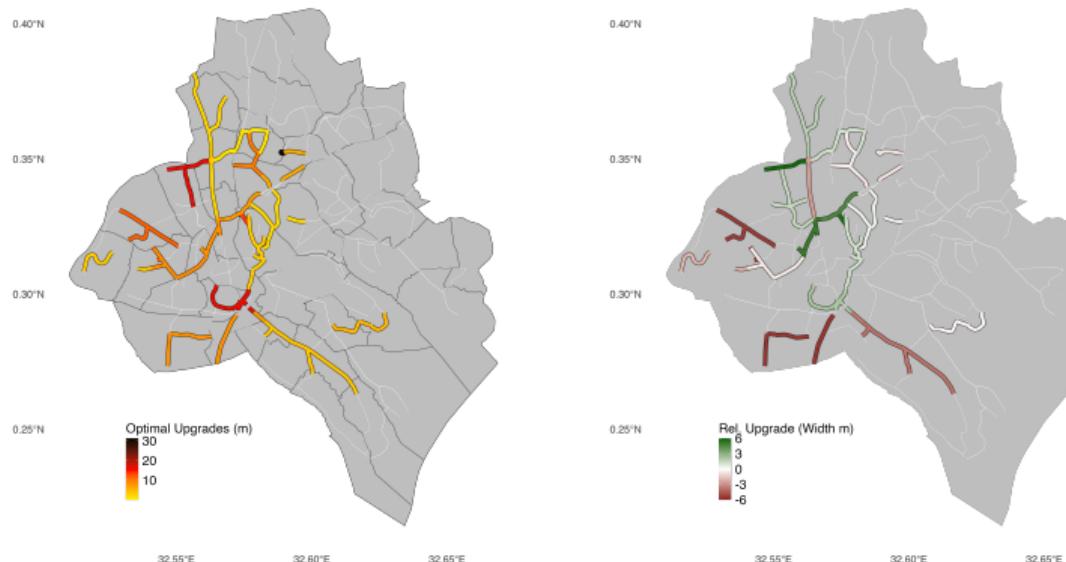
Map Property Right Regimes

Property Right Regimes

Land use

Table

Policy Counterfactuals: Enforcing Land Payment Rule



Market Value
\$67

Status quo - market value (diff)
\$217

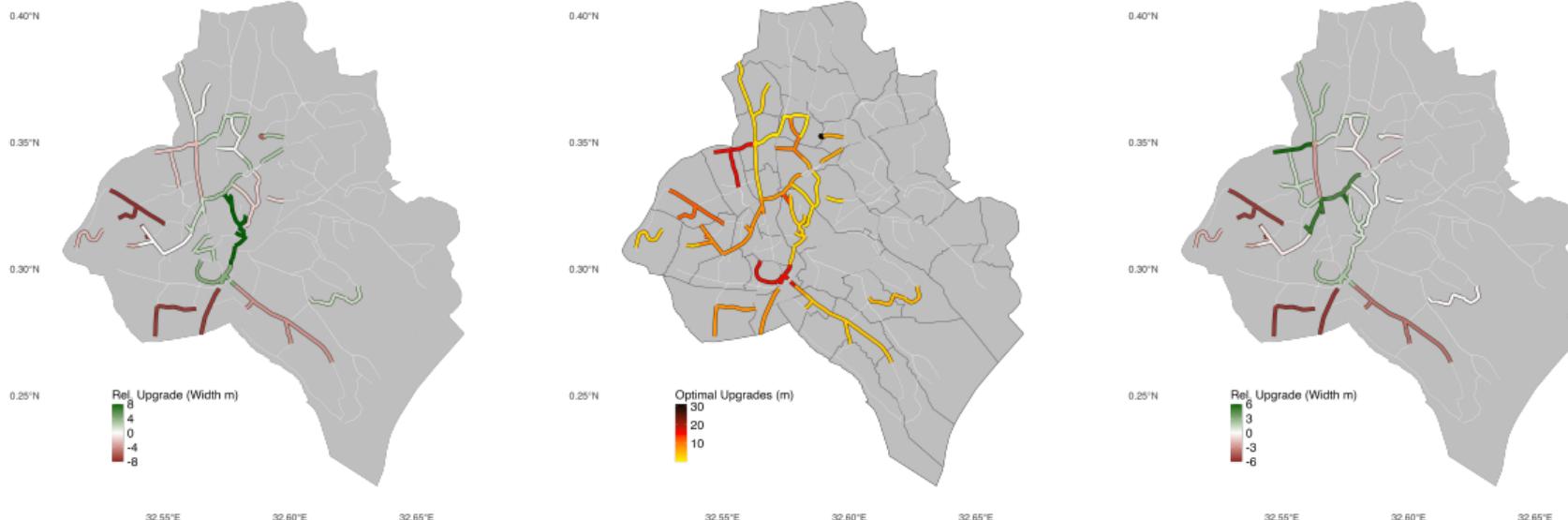
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No payment - market value (diff)
\$315

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Conclusion

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 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 given the high cost of raising domestic funds
 - ▶ 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!

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Appendix

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) [Overview](#)
- ▶ **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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- ▶ **Concern:** SUTVA violation traffic flows Matching
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| | <i>Dependent variable:</i> | | | |
|--------------------|----------------------------|---------------------|---------------------|---------------------|
| | Traffic Speed (km/h) | | | |
| | (1) | (2) | (3) | (4) |
| Upgraded (dummy) | 3.741*** (0.912) | 3.753*** (0.830) | 3.401*** (0.667) | 3.289*** (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

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

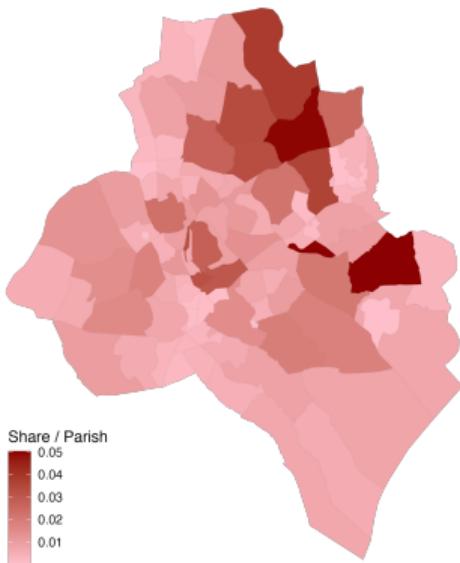
- ▶ Strong private property rights conflict with public investments
Property rights & private investments: North '90, Acemoglu et al. '01, Besley and Ghatsak '10, Bird and Venables '20
Property rights & public goods: Acemoglu and Robinson '12, Posner and Weyl '17, Holland '23
Eminent domain: Munch '76,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

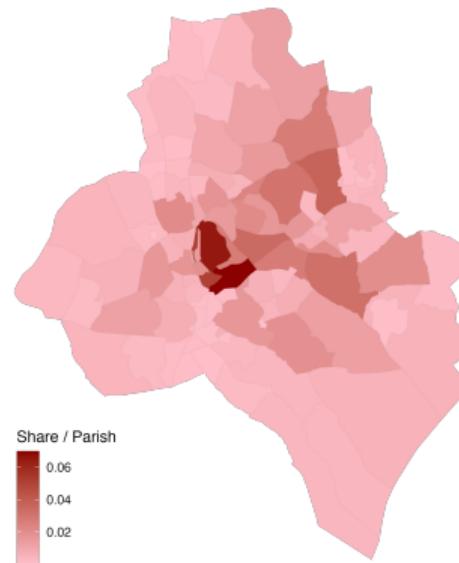
Preview Results

Research Question

Commuting Flows

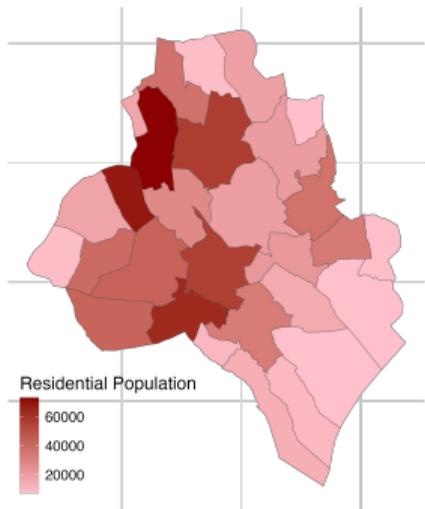


(a) Origin Parish

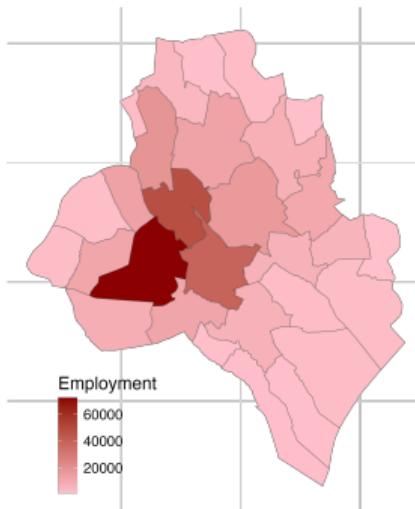


(b) Destination Parish

Census Data

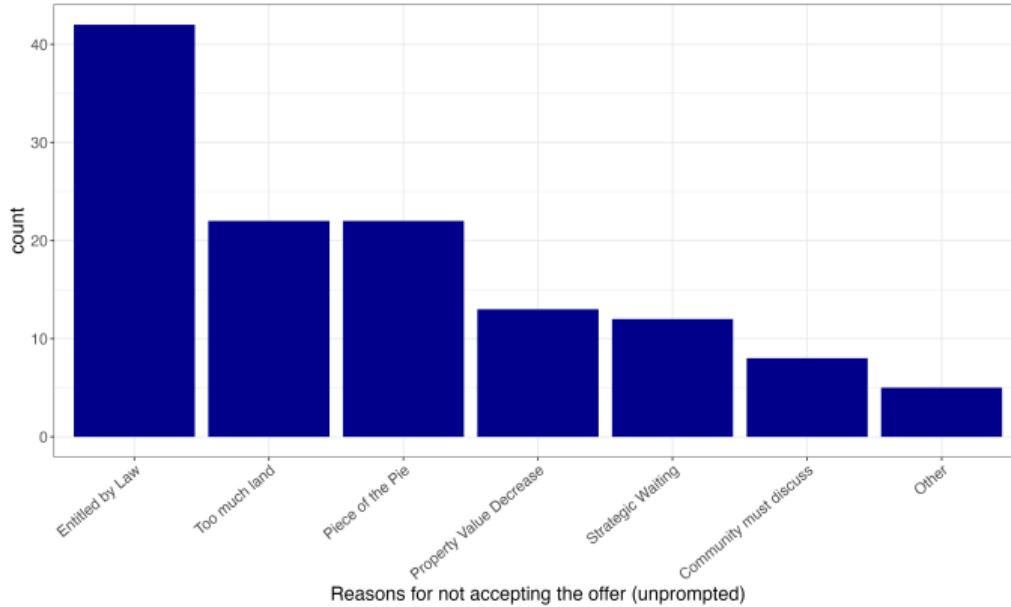


(c) Population



(d) Employment

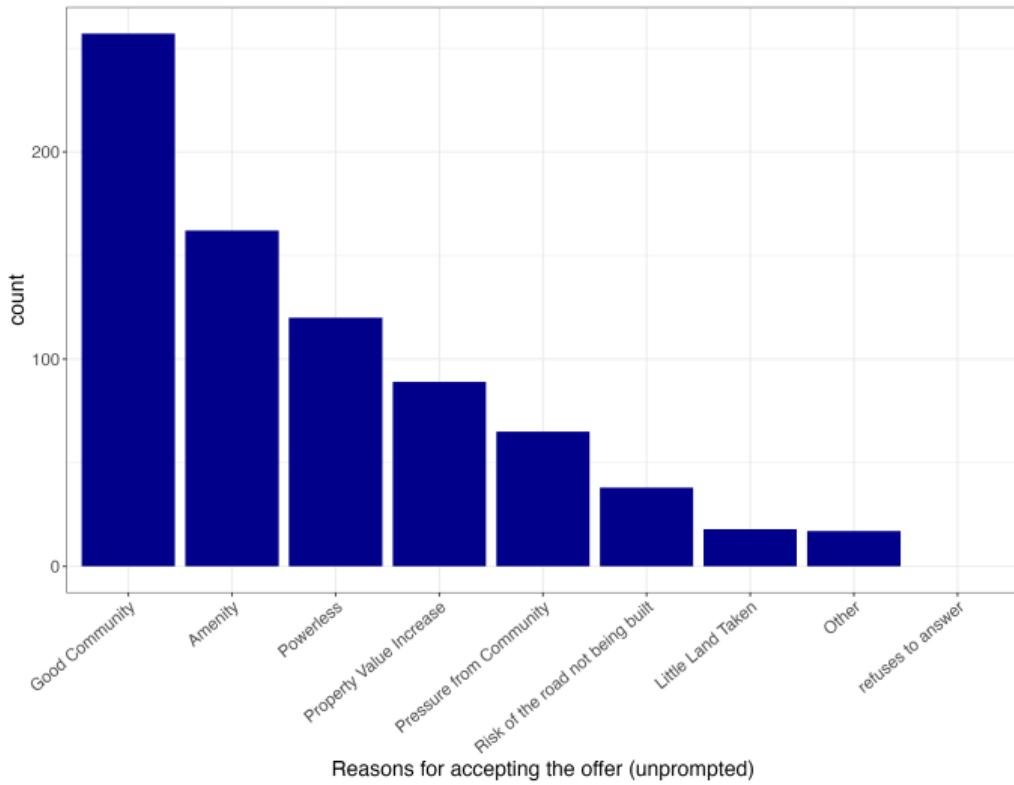
Reasons to Claim the Compensation



Data

Reduced-form

Reasons to Not Claim the Compensation



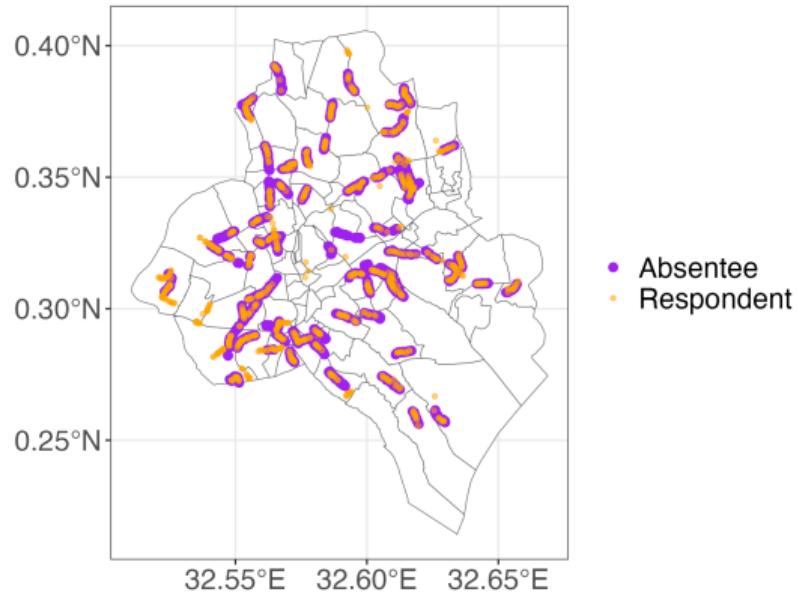
Negotiation and Property Right Regimes

| | <i>Dependent variable:</i> | | | |
|---------------------------|---------------------------------|---------------------|---------------------|--------------------|
| | Above Median Cost Ownership Doc | Nego ↓ Affected | Nego ↑ Money | Negotiate (d) |
| | (1) | (2) | (3) | (4) |
| Leasehold Property Rights | -0.200*** (0.056) | 0.477*** (0.151) | 0.398*** (0.148) | 0.104** (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.

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 |
|-----------------------------------|------------------------------|-----------|----------------------------|--------------|
| <i>Panel A: Wealth Indicators</i> | | | | |
| 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 |
| <i>Panel B: Education</i> | | | | |
| No formal education (share) | 0.18 | | | 0.03 |
| Some secondary education (share) | 0.55 | | | 0.75 |
| <i>Panel C: Property</i> | | | | |
| 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.

Mechanisms Behind The Impact of Land Tenure on Negotiation

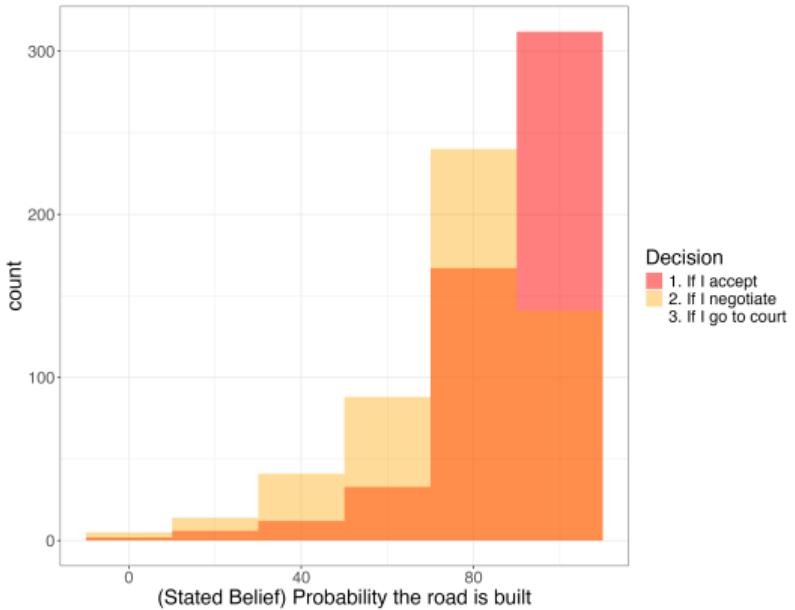
| | <i>Dependent variable:</i> | | | | |
|-------------------------------|------------------------------------|--------------------------|--|---------------------------------------|---------------------|
| | Beliefs Better Compensation (1) | Beliefs Less Land (2) | Cost Copy Ownership Docs Abv Median (3) | Knowledge WB Compensation Rule (4) | |
| Mailo Tenure (d) | -0.084*** (0.031) | -0.115*** (0.032) | 0.190*** (0.058) | | 0.041 (0.028) |
| Freehold Tenure (d) | -0.119** (0.057) | -0.052 (0.059) | 0.257** (0.103) | | -0.106** (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

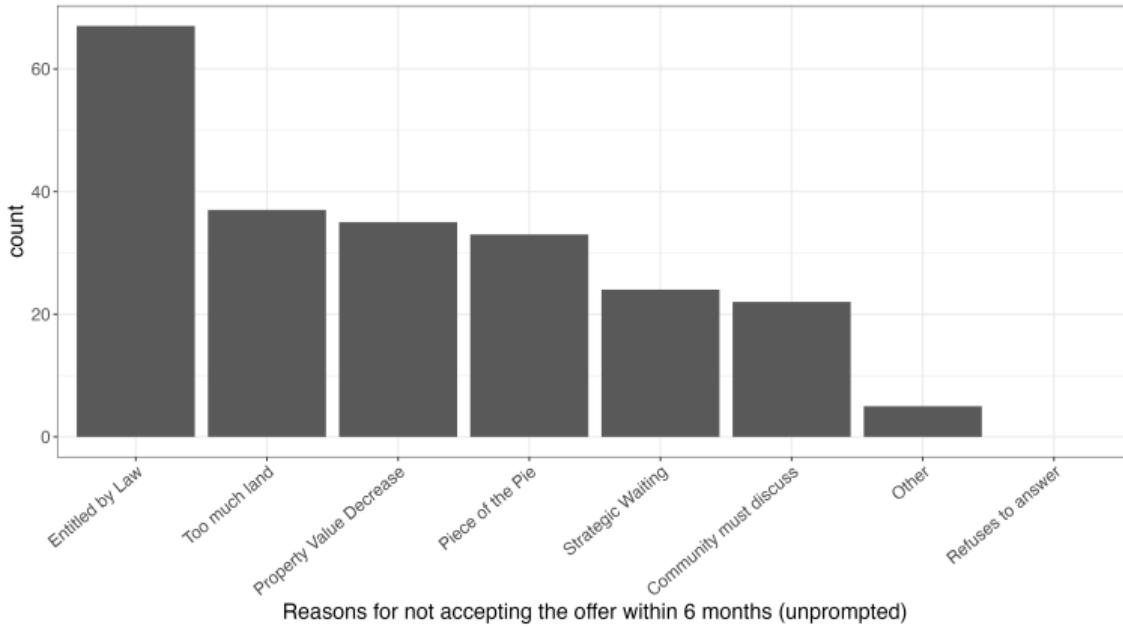
Data

Reduced-form

Assumption: No individual pivotality



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:

$$\ln p_{pt}^b = \alpha + \beta \times \ln p_{pt}^o + \gamma_t + \gamma_p + e_{pt}$$

| | <i>Dependent variable:</i> | | | | |
|--|---|---------------------|--------------------|--------------------|---------------------|
| | Log Parish-Level Mean Broker Survey Price (USD) | | | | |
| | (1) | (2) | (3) | (4) | (5) |
| Log Parish-Level Mean Online Price (USD) | 0.396*** (0.099) | 0.400*** (0.100) | 0.497** (0.194) | 0.494** (0.198) | 0.272*** (0.080) |
| Year FE | | Y | | Y | Y |
| Parish FE | | | Y | 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 |

Early vs Late Road Upgrade Selection

| | <i>Dependent variable:</i> | |
|-----------------------------|----------------------------|-------------------|
| | Early Wave (1) | Early Wave (2) |
| In central division (dummy) | | -0.050 (0.181) |
| Length road | -0.055 (0.113) | -0.062 (0.117) |
| Road class: primary | 0.238 (0.253) | 0.239 (0.256) |
| Road class: secondary | 0.190 (0.238) | 0.186 (0.241) |
| Road class: tertiary | -0.105 (0.231) | -0.115 (0.236) |
| Constant | 0.347* (0.201) | 0.365* (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

Impact on Traffic Speed - by Hour

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

| | <i>Dependent variable:</i> | | | | | | | |
|--------------------|----------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| | Traffic Speed (km/h) | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Upgraded (dummy) | 4.194*** (1.068) | 4.080*** (0.998) | 3.574*** (0.780) | 3.265*** (0.774) | 2.824*** (0.841) | 2.938*** (0.777) | 2.762*** (0.678) | 3.417*** (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

Road Matching (SUTVA)

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

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

- ▶ 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 $i, j \in \mathcal{J}$ & fixed nb workers \bar{L}
- ▶ **Heterogeneous locations:** residential amenities B_i , productive amenities A_i , landowner property rights Z_i

Extension

Environment: Land is Used for Residential and Road Purposes

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

Extension

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

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- ▶ **Infrastructure land** sums over all i 's roads of width R_{mi} and length l_{mi} ; $H_i^P = \sum_{m \in \mathcal{C}_i} R_{mi} \times \frac{l_{mi}}{2}$

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

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

Overview

Mobile Workers Choose Where to Live, Work, Commute

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

Extension

Mobile Workers Choose Where to Live, Work, Commute

- ▶ **Production:** Perfectly competitive firms + freely tradeable good + labor only $\Rightarrow w_j = A_j$
- ▶ **Preferences:** mobile workers choose where to live i , where to work j , commuting route r

Extension

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

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

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

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

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

- ▶ Commuting costs on link d_{kl}

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- ▶ Commuting costs on link d_{kl}
 - ▶ increasing in time t_{kl} at rate $\kappa \equiv$ elasticity of commuting cost on time

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

- ▶ Commuting time on link t_{kl}

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

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

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

$$t_{kl} = \frac{\bar{t}_{kl}}{(R_{kl})^{\xi}}$$

Marginal Land Costs Depend on Landowners Claiming the Compensation

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

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

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

Overview

- ▶ idiosyncratic fixed cost $c_k \sim \text{Logistic}(0, 1)$
- ▶ 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

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

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

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

Equilibrium

Equilibrium: Given the model's parameters $\{B^o, \beta, \theta, \kappa, \xi, a, f(\cdot), \omega_i^o, \omega^w, \eta, \bar{L}, \bar{M}, \bar{p}\}$, 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 $\{q_i\}, \{p_i^l\}, \phi$ 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

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

Model overview Model Firms Impact Realized Conclusion

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

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

- ▶ 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)

▶ $\downarrow \text{trade costs } \tau_{ij}^F \Rightarrow \uparrow \text{demand for } j \text{ goods} \Rightarrow \uparrow p_j$ (demand curve out)

Amenities

- ▶ **Empirically:** road upgrades ↑ local amenities: ↓ flood risk, ↓ dust, ↓ accidents...

- ▶ **Current model:** exogenous amenities B_i

Model overview

Model environment

Impact Realized

Conclusion

- ▶ **Implication:** benefits of road improvements biased downwards

- ▶ **Potential model extension**

- ▶ residential amenities B_i depend on local road quality in location i

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

- ▶ **Estimation: past transactions from broker survey**

- ▶ impact on local amenities ≈ residual impact on local property values controlling for Δ market access

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

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

Estimating Owners' Costs of Claiming the Compensation

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

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

- ▶ $X_o \in \{\text{property right regime, wealth index, social integration index}\}$
- ▶ $Z_i \in \text{parish-level geo + socio-economic characteristics}$
- ▶ **Estimation:** assume that $c_{oi} \sim \text{logistic distribution } (0, 1) \Rightarrow$ estimate a_1, a_0, μ, v through MLE

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** (0.113) | 0.286** (0.114) | 0.376*** (0.125) |
| Tenure Mailo (d) | -0.72*** (0.253) | -0.723*** (0.259) | -0.765** (0.352) |
| Tenure Freehold (d) | -0.741** (0.331) | -1.291*** (0.402) | -1.26** (0.599) |
| Observations | 544 | 544 | 544 |
| Ref Tenure | | Leasehold | Leasehold |
| Geo FE | | | Leasehold Grid |
| Parish Geo Controls | | | Y |
| Parish SocioEcon Controls | | | 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 $L_{ij,ym}$, $\text{time}_{ij,ym}$ from **local ride-hailing company**

Params

- Sampled periods in 2019, 2023 and 2024
- DoW rush-hour to capture work-related trips
- Avg by user \times month \times year \times 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
- $\hat{\theta}\kappa = 0.033 \Rightarrow \{\kappa, \theta\} = \{0.01, 3.3\}$

| | Dependent variable: | |
|----------------------|----------------------|----------------------|
| | (1) | (2) |
| Time (in Min) | -0.033*** (0.001) | -0.023*** (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 $\hat{\theta}\kappa \in [\underbrace{0.028}_{\text{Tsivanidis '23}}, \dots, \underbrace{0.0706}_{\text{Ahlfeldt et al. '15}}]$

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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
 - ▶ Robustness: road FE (subset roads)
 - ▶ Standard errors clustered at the road + day level

Balance

Parameters

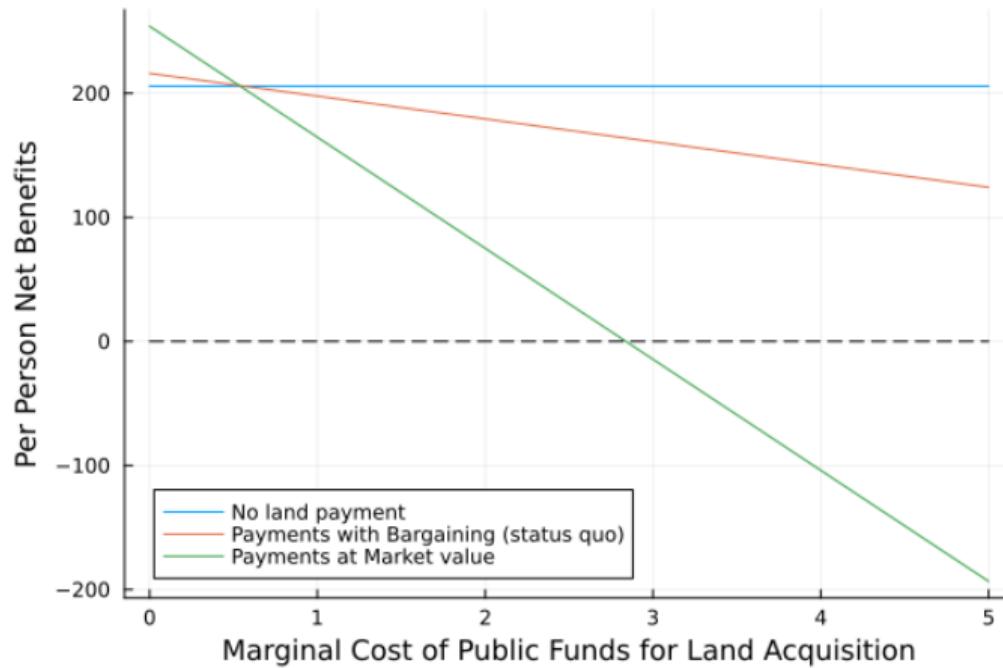
Estimation ξ

| | Dependent variable: | | | | | |
|-----------------------------------|--------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| | Log Traffic Speed (km/h) | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Log Road Infrastructure (width m) | 0.386*** (0.093) | 0.344*** (0.082) | 0.422*** (0.112) | 0.390*** (0.096) | 0.314*** (0.089) | 0.253*** (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 |

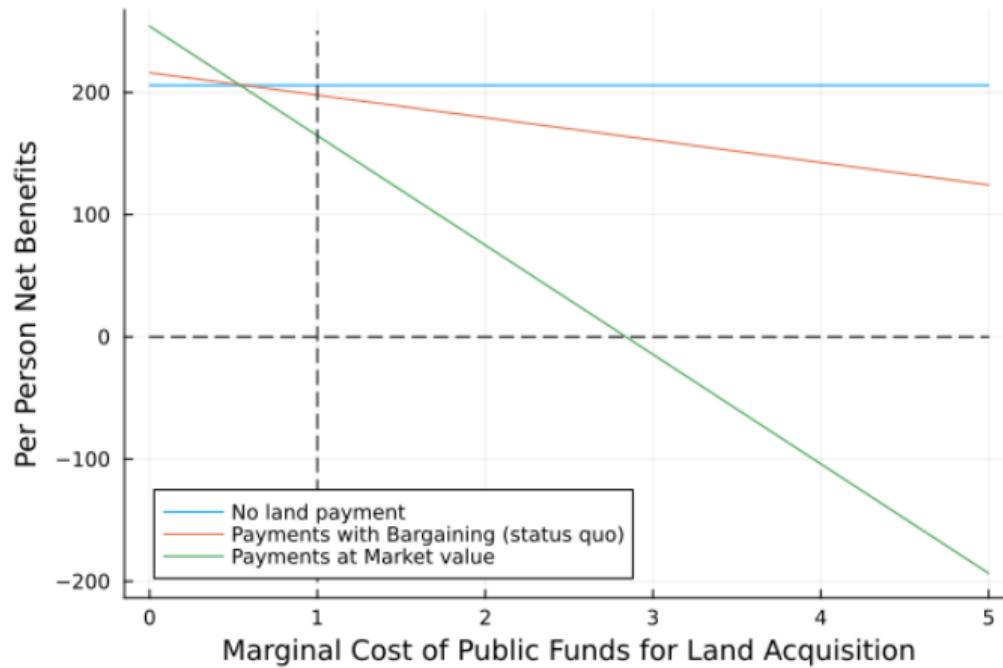
- ▶ Literature $\hat{\xi} \in$
 - ▶ [0.1, 0.13] Fajgelbaum and Schaal 22'
 - ▶ [0.13] Bordeu 24'

Parameters Balance

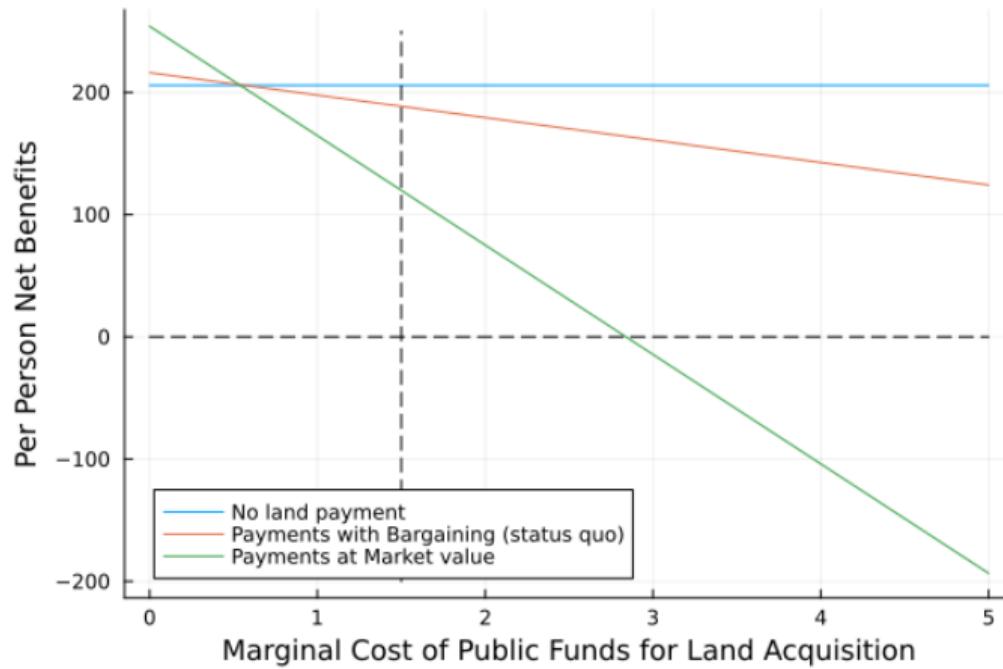
Welfare Impacts of Kampala Road Improvements



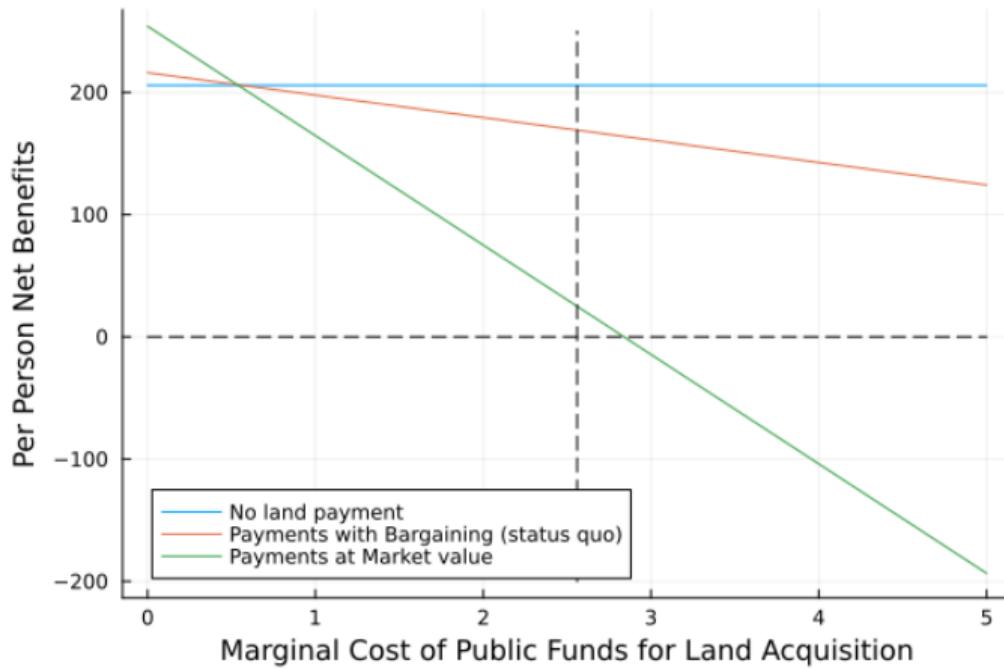
Welfare Impacts of Kampala Road Improvements



Welfare Impacts of Kampala Road Improvements



Welfare Impacts of Kampala Road Improvements



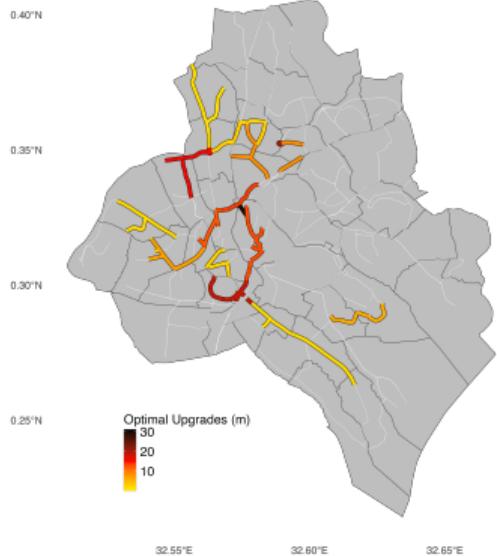
More Upgrades Around Low Costs, High Benefits Links

| | <i>Dependent variable:</i> | | | | | | | |
|--|----------------------------------|-------------------|--------------------|-------------------|--------------------|----------------------|----------------------|----------------------|
| | Log Length of Upgraded Roads (m) | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Log Final Net Welfare | 0.410*** (0.132) | | | | 0.565** (0.260) | | | |
| Log Final Worker Welfare | | 0.413 (0.342) | 0.413** (0.162) | 0.504 (0.304) | | 0.569 (0.343) | 0.569*** (0.130) | 0.906*** (0.316) |
| Log Land Costs (Bargaining) | | -0.875 (0.721) | -0.875 (0.825) | | | -2.185*** (0.724) | -2.185*** (0.683) | |
| Log Land Costs (Market Value) | | | | -0.664 (0.730) | | | | -2.437*** (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 |
| 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 |

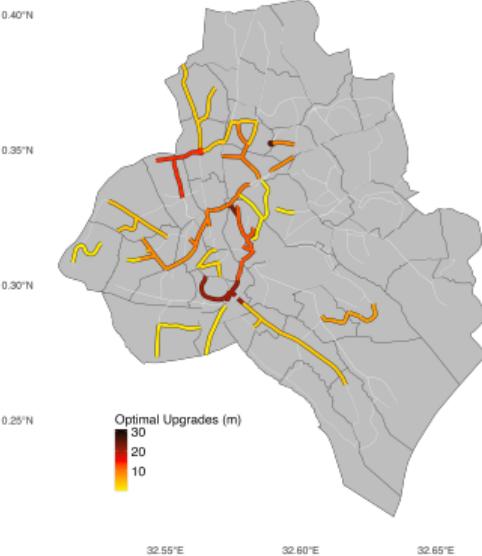
Note:

*p<0.1; **p<0.05; ***p<0.01

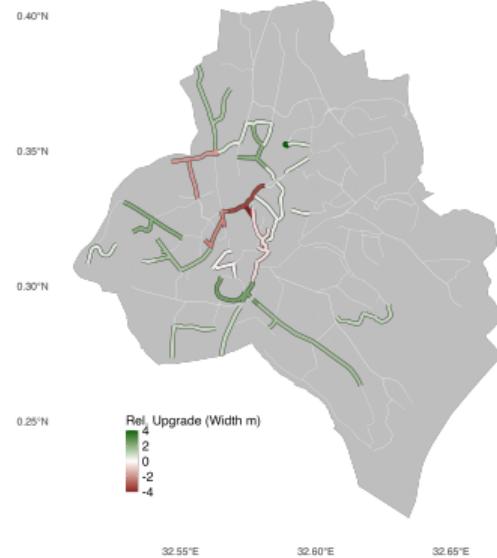
Counterfactuals: Accounting for Land Use



No land Use
\$376



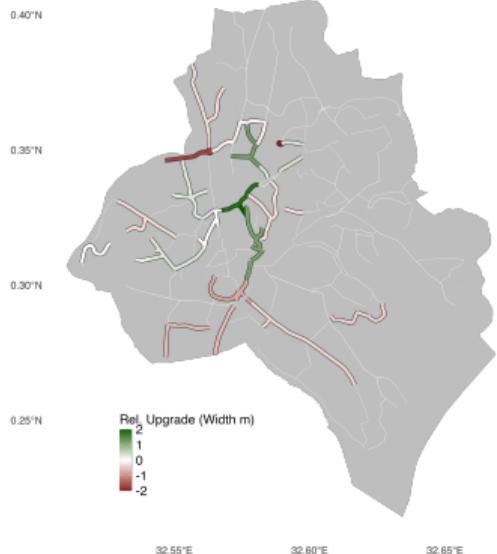
Land Use
\$315



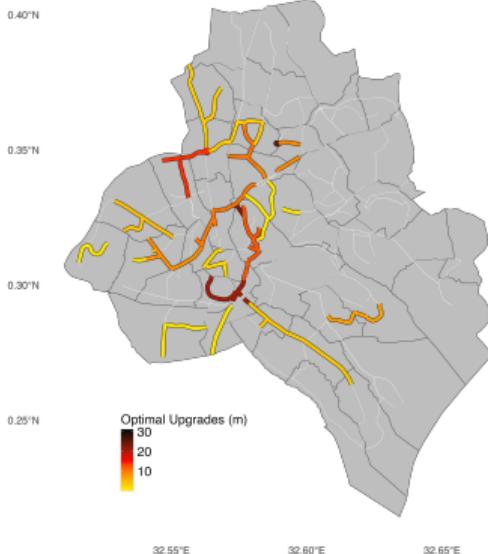
Difference (use - no use)

Counterfactual Payment

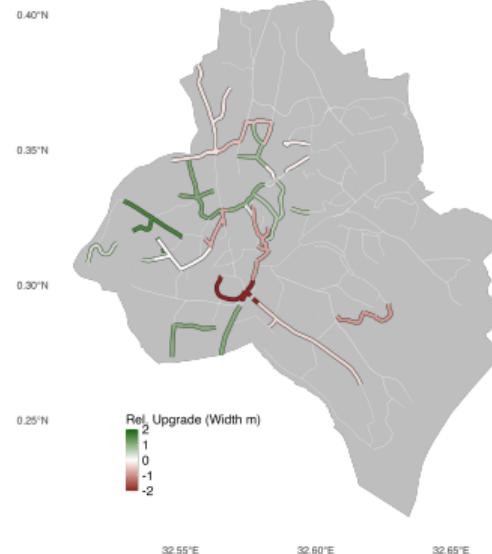
Counterfactuals: Enforcing Different Property Right Regimes



All freehold (diff)
\$242



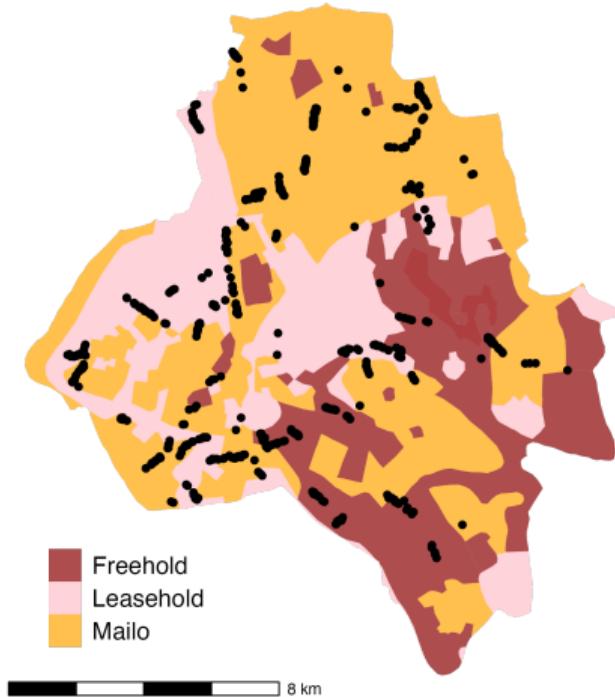
Status-quo
\$ 217



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 (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