

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

**Jeanne Sorin**

University of Chicago

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# Poor Road Infrastructure in African Cities Hinder Development



- ▶ 30% roads in African cities are paved

(Kumar et al. 2008)

# Poor Road Infrastructure in African Cities Hinder Development



*“Poor transportation infrastructure limits access to markets and public services for many residents of developing countries”*

(World Bank 2009)

- ▶ 30% roads in African cities are paved (Kumar et al. 2008)
- ▶ Urban road quality & major roads are associated with economic development (Akbar et al. 2023)
- ▶  $\uparrow$  road quality  $\Rightarrow$   $\uparrow$  speed  $\Rightarrow$   $\downarrow$  commuting time  $\Rightarrow$   $\uparrow$  mobility  $\Rightarrow$   $\uparrow$  property values & access to jobs

# Complex and Overlooked Costs of Road Improvements



Costs = construction

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

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# Complex and Overlooked Costs of Road Improvements



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

- ▶ Land acquisition costs depend on policy
  - ▶ Amount paid: Compensation rule & enforcement
  - ▶ Source of funds: 30% of WB-funded projects delayed because no donor funds for land (WB '96)

## This Paper: Net Gains from Urban Road Improvements in SSA

1. What are residents' net welfare impacts from road improvements? (benefits minus costs)
2. How does land acquisition affect the welfare maximizing location of road improvements?

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 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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  - ▶ **quantitative spatial model & government problem** : citywide impacts & policy implications

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▶ **quantitative spatial model & government problem** : citywide impacts & policy implications

▶ Contributions:

1. measurement: benefits + land costs of road improvements in SSA city (RF & structural)
2. optimal road improvements w/ heterogeneous & endogenous land costs
3. second best: positive welfare impacts of weak property rights w/ high cost of funds

Literature

# Preview of the Results

1. Kampala's road upgrades (since 2017) had large positive net returns because of partial land payments
  - ▶ **Local benefits:** ↑ road quality, +2.6-4km/h local speed, +26% local property values
  - ▶ **Citywide benefits** (road network spillovers + eq relocation):  $\approx 3\times$  construction costs
  - ▶ **Land payments:** enforcement of market value compensation rule depends on property right regime
    - ▶ leasehold owners less likely to be affected, more likely to get compensated
  - ▶ Land payments funded domestically (**high cost of funds**) because of restrictions on donors' funds (only for construction)

# Preview of the Results

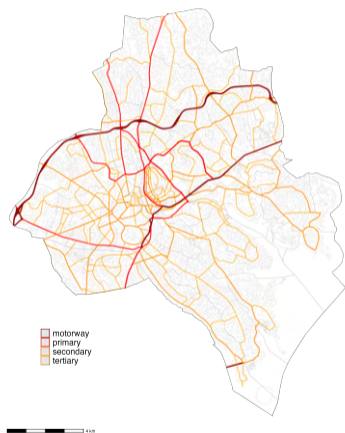
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  - ▶ Land payments funded domestically (**high cost of funds**) because of restrictions on donors' funds (only for construction)
2. Land acquisition rules shape the location of welfare maximizing road upgrades
  - ▶ **Kampala:** more upgrades along links w/ larger marginal benefits & lower land costs
  - ▶ **Distortions:** high cost of public funds for land acquisition & unequal enforcement
  - ▶ **Second best policies:** enforcing market value payments to all
    - 2.1 ↓↓ welfare & allocative efficiency because of the cost of funds.
    - 2.2 ↑↓ welfare & allocating efficiency when combined with relaxing external fund use restrictions (e.g. WB, AfDB)

# Outline

1. Context & Data
2. Local Impacts of Road Improvements
  - 2.1 Land Costs
  - 2.2 Benefits
3. Citywide Impacts of Road Improvements with Land Take
  - 3.1 Quantitative Spatial Model Overview
  - 3.2 Model Estimation
  - 3.3 Net Returns
4. Counterfactuals: Impact of Land Acquisition on Optimal Location:
  - 4.1 Government Problem of Optimal Road Improvements
  - 4.2 Policy 1: Land Compensation Rule
  - 4.3 Policy 2: Relaxing Restrictions on the Use of External Funds

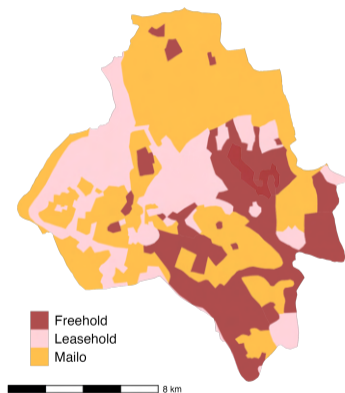
# Context & Data

# Context: Road Quality & Property Right Regimes



► 45% of Kampala's major roads are paved

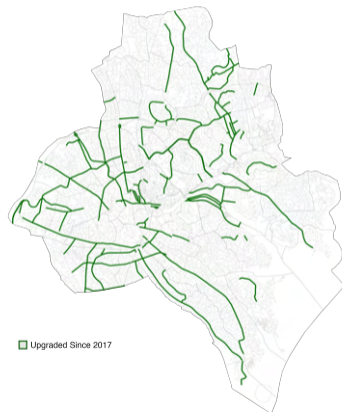
# Context: Road Quality & Property Right Regimes



▶ 45% of Kampala's major roads are paved

▶ 3 property right regimes coexist

# Context: Road Improvements



- ▶ 180 km of road improvements (since 2017)
- ▶ Construction mostly funded by WB & AfDB

# Context: Road Widening Requires Private Land



- ▶ 180 km of road improvements (since 2017)
- ▶ Construction mostly funded by WB & AfDB
- ▶ Private land required for paving + widening
  - ▶ Average width per owner = 1.5 meter (survey)

# Context: Road Widening Requires Private Land

## 4.1.2 Alternatives to minimize land acquisition and resettlement

Being an urban setting, the proposed road projects are in close proximity to informal, residential, commercial and industrial structures implying severe potential impact on the adjacent land and buildings. The AfDB policy on resettlement recommends avoiding displacement where feasible, or minimized by exploring all viable alternative designs. Design options/alternatives have been considered to minimize impacts of land acquisition and physical resettlement. KCCA took into consideration the need to minimize land take beyond the existing road reserve to come up with a number of design options. Design options have been modified a number of times in order to come up with the best options that meet the above objective. The following factors mandated the need to minimize land acquisition and resettlement:

- High values for land and structures along the different roads thus making the compensation cost very high.
- Limited resources to compensate affected property.
- Dense population along the different roads due to their urban nature.

- ▶ 180 km of road improvements (since 2017)
- ▶ Construction mostly funded by WB & AfDB
- ▶ Private land required for paving + widening
  - ▶ Average width per owner = 1.5 meter (survey)
  - ▶ Land acquisition shaped project design (admin data)
- ▶ Regime: eminent domain w/ market value compensation

# Overview: Costs and Benefits of Road Improvements

## 1. Land payments for land take

1.1 Land market value (legal regime)

Broker survey

1.2 Probability of claiming land compensation (practice)

Landowner survey

## 2. Benefits of road improvements

2.1 Local

▶ Road quality

Landowner survey

▶ Local Property Values

Broker survey

▶ Traffic speed

GoogleMaps queries Data

2.2 Citywide (spatial spillovers from transportation network + reallocation)

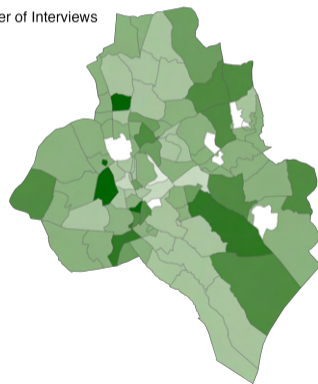
QSM

# Data: Novel Real Estate Broker Survey



► 377 (informal) real estate brokers

Number of Interviews



0 km

# Data: Novel Real Estate Broker Survey

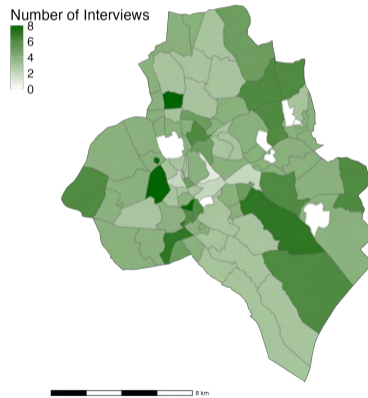
▶ 377 (informal) real estate brokers

## 1. $\approx 3,250$ past transactions

- ▶ detailed characteristics
- ▶ sales (2018-2024) and rental (2023-2024)
- ▶ median sales price residential = \$40,541
  - ▶ monthly rental = \$108
- ▶ Follow-up in progress (Dec 2025)

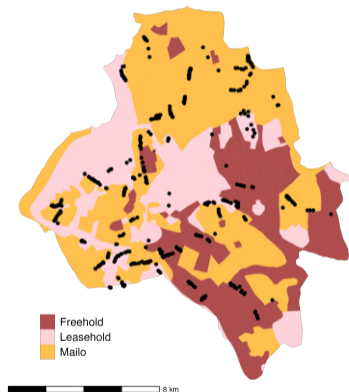
## 2. standardized property appraisal exercise

- ▶ vary characteristics one by one



# Data: Novel Landowner Survey

- ▶ 548 owners w. affected property
- ▶ 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



# Land Payments

$$\sum_i \underbrace{P_i^{\text{land}}}_{\text{payments in location } i} = \sum_i \sum_o \underbrace{\left[ q_i^{\text{land}} \times \Delta H_i^o \right]}_{\text{legal: market value}} \times \underbrace{\gamma(X_i^o)}_{\text{proba owners in } i \text{ claim compensation}}$$

## Cash-strapped KCCA sweet-talks landlords for land

January 13, 2017 Written by ABUBAKER MAYEMBA

 Tweet

0

Cash-strapped Kampala City Council Authority (KCCA) has resorted to sweet-talking landlords into giving away their land before compensation to enable it expand some roads in the city.

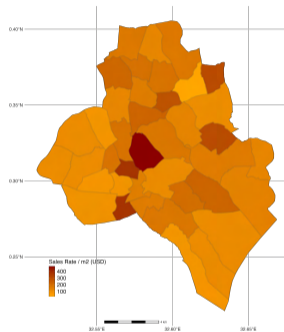
## Amount of Land Taken $\Delta H_i$

$$\sum_i \underbrace{P_i^{\text{land}}}_{\text{payments in location } i} = \sum_i \sum_o \underbrace{\left[ q_i^{\text{land}} \times \Delta H_i^o \right]}_{\text{legal: market value}} \times \underbrace{\gamma(X_i^o)}_{\text{proba owners in } i \text{ claim compensation}}$$

▶ Landowner survey:

- ▶ average amount of land affected:  $73m^2$  (eq.  $1.5m$  wide  $\times$   $50m$  long)
- ▶ equivalent to adding 1 lane (3.2 meters) in total

# Land Market Rate $q_i^{\text{land}}$

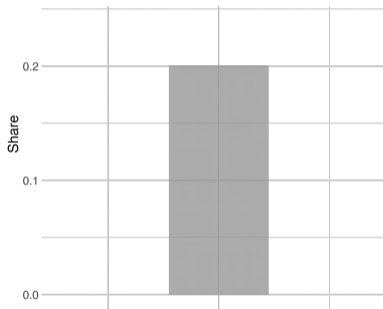


Residential Market Rate / m<sup>2</sup> (USD)

- ▶ **Data:** Broker survey
- ▶ **Variation:** Past transactions (2023/2024) + model  $\Rightarrow$  pre-policy market value

# Probability to Claim the Compensation $\gamma(X_i)$

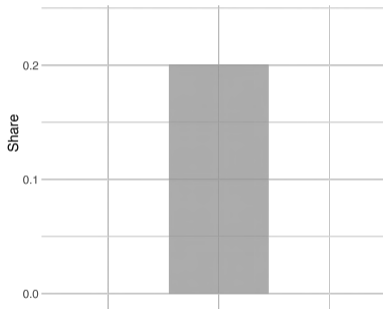
Share of owners claiming the compensation



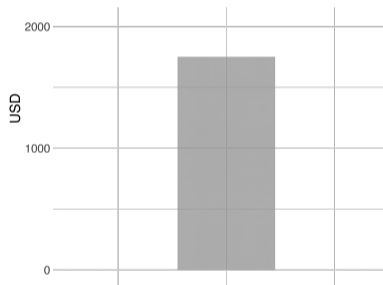
- ▶ 20% of interviewed owners claim the market value compensation
- ▶ Probability increasing in the market value of affected land

# Owners Report Large Fixed Costs of Claiming the Compensation

## Share of owners claiming the compensation

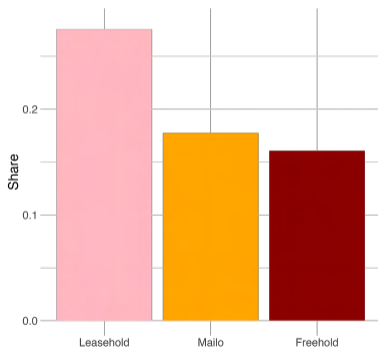


## Cost of Copy Ownership Documents

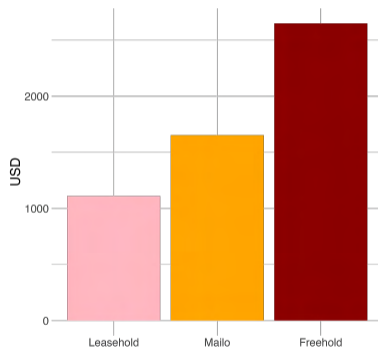
[Claim by value](#)[Reasons Not Claim](#)[Reasons Claim](#)[Not pivotal](#)[Census](#)[Owner Sampling](#)[Data](#)[Estimation](#)[Heterogeneity by Property Right](#)[Table](#)

# Heterogeneity Across Property Right Regimes

## Share of owners claiming the compensation



## Cost of Copy Ownership Documents

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# Predicting Land Payment Across Kampala

- ▶ Discrete choice model of owners' decisions to claim compensation across Kampala

Estimation

$$\gamma(Z_i^o) = \mathbb{P} \left( a \times \underbrace{q_i^0 \Delta H_i^o}_{\text{potential compensation}} + g(X_i^o) > \underbrace{f(Z_i^o) + c_i^o}_{\text{fixed cost}} \right)$$

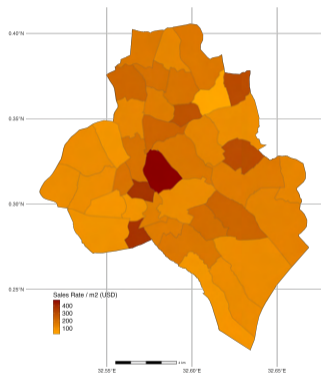
- ▶ Potential compensation:  $q_i^0$  (property rate prior to updates)  $\times$   $\Delta H_i^o$  (affected land size)
  - ▶  $Z_i^o$  : owner  $o$ 's observable characteristics, including property right regime.
- ▶  $c_i^o \sim \text{Logistic}(0,1) \Rightarrow$  estimate parameters through MLE using survey data
- ▶ Modeling assumption: no holding out
- ▶ External validity assumption: no selection on unobservables

Reasons Not Claim

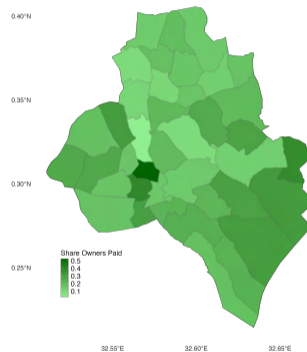
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# Land Payments Are Heterogeneous Over Space



Res Market Rate / m<sup>2</sup> (USD)



Predicted Probability Owners Claim Compensation

# Local Benefits of Road Improvements

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## 2. Benefits of road improvements

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- ▶ Road quality Amenity Road Amenity 1 Amenity 2 Landowner survey
- ▶ Local Property Values (+23% appraisals ; +16% transactions) Value Density Broker survey
- ▶ Traffic speed (+2.6 rush to 4.8km/h non-rush) Speed Table Speed Density GoogleMaps queries

### 2.2 Citywide (spatial spillovers from transportation network + reallocation)

QSM

# Citywide Impacts of Road Improvements

# Model Overview: Citywide Impacts of Road Widening

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

1. Freely tradable consumption good Extension: Trading costs
2. Workers freely choose where to live, work and commute Extension: Amenities
3. Land is split between roads and residential land owned by representative immobile owners

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  - ▶ loss in rental income for owners

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- ▶ **Fiscal losses from land payments**:
  - ▶ private land is acquired at price  $p^{land} = f$  (market value, property rights)
  - ▶ cost of raising public funds (MCPF):  $\eta^{mcpf} \geq 1$

# Model Estimation: Parameters Overview

Parameter		Source	Value
$a, f(Z_k)$	owner compensation claim model	Owner survey	
$\xi$	elasticity of time $_{kl}$ on road width $R_{kl}$	GoogleMaps + upgrade rollout	0.39
$\theta$	elasticity of location choice on commuting costs	Local ride hailing app	3.3
$\kappa$	elasticity of commuting costs on time	Ahlfeldt et al. (2015)	0.01
$\beta$	share of worker's expenditure on consumption	UNPS (2019)	0.76
$\rho$	elasticity of route-choice on route-cost	$\approx$ shortest path	50
$\omega^o, \omega^w$	welfare weights on owners and workers	Utilitarian	
$\eta^{\text{mcpf}}$	marginal cost of public funds	Varying	

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►  $\hat{\xi} = 0.39$  (Fajgelbaum and Schaal 22' [0.1] ; Bordeu '24 [0.13])

Quantities

Owner Model

 $\xi$  $\theta\kappa$

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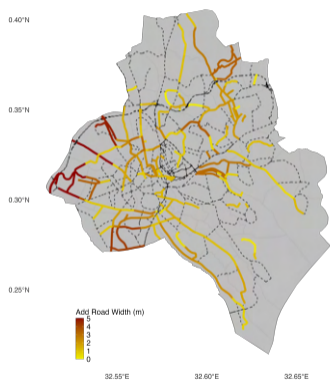
► Data on:  $L_i^R, L_i^F, q_i^R, l_{kl}, R_{kl}, \bar{t}_{kl}; A_i, B_i$  by inverting the model

Quantities

Owner Model

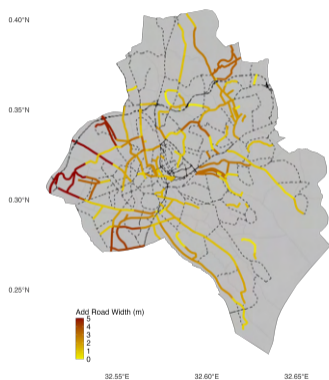
 $\xi$  $\theta\kappa$

# Impacts of the Realized Road Improvements For Residents



Upgraded Roads (width per link)

# Impacts of the Realized Road Improvements For Residents



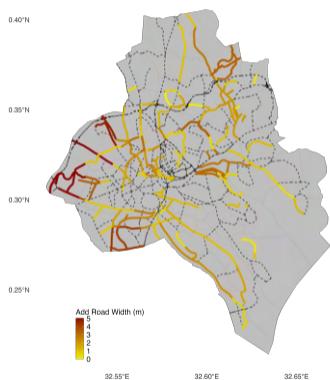
- ▶ Payments (total)
  - ▶ construction: \$103 mln (\$123 / worker)
  - ▶ land: \$19 mln (\$94 mln eminent domain)
- ▶ Local benef (property value + \$90 mln ) < construction
- ▶ Citywide benefits  $\equiv 5 \times$  local benefits (magnitude)
  - ▶ avg commuting time:  $-6.9\%$  (fixed pop) to  $-5.0\%$
  - ▶ avg rental rate:  $+3.7\%$

RF

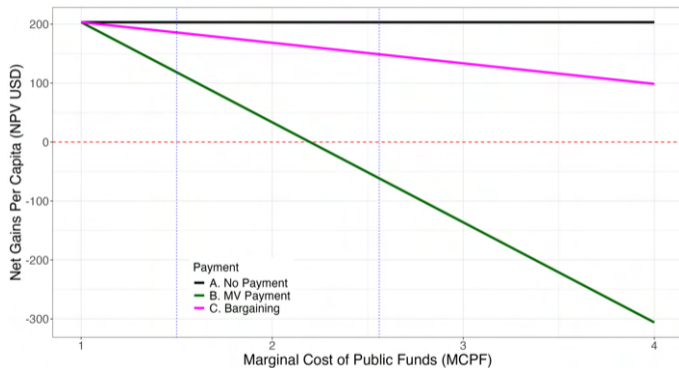
Extensions

Upgraded Roads (width per link)

# Impacts of the Realized Road Improvements For Residents



Upgraded Roads (width per link)



Net Gains Per Capita

# Counterfactuals

# Land Acquisition Shapes Transportation Infrastructure Projects

- ▶ Infrastructure projects are shaped by spatially heterogeneous (i) benefits and (ii) land costs
  - ▶ Kampala: more upgrades along links w/ larger benefits and lower land payments [Map](#) [Table](#)
  - ▶ Kampala upgrades: leasehold owners (i) less affected & (ii) more likely to be paid if affected [Reg](#)
- ▶ The impact of land acquisition on the projects' location is shaped by policies
  1. Land payments depend on the enforcement of the compensation policy & land tenure regime
  2. The fiscal cost of land payments depend on whether external funds can be used for land payments

⇒ How do land acquisition policies lead to spatial misallocations of road improvements?

# Land Acquisition Shapes Transportation Infrastructure Projects

- ▶ Infrastructure projects are shaped by spatially heterogeneous (i) benefits and (ii) land costs
  - ▶ Kampala: more upgrades along links w/ larger benefits and lower land payments [Map](#) [Table](#)
  - ▶ Kampala upgrades: leasehold owners (i) less affected & (ii) more likely to be paid if affected [Reg](#)
- ▶ The impact of land acquisition on the projects' location is shaped by policies
  1. Land payments depend on the enforcement of the compensation policy & land tenure regime
  2. The fiscal cost of land payments depend on whether external funds can be used for land payments

⇒ How do land acquisition policies lead to spatial misallocations of road improvements?

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# Gov Problem: Optimal Location of Road Improvements

- ▶ Gov chooses additional road width  $\{dR_{kl}\}_{kl}$  to maximize net welfare under constraints

$$\max_{\{dR_{kl}\}_{kl}} \underbrace{\omega^w \bar{L} W^w(dR_{kl})}_{\text{workers}} + \underbrace{\omega^o \sum W_i^o(dR_{kl})}_{\text{owners}} - \underbrace{\eta^{MCPF} \sum_i \left( p_i^{\text{land}} \sum_{m \in \mathcal{C}_i} \left( dR_{mi} \frac{\bar{l}_{mi}}{2} \right) \right)}_{\text{land payments}}$$

[external budget constraint] s.t.  $\bar{p} \sum_i \sum_{m \in \mathcal{C}_i} \left( dR_{mi} \frac{\bar{l}_{mi}}{2} \right) \leq \bar{M}$

- ▶  $W^w, W_i^o$ : equilibrium workers' and owners' welfares as a function of road width  $\{dR_{kl}\}_{kl}$
- ▶  $\omega^w, \omega^o$ : relative weights on workers' and owners' welfares
- ▶  $p_i^{\text{land}}$ : land acquisition rate depends on policy  $\in \{0, q_i^0, q_i^0 \times \gamma_i\} \Rightarrow$  different levels and spatial distribution
- ▶  $\eta^{MCPF} \geq 1$ : marginal cost of public funds
- ▶  $\bar{M}$ : external budget for construction (not for land)

# Equilibrium $dR_{kl}^*$

$$\underbrace{-\frac{l_{kl}}{2} \left( \phi_k^{HR} + \phi_l^{HR} + (\eta^{\text{mcpf}} - 1) (p_k^{\text{land}} + p_l^{\text{land}}) + \lambda \bar{p} l_{kl} \right)}_{\text{marginal costs of } dR_{kl}} = \underbrace{\frac{1}{(R_{kl}^0 + dR_{kl})^\xi} (\kappa \xi \bar{t}_{kl} d_{kl}) (-(\psi_{kl} + \psi_{lk}))}_{\text{marginal benefits of } dR_{kl}}$$

1.  $\eta^{\text{mcpf}} = 1$ : payment for land has no impact on  $dR_{kl}^*$
2.  $\eta^{\text{mcpf}} > 1$ : any land payment is distortionary

▶ the larger cor  $\left( \underbrace{(\eta^{\text{mcpf}} - 1) (p_k^{\text{land}} + p_l^{\text{land}})}_{\text{net cost of payments}}, \underbrace{\frac{1}{(R_{kl}^0 + dR_{kl})^\xi} (\kappa \xi \bar{t}_{kl} d_{kl}) (-(\psi_{kl} + \psi_{lk}))}_{\text{marginal benefits}} \right)$ , the larger the distortion

▶ status-quo:  $p_k^{\text{land}} = q_{k,0}^{\text{land}} \times \gamma(Z_k)$

▶  $\gamma(Z_k) < 1 \Rightarrow$  lower distortion than market value

▶  $\text{cor}(\gamma(Z_k), \text{marginal benefits}) < 1 (> 1) \Rightarrow$  lower (larger) distortion than market value

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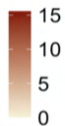
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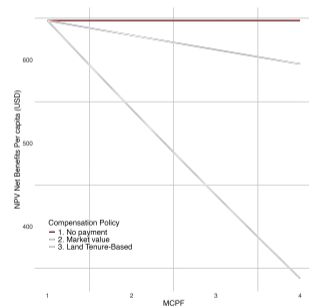
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# A. Payment Rule: No Land Payment

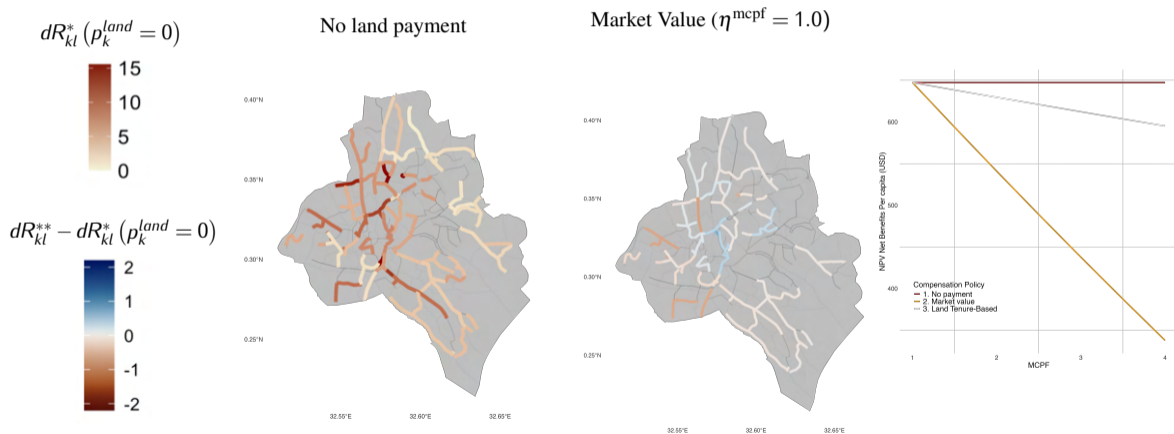
$$dR_{kl}^* (p_k^{land} = 0)$$



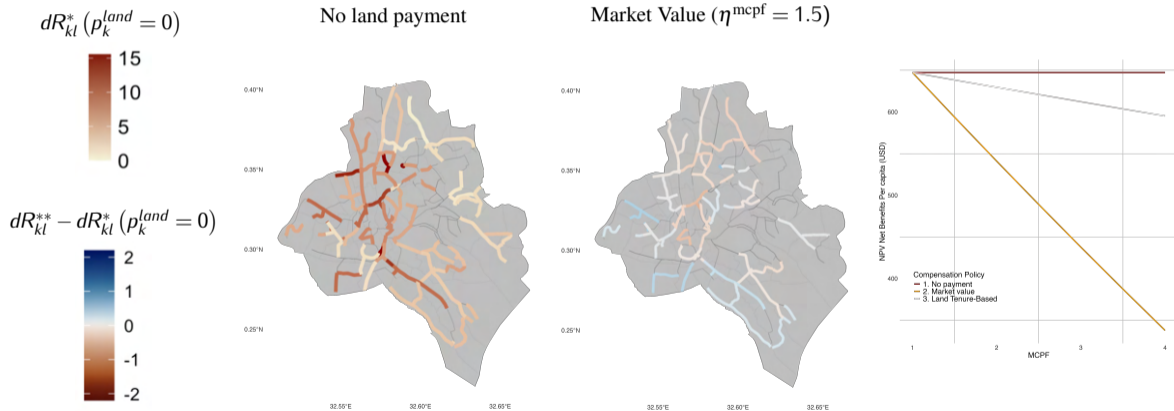
No land payment



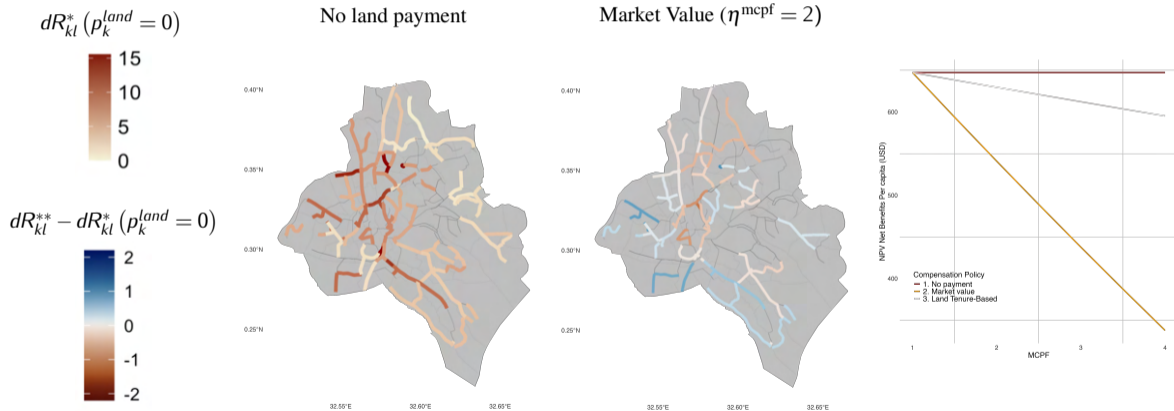
# A. Payment Rule: Market Value Compensation



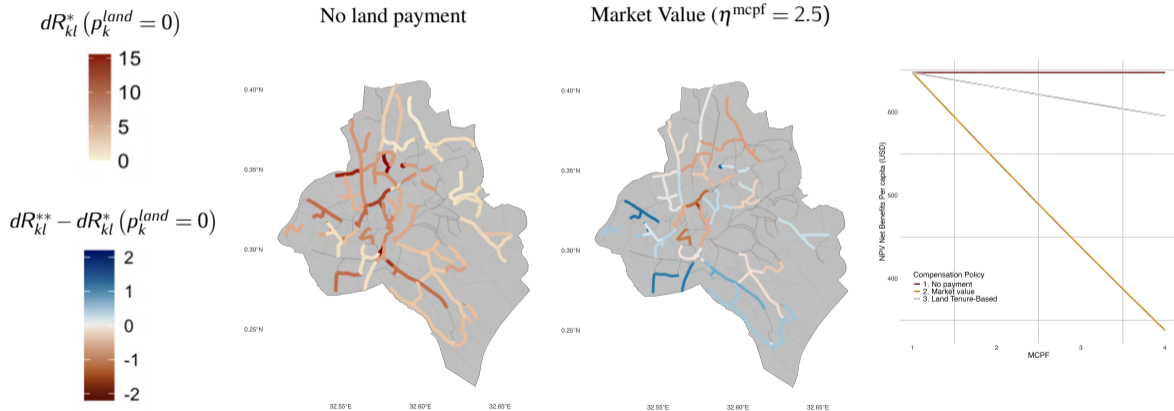
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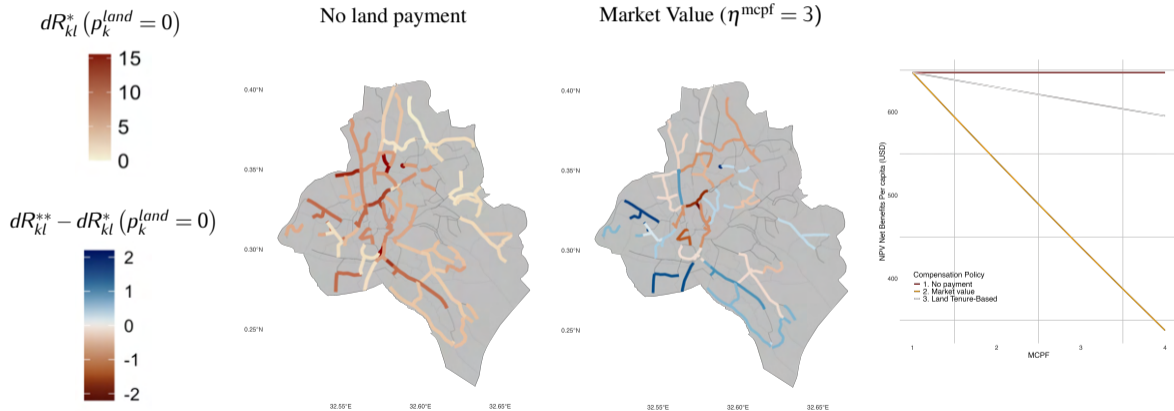
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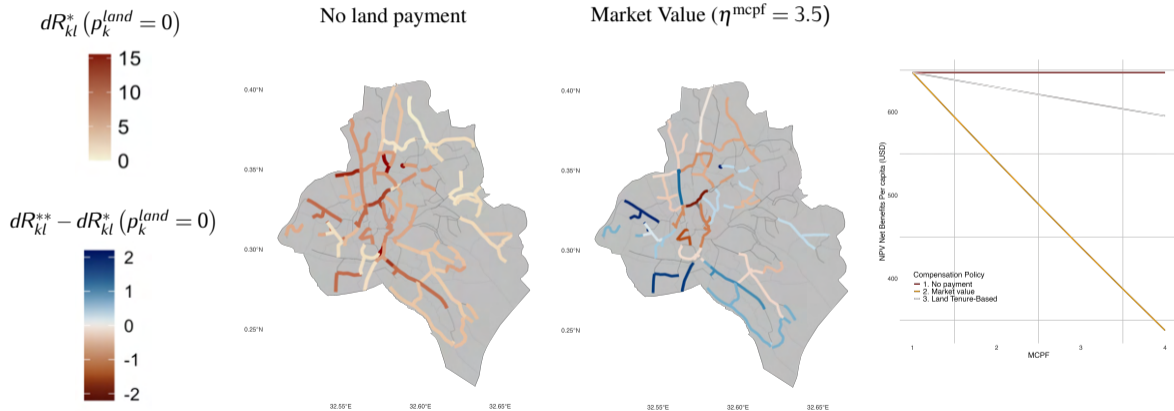
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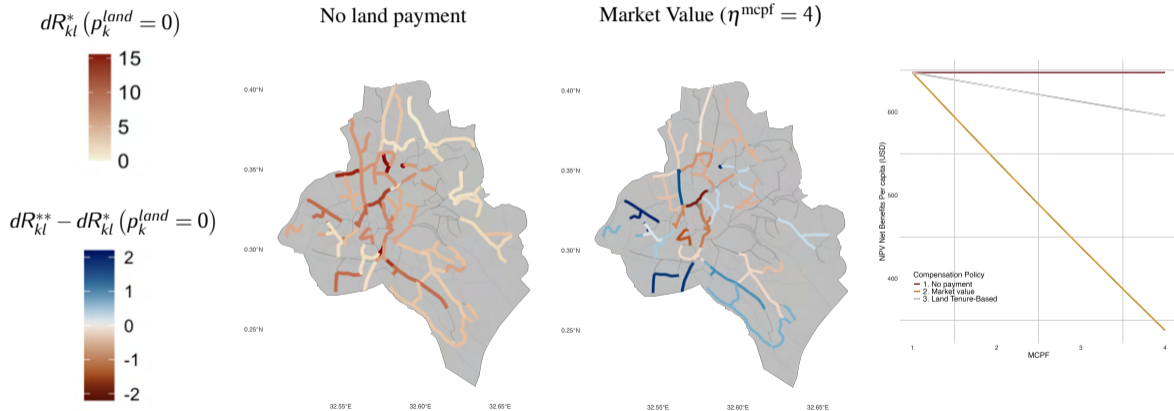
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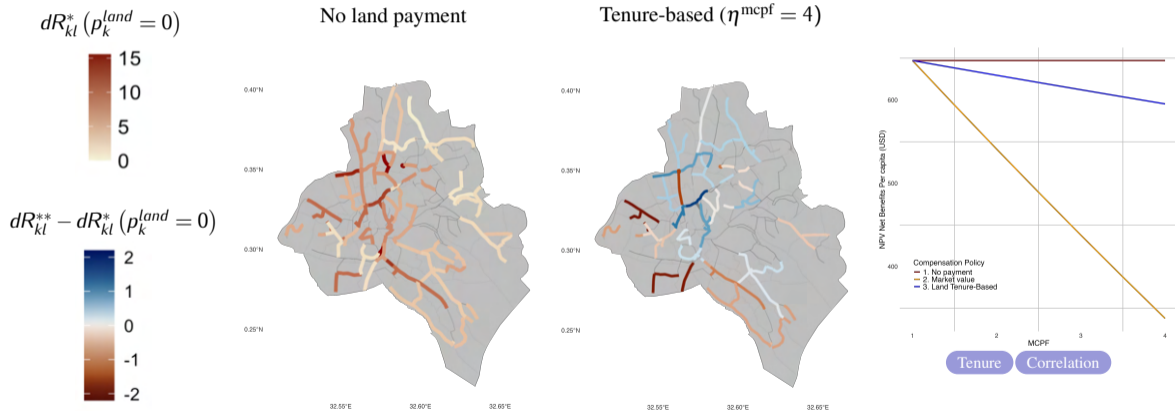
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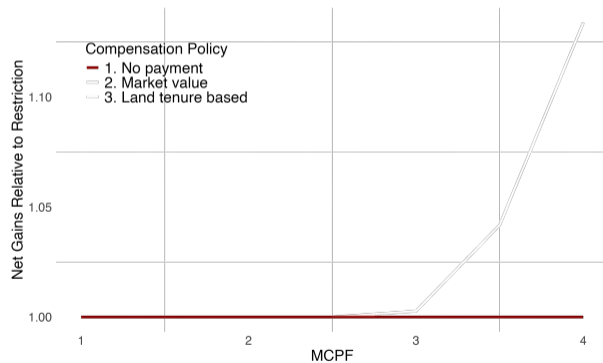


# A. Payment Rule: Payment Based on Land Tenure (Status-quo)



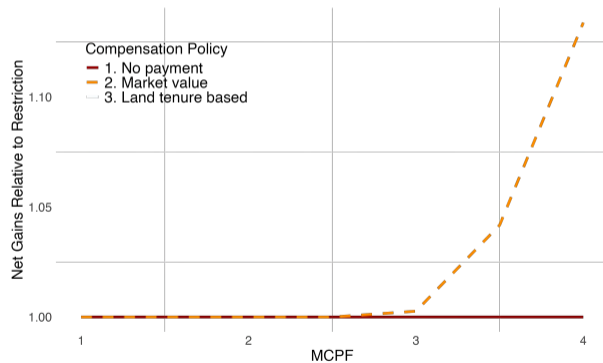
## B. Relaxing Restrictions on Funds

Figure: Net Welfare Gains Relative to Restriction (Ratio)



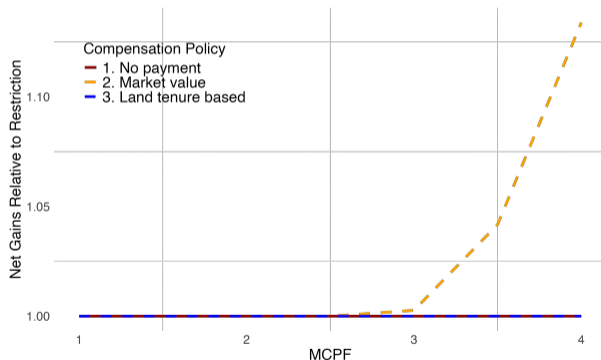
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Figure: Net Welfare Gains Relative to Restriction (Ratio)



⇒ Under MV payment, relaxing restrictions on the use of funds can achieve up to 12% more net gains despite less roads widened.

# Conclusion

- ▶ This paper: **new data** + **QSM**  $\Rightarrow$  net impacts of road improvements w/ land acquisition
- ▶ Realized road improvements in Kampala: large benefits but threatened by land costs
  - ▶ Large benefits: +3km/h speed ; -5% commuting time ; +26% local property values ; +3.7% citywide property values
  - ▶ High cost of land funds  $\Rightarrow$  net benefits may have been negative if land had been acquired at market value
- ▶ Welfare-maximizing location of road improvements is distorted by land payments
  - ▶ Theory: ambiguous welfare impacts of enforcing payment at market value (higher cost but potentially lower distortion)
  - ▶ Quantitatively: enforcing payment at market value leads to more distortions than the status-quo payment
- ▶ Policy implications
  - ▶ Policy design should account for all costs (construction + land)
  - ▶ If external donors (WB, AfDB) care about market value compensation, they should reconsider restrictions on funds
  - ▶ Unintended positive consequences of weak property rights when the cost of funds is high

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# 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  $\uparrow$ , local property values  $\uparrow$ , 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
- ▶ **Heterogeneous land usage costs and financial land costs also shape the location of welfare-maximizing improvements**  
Financial and costs USA: Mehrotra et al. '21, Brooks & Liscow '23  
Other financial costs LICs: Olken '07, Collier & Venables '16, Collier '19, Wolfram et al. '24  
Optimal QSM: Allen & Arkolakis '20, Fajgelbaum & Schaal '22, Bordeu '24

Intro

## 2. Compensations for land take are likely to distort public investments in LMICs

- ▶ **Payments for land take must not have positive welfare impacts**  
Eminent domain: Munch '76, Shavell '10, Jeong et al. '16
- ▶ **Land compensation can shape the allocative efficiency of investments because of distortions faced by LMICs govts**
  - ▶ **High cost of public funds in LMICs increase the effective cost of land payments**  
High cost of public funds and taxes: Traxler '10, Besley and Persson '14, Knebelmann '19, Bergeron et al. '23, Brockmeyer et al. '23
  - ▶ **Weak private property rights can have unintended positive consequences**  
Property rights & private investments: North '90, Acemoglu et al. '01, Besley and Ghatak '10, Bird and Venables '20  
Property rights & public goods: Acemoglu and Robinson '12, Posner and Weyl '17, Holland '23

# Data: GoogleMaps Data

▶ > 180,000 GoogleMaps Direction API queries (Mar 23 - Aug 24)

(in progress to Dec 2025)

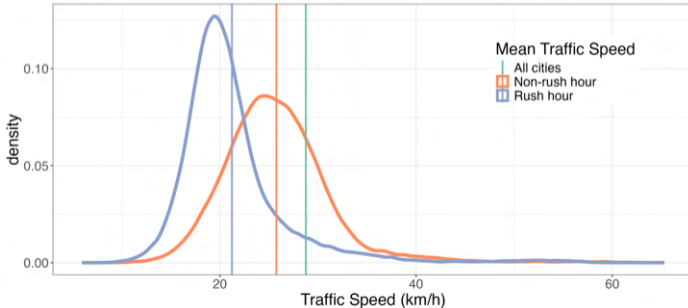
▶ 96×96 unique parish-to-parish trips ⇒ speed by road type (model)

▶ 52 policy roads ⇒ impact of upgrade on speed

▶ traffic speed + average speed + path (approx mapping to OSM)

Overview

▶ Avg speed = 24.5km/h  $\approx$  25<sup>th</sup> ptile world cities (rush = 25.8 km/h ; non-rush = 21.2 km/h)



# Environment and Land Usage Cost

- ▶ **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  $A_i$ , property right regime  $Z_i$
- ▶ **Fixed amount of land per location**  $\bar{H}_i$  imply an **opportunity cost of land of additional road**

Overview

Extension

$$\bar{H}_i = \underbrace{H_i^r}_{\text{residential}} + \underbrace{\sum_{m \in \mathcal{C}_i} (\bar{R}_{mi}^0 + dR_{mi})}_{\text{road}} \times \frac{\bar{l}_{mi}}{2}$$

- ▶  $\bar{l}_{mi}$  length of road  $m \rightarrow i$ , equally split between  $m$  and  $i$
- ▶  $\bar{R}_{mi}^0$  width of road connecting  $i$  to  $m$  at baseline,  $\forall$  neighboring  $m$
- ▶  $dR_{mi}$  additional road width

# 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

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

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

$$\underbrace{W^w}_{\text{expected worker welfare}} \propto \left( \sum_{ij} \left( \frac{B_i w_j}{\tau_{ij} q_i^{1-\beta}} \right)^\theta \right)^{\frac{1}{\theta}}$$

# Benefits: Commuting Costs Decrease In Road Infrastructure

▶ Average commuting costs  $\tau_{ij}$

- ▶  $\rho$  : elasticity of average  $\tau_{ij}$  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  $d_{kl}$

$$d_{kl} = \exp \left( \kappa \times \frac{\bar{t}_{kl}}{\underbrace{(\bar{R}_{kl}^0 + dR_{kl})}_{\equiv t_{kl}}}^{\xi} \right)$$

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

# Landowners Receive Land Income

- ▶ Residential land is owned by a immobile representative landowner in each location
- ▶ Owners get utility from consuming the tradeable and receive land-related income:

$$U_i^o = C_i^o \quad \text{s.t.} \quad C_i^o \leq \underbrace{H_i^r q_i}_{\text{rental income}} + \underbrace{p_i^{land} \left( \sum_{m \in \mathcal{L}_i} dR_{mi} \frac{\bar{l}_{mi}}{2} \right)}_{\text{payments for land take}}$$

- ▶ rental income:  $H_i^r q_i$
- ▶ land acquisition-related payments:  $p_i^{land} \left( \sum_{m \in \mathcal{L}_i} dR_{mi} \frac{\bar{l}_{mi}}{2} \right)$

$$W_i^o = H_i^r q_i + p_i^{land} \left( \sum_{m \in \mathcal{L}_i} dR_{mi} \frac{\bar{l}_{mi}}{2} \right)$$

# Land Payment And Enforcement of Land Acquisition Rules

$$p_i^{\text{land}} = \left\{ \begin{array}{l} q_i^0 \times \underbrace{\gamma(Z_i)}_{\text{share of payments made}} \end{array} \right. \quad (1) \text{ status-quo: imperfectly enforced legal regime based on property rights } z_i$$

$$\gamma(Z_i) = \mathbb{P} \left( \underbrace{a \times q_i^0 \left( \sum_{m \in \mathcal{C}_i} dR_i \frac{\bar{l}_{mi}}{2} \right)}_{\text{potential compensation}} > \underbrace{f(Z_i) + c_i}_{\text{fixed cost}} \right)$$

- ▶  $q_i^0$  : property rate evaluated at baseline (prior to the policy) ;  $f(Z_i)$  = owner's fixed costs as a function of property rights & obs. char.  $Z_i$
- ▶ idiosyncratic fixed cost  $c_i \sim \text{Logistic}(0, 1)$
- ▶ assumption: no holding out

Reasons Not Claim

Reasons Claim

Not pivotal

# Land Payment And Enforcement of Land Acquisition Rules

$$p_i^{\text{land}} = \begin{cases} q_i^0 \times \underbrace{\gamma(Z_i)}_{\text{share of payments made}} & \text{(1) status-quo: imperfectly enforced legal regime based on property rights } Z_i \\ 0 & \text{(2) counterfactual: no compensation} \end{cases}$$

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# Government's Choice of Additional Road Width

- ▶ Gov chooses additional road width  $\{dR_{kl}\}_{kl}$  to maximize net welfare under constraint

$$\max_{\{dR_{kl}\}_{kl}} \underbrace{\omega^w \bar{L} W^w(dR_{kl})}_{\text{workers}} + \underbrace{\omega^o \sum W_i^o(dR_{kl})}_{\text{owners}} - \underbrace{\eta^{MCPF} \sum_i \left( p_i^{land} \sum_{m \in \mathcal{C}_i} \left( dR_{mi} \frac{\bar{l}_{mi}}{2} \right) \right)}_{\text{land payments}}$$

[external budget constraint] s.t.  $\bar{p} \sum_i \sum_{m \in \mathcal{C}_i} \left( dR_{mi} \frac{\bar{l}_{mi}}{2} \right) \leq \bar{M}$

- ▶  $\omega^w, \omega^o$ : relative weights on workers' and owners' welfares
- ▶  $\eta^{MCPF} \geq 1$ : marginal cost of public funds

# Model Equilibrium

- ▶ **Equilibrium:** Given the model's parameters  $\{\beta, \theta, \kappa, \xi, f(\cdot), \eta^{\text{mcpf}}, \bar{L}, \bar{M}, \bar{p}, \omega^w, \omega^o\}$ , location and link characteristics at baseline  $\{B_i\}, \{A_i\}, \{\bar{H}_i\}, \{Z_i\}, \{\bar{t}_{kl}\}, \{R_{kl}^0\}$ , the equilibrium of the model is the set of prices  $\{q_i\}, \{p_i^{\text{land}}\}$  and quantities  $\{L_{ij}\}, \{H_{ij}\}, \{C_{ij}\}, \{dR_{kl}\}$  such that
- ▶ the government chooses  $\{dR_{kl}\}$  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 get compensated for land at rate  $p_i^{\text{land}}$
  - ▶ residential land markets clear  $\sum_j H_{ij} = H_i^r \forall i$
  - ▶ the good market clears

# Equilibrium $dR_{kl}^*$

- ▶ Solve for the optimal road widening on  $kl$ :  $dR_{kl}^*$

$$\underbrace{-\frac{l_{kl}}{2} \left( \phi_k^{HR} + \phi_l^{HR} + \left( \eta^{MCPF} - 1 \right) \left( p_k^{land} + p_l^{land} \right) + \lambda \bar{p} l_{kl} \right)}_{\text{marginal costs of } dR_{kl}} = \underbrace{\frac{1}{\left( R_{kl}^0 + dR_{kl}^* \right)^\xi} \left( \kappa \xi \bar{t}_{kl} d_{kl} \right) \left( - \left( \psi_{kl} + \psi_{lk} \right) \right)}_{\text{marginal benefits of } dR_{kl}}$$

- ▶ shadow benefit of higher link-level commuting cost  $d_{kl}$ :  $\psi_{kl}^d \leq 0$
- ▶ shadow benefit of additional budget for the gov  $\bar{M}$ :  $\lambda \geq 0$
- ▶ shadow benefit of additional residential land  $H_k^r$ :  $\phi_k^{HR} \geq 0$
- ▶ Simplification:  $\omega^o, \omega^w = 1$
- ▶ Counterfactual policies: How do land compensation policies impact the equilibrium?
  1. enforcement of the land payment rule  $\Rightarrow p_i^{land}$
  2. relaxing restrictions on external funds:  $w = \omega^w \bar{L} W^w + \omega^o \Sigma W_i^o - \eta^{MCPF} \left[ \Sigma_i \left( p_i^{land} \Sigma \left( dR_{mi} \frac{l_{mi}}{2} \right) \right) - \max \left( \bar{M} - \bar{p} \Sigma_{mi} \frac{l_{mi}}{2} dR_{mi}, 0 \right) \right]$

# Equilibrium $dR_{kl}^*$

- ▶ Solve for the optimal road widening on  $kl$ :  $dR_{kl}^*$

$$\underbrace{-\frac{l_{kl}}{2} \left( \phi_k^{HR} + \phi_l^{HR} + \left( \eta^{MCPF} - 1 \right) \left( p_k^{land} + p_l^{land} \right) + \lambda \bar{p} l_{kl} \right)}_{\text{marginal costs of } dR_{kl}} = \underbrace{\frac{1}{\left( R_{kl}^0 + dR_{kl}^* \right)^\xi} \left( \kappa \xi \bar{t}_{kl} d_{kl} \right) \left( - \left( \psi_{kl} + \psi_{lk} \right) \right)}_{\text{marginal benefits of } dR_{kl}}$$

- ▶ shadow benefit of higher link-level commuting cost  $d_{kl}$ :  $\psi_{kl}^d \leq 0$
  - ▶ shadow benefit of additional budget for the gov  $\bar{M}$ :  $\lambda \geq 0$
  - ▶ shadow benefit of additional residential land  $H_k^r$ :  $\phi_k^{HR} \geq 0$
- ▶ Simplification:  $\omega^o, \omega^w = 1$
  - ▶ Counterfactual policies: How do land compensation policies impact the equilibrium?
    1. enforcement of the land payment rule  $\Rightarrow p_i^{land}$
    2. relaxing restrictions on external funds:  $\mathbf{w} = \omega^w \bar{L} W^w + \omega^o \Sigma W_i^o - \eta^{MCPF} \left[ \Sigma_i \left( p_i^{land} \Sigma \left( dR_{mi} \frac{l_{mi}}{2} \right) \right) - \max \left( \bar{M} - \bar{p} \Sigma_{mi} \frac{l_{mi}}{2} dR_{mi}, 0 \right) \right]$

## Equilibrium $dR_{kl}^*$

$$\underbrace{-\frac{l_{kl}}{2} \left( \phi_k^{HR} + \phi_l^{HR} + (\eta^{\text{mcpf}} - 1) (p_k^{\text{land}} + p_l^{\text{land}}) + \lambda \bar{p}_{l_{kl}} \right)}_{\text{marginal costs of } dR_{kl}} = \underbrace{\frac{1}{(R_{kl}^0 + dR_{kl})^\xi} (\kappa \xi \bar{t}_{kl} d_{kl}) (-(\psi_{kl} + \psi_{lk}))}_{\text{marginal benefits of } dR_{kl}}$$

1.  $\eta^{\text{mcpf}} = 1$ : payment for land has no impact on  $dR_{kl}^*$

2.  $\eta^{\text{mcpf}} > 1$ : any land payment is distortionary

▶ the larger  $\text{cor} \left( \underbrace{(\eta^{\text{mcpf}} - 1) (p_k^{\text{land}} + p_l^{\text{land}})}_{\text{net cost of payments}}, \underbrace{\frac{1}{(R_{kl}^0 + dR_{kl})^\xi} (\kappa \xi \bar{t}_{kl} d_{kl}) (-(\psi_{kl} + \psi_{lk}))}_{\text{marginal benefits}} \right)$ , the larger the distortion

▶ status-quo:  $p_k^{\text{land}} = q_{k,0}^{\text{land}} \times \gamma(Z_k)$

▶  $\gamma(Z_k) < 1 \Rightarrow$  lower distortion than market value

▶  $\text{cor}(\gamma(Z_k), \text{marginal benefits}) < 1 (> 1) \Rightarrow$  lower (larger) distortion than market value

# Equilibrium $dR_{kl}^*$

$$\underbrace{-\frac{l_{kl}}{2} \left( \phi_k^{HR} + \phi_l^{HR} + (\eta^{\text{mcpf}} - 1) (p_k^{\text{land}} + p_l^{\text{land}}) + \lambda \bar{p} l_{kl} \right)}_{\text{marginal costs of } dR_{kl}} = \underbrace{\frac{1}{(R_{kl}^0 + dR_{kl})^\xi} (\kappa \xi \bar{t}_{kl} d_{kl}) (-(\psi_{kl} + \psi_{lk}))}_{\text{marginal benefits of } dR_{kl}}$$

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# Leasehold Owners Are Less Likely to Be Affected

	<i>Dependent variable:</i>	
	Affected Owner (d)	
	(1)	(2)
Leasehold (d)	-0.045 (0.078)	-0.139*** (0.053)
Mailo (d)	0.068 (0.074)	0.004 (0.048)
Log (property value today USD)	-0.046*** (0.017)	-0.034** (0.016)
Log (owner's weekly food exp USD)	-0.003 (0.024)	-0.041 (0.025)
Road FE	Y	
Ref Tenure	Freehold	Freehold
Observations	673	673
R <sup>2</sup>	0.473	0.030
Adjusted R <sup>2</sup>	0.399	0.023
Residual Std. Error	0.355 (df = 589)	0.453 (df = 667)

*Note:*

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

## Affected Leasehold Owners More Likely to Claim the Compensation

	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	Leasehold
Geo FE			Grid
Parish Geo Controls		Y	Y
Parish SocioEcon Controls		Y	Y

# 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)
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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

Overview Model

Stylized

Sampling

Data

# Estimating Owner Fixed Costs

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All Parameters

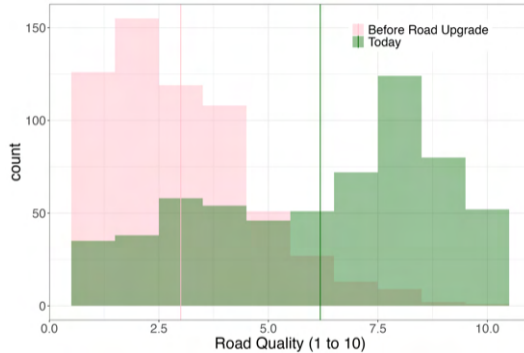
Overview Model

Stylized

Sampling

Data

# Local Benefit: Improvement in Road Quality



- ▶ **Data:** owner survey
- ▶ **Variation:** within owner (before vs after road upgrade)

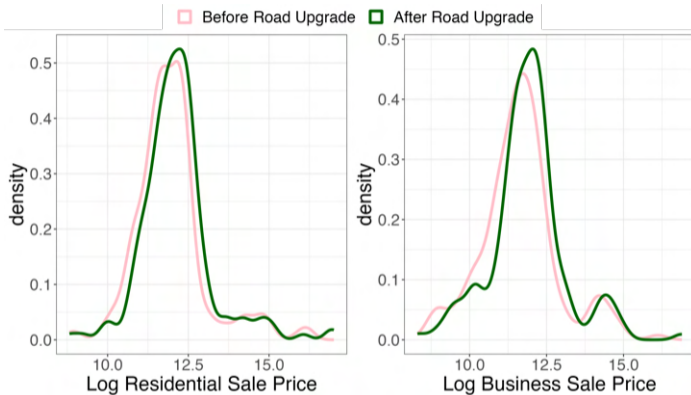
Local benefits overview

Main estimation benefits

Environmental Amenities

Traffic Amenities

# Local Benefit: Increase in Property Values



- ▶ **Data:** Broker survey
- ▶ **Variation:** Property appraisal: hypothetical road upgrade +23% sales price
- ▶ **Extrapolate to all properties on the side of upgraded roads**  $\approx$  \$86 million

Main estimation benefits

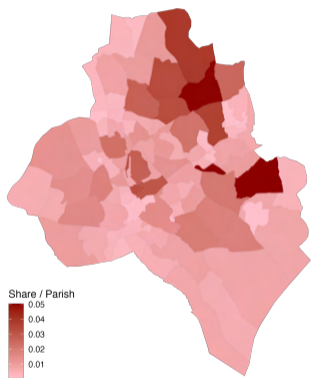
Citywide

Online

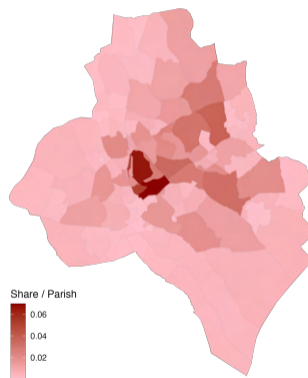
Appraisal

Transactions

# Commuting Flows

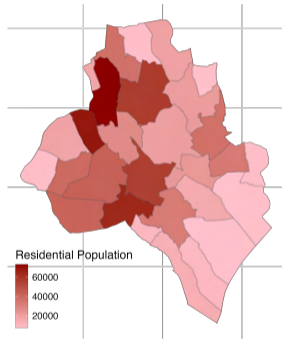


(a) Origin Parish

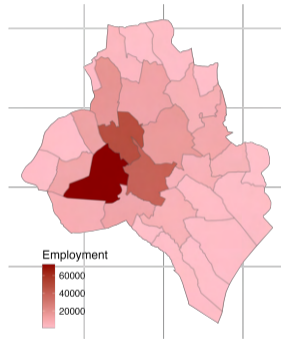


(b) Destination Parish

# Census Data



(c) Population



(d) Employment

# 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:

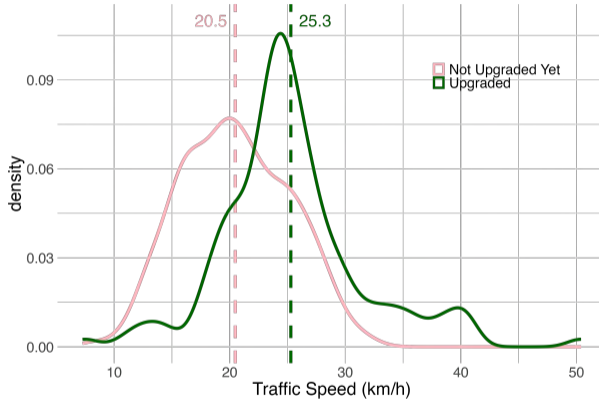
$$\ln p_{pt}^b = \alpha + \beta \times \ln p_{pt}^o + \gamma_t + \gamma_p + e_{pt}$$

	<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	
Parish FE			Y	Y	
Level of Observation	Parish-Year	Parish-Year	Parish-Year	Parish-Year	Parish
Observations	181	181	181	181	309
R <sup>2</sup>	0.083	0.108	0.644	0.659	0.036
Adjusted R <sup>2</sup>	0.078	0.077	0.433	0.431	0.033

# Owner Survey

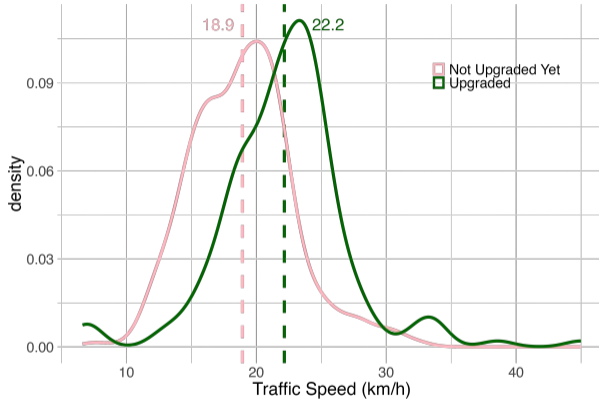
	Overall	Leasehold	Freehold	Mailo
<i>Panel A: Sample Characteristics</i>				
Number of owners	548	127	112	293
Share on already upgraded roads	0.78	0.68	0.63	0.87
Car ownership (share)	0.4	0.25	0.48	0.42
<i>Panel B: Property Characteristics</i>				
Purchased property (share)	0.41	0.5	0.36	0.4
Tenure (years)	35.5	35.2	38.9	34
Cost Copy of Ownership Documents (USD)	1750	1111	2651	1653
<i>Panel C: Land Acquisition</i>				
Land Affected (m2)	72.7	50.33	79.68	80.62
Negotiated Over Initial Compensation Offer (share)	0.2	0.28	0.16	0.18
Perceived Probability to Increase Compensation if Negotiation	0.31	0.38	0.24	0.3

## 1.2 Local Benefit: Increase in Non-Rush Hour Speed



- ▶ GoogleMaps API queries (41 policy roads ; 03/2023 - 08/2024 ; 682 trips non-rush hour)
- ▶ Cross-sectional variation: upgraded before / after data collection

## 1.2 Local Benefit: Increase in Rush Hour Speed



- ▶ GoogleMaps API queries (41 policy roads ; 03/2023 - 08/2024 ; 426 trips rush hour)
- ▶ Cross-sectional variation: upgraded before / after data collection

## 1.2 Local Benefit: Increase in Road Speed

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

- ▶ **Data:** GoogleMaps queries (03/23-08/24) [Data](#)
- ▶ **Sample:** Policy roads [Descriptives](#)
- ▶  $s_{kl,t}$ : speed on  $kl$  at time  $t$  [ξ Estimation](#)
- ▶  $D_{kl,t}$ : dummy variable if  $kl$  upgraded by  $t$
- ▶  $X_{kl}$  road controls: polynomial in lat/lon, class
- ▶  $\eta_t$ : time fixed-effects [Balance](#) [Congestion Extension](#)
- ▶ **Identifying variation:** early vs late upgrade
  - ▶ Robustness: road FE (subset of roads) [Robustness](#)
  - ▶ [local\\_benefits\\_overview](#) [Local benefits overview](#)

# 1.1. Local Benefit: Increase in Road Speed

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

▶ **Data:** GoogleMaps queries (03/23-08/24) Data

▶ **Sample:** Policy roads Descriptives

▶  $s_{kl,t}$ : speed on  $kl$  at time  $t$   $\xi$  Estimation

▶  $D_{kl,t}$ : dummy variable if  $kl$  upgraded by  $t$

▶  $X_{kl}$  road controls: polynomial in lat/lon, class

▶  $\eta_t$ : time fixed-effects Balance Congestion Extension

Local benefits overview

▶ **Identifying variation:** early vs late upgrade

▶ **Robustness:** road FE (subset of roads) Robustness

	<i>Dependent variable:</i>		
	Traffic Speed (km/h)		
	(1)	(2)	(3)
Upgraded	3.817*** (0.673)	4.449*** (0.859)	2.616*** (0.612)
In Progress	-1.299 (1.105)	-1.319 (1.264)	-1.283 (0.907)
Sample	All	Non-Rush	Rush
Avg Speed Control (km/h)	19.9	20.5	18.9
Road Controls	Y	Y	Y
Day + Hour FE	Y	Y	Y
SE Clustered	road+day	road+day	road+day
Observations	1,108	682	426
R <sup>2</sup>	0.446	0.473	0.407

# 1.1. Local Benefit: Increase in Road Speed

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

▶ **Data:** GoogleMaps queries (03/23-08/24) Data

▶ **Sample:** Policy roads Descriptives

▶  $s_{kl,t}$ : speed on  $kl$  at time  $t$   $\xi$  Estimation

▶  $D_{kl,t}$ : dummy variable if  $kl$  upgraded by  $t$

▶  $X_{kl}$  road controls: polynomial in lat/lon, class

▶  $\eta_t$ : time fixed-effects Balance Congestion Extension

Local benefits overview

▶ **Identifying variation:** early vs late upgrade

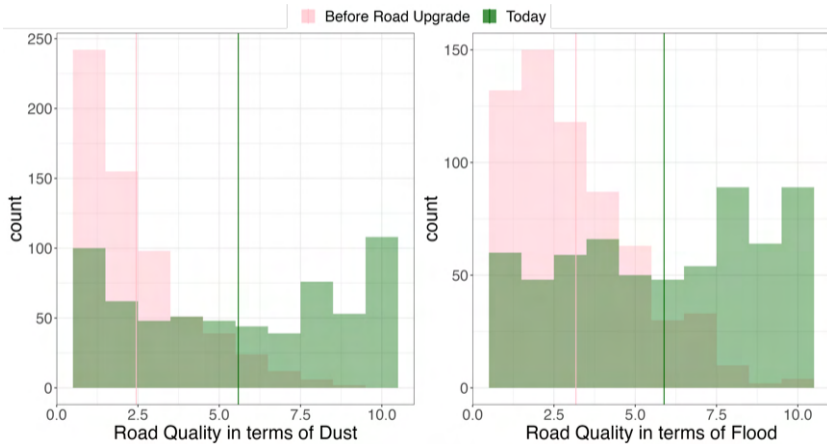
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SE Clustered	road+day	road+day	road+day
Observations	1,108	682	426
R <sup>2</sup>	0.446	0.473	0.407

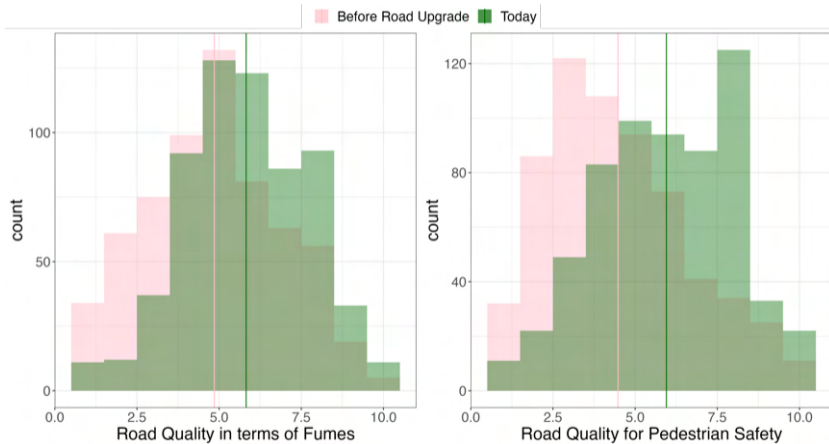
## Benefits: Increase in Local Road Speed

	<i>Dependent variable:</i>					
	Traffic Speed (km/h)					
	(1)	(2)	(3)	(4)	(5)	(6)
Upgraded	3.817*** (0.673)	3.545* (1.812)	4.449*** (0.859)	4.351** (1.598)	2.616*** (0.612)	1.957 (2.167)
In Progress	-1.299 (1.105)	-1.255 (1.004)	-1.319 (1.264)	-1.112 (1.267)	-1.283 (0.907)	-1.523* (0.751)
Sample	All	All	Non-Rush	Non-Rush	Rush	Rush
Avg Speed Control (km/h)	19.9	19.9	20.5	20.5	18.9	18.9
Road Controls	Y		Y		Y	
Road FE		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	1,108	1,108	682	682	426	426
R <sup>2</sup>	0.446	0.598	0.473	0.641	0.407	0.613

## 1.2. Local Benefit: Increase in Amenities



## 1.2. Local Benefit: Increase in Amenities



# 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  $L_{ijym}$ ,  $\text{time}_{ijym}$  from **local ride-hailing company**

## Params

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

	<i>Dependent variable:</i>	
	(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 <sup>2</sup>	0.437	0.687

Literature  $\hat{\theta} \kappa \in [ \underbrace{0.028}, \dots, \underbrace{0.0706} ]$

# 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  $L_{ijym}$ ,  $\text{time}_{ijym}$  from **local ride-hailing company**

## Params

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	<i>Dependent variable:</i>	
	(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
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Literature  $\hat{\theta} \kappa \in [ \underbrace{0.028}, \dots, \underbrace{0.0706} ]$

# Estimating $\xi$

- ▶  $\xi$  = 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
- ▶  $\eta_t$ : time fixed-effects
- ▶ **Identifying** variation: early vs late upgrades Balance
  - ▶ Robustness: road FE (subset roads)
- ▶ Standard errors clustered at the road + day level

Parameters

Reduced-Form Upgrades

Congestion Extension

# Estimation $\xi$

	<i>Dependent variable:</i>					
	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 <sup>2</sup>	0.323	0.417	0.312	0.465	0.318	0.348

▶ Literature  $\hat{\xi} \in$

▶ [0.1, 0.13]

▶ [0.13]

Fajgelbaum and Schaal 22'

Bordeu 24'

Parameters

Reduced-Form Upgrades

Balance

Congestion Extension

# Early vs Late Road Upgrade Selection

	<i>Dependent variable:</i>	
	Early Wave	
	(1)	(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 <sup>2</sup>	0.093	0.095
Adjusted R <sup>2</sup>	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

# Extension: Modeling Traffic Congestion

ξ Estimation

Parameters

Reduced-Form Upgrades

## ▶ Current approach

- ▶ no traffic congestion
- ▶  $\xi$  = average impact of road improvement on local speed
- ▶ estimation

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

1. non-rush hour trips: free-flow impact of road improvement on local speed  $\Rightarrow$  bias upward
2. all trips: potential SUTVA violation  $\Rightarrow$  bias downward

## ▶ Potential estimation extension:

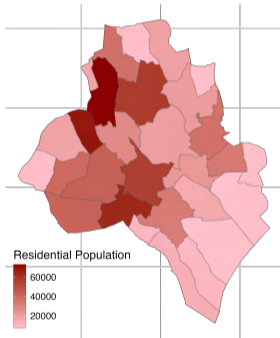
$$s_{kl,t} = \alpha + \beta D_{kl,t} + X'_{kl} \gamma + \mu \log \hat{\phi}_{kl,t} + \eta_t + e_{kl,t}$$

- ▶ control for  $\hat{\phi}_{kl,t}$  predicted flows on road  $kl$  at time  $t$ 
  - ▶ GoogleMaps trips  $\forall ij$  at  $t \Rightarrow$  map corresponding  $kl$  & weight by  $L_{ij,t}$  (model)

## ▶ Potential model extension: $\mu \equiv$ congestion elasticity

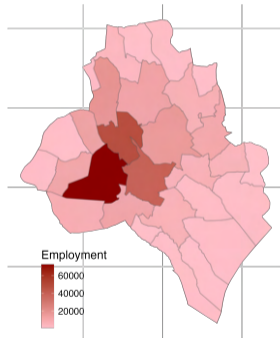
# Data on Kampala - Aggregated By Neighboring Parishes

## Residential Population



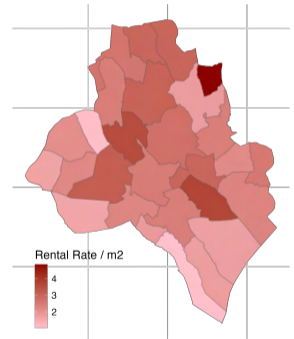
Source: 2014 Census (UBOS)

## Employment



Source: 2010 Census (UBOS)

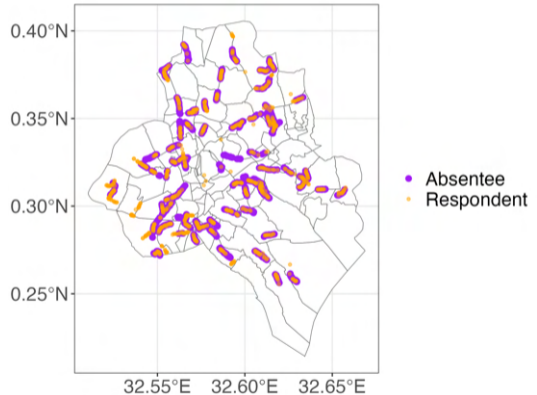
## Rental Rate



Source: Broker survey [Params](#)

# Owner Survey: Sampling

- ▶ Sampling unit: Road segment level
  - ▶ Estimation
  - ▶ Data
  - ▶ Stylized
- ▶ 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.

Data

Stylized

Estimation

# 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

Model overview

Model Firms

Impact Realized

Conclusion

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

▶ **Potential model extension**

▶ perfectly competitive firms in each location produce a unique variety, CES demand w/ elasticity  $\sigma$

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

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

▶ 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)

▶  $\downarrow$  trade costs  $\tau_{ij}^F \Rightarrow \uparrow$  demand for  $j$  goods  $\Rightarrow \uparrow p_j$

(demand curve out)

# Amenities

▶ **Empirically:** road upgrades  $\uparrow$  local amenities:  $\downarrow$  flood risk,  $\downarrow$  dust,  $\downarrow$  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  $i$

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

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

▶ impact on local amenities  $\approx$  residual impact on local property values controlling for  $\Delta$  market access

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

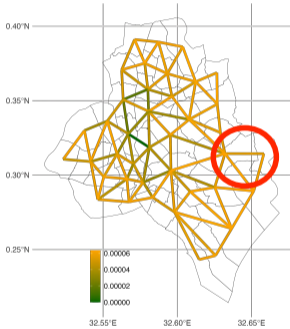
## Data

- ▶ Residential population count  $L_i^R$ : 2014 Population Census (UBOS)
- ▶ Employment count  $L_i^F$ : 2010 Census of Business Establishments (UBOS)
- ▶ Rental Rate  $q_i^R$ : Broker Survey
- ▶ Road infrastructure  $R_{kl}^{\text{road}}$  and area  $H_i^{\text{road}}$ : Open Street Maps
  - ▶  $R_{kl}^{\text{road}}$ : average width of roads in  $k$  and  $l$  (weighted by length)
- ▶  $\bar{\text{time}}_{kl}$ 
  - ▶ grid-to-grid GoogleMaps queries  $\Rightarrow$  avg speed by road type  $\Rightarrow$  avg speed on  $kl$
  - ▶ given speed $_{kl}$ , dist $_{kl}$ ,  $R_{kl}$  and  $\xi \Rightarrow \bar{\text{time}}_{kl}$

# Were the realized upgrades the highest-return ones?

- ▶ **Link-level analysis:** add  $1 \text{ m}^2$  on each road segment  $\Rightarrow$  solve for the new general equilibrium

Main



Link-level Relative Avg  $\tau$

Avg Commuting Time

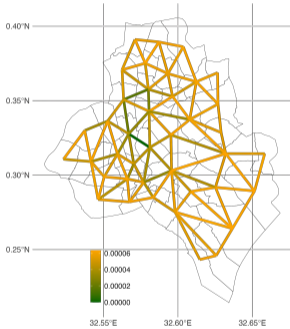
Land costs

- ▶ link color = city-level impact from improving this link

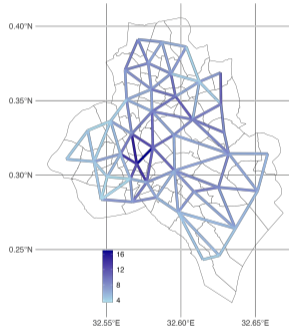
# Were the realized upgrades the highest-return ones?

► Link-level analysis: add  $1 \text{ m}^2$  on each road segment  $\Rightarrow$  solve for the new general equilibrium

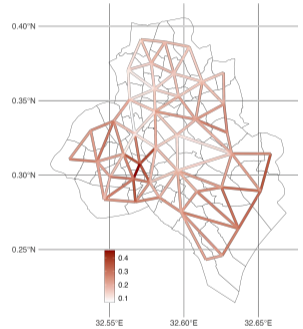
Main



Link-level Relative Avg  $\tau$



Link-level MV Payments



Link-level Share Negotiation

Avg Commuting Time

Land costs

Main

# Correlation Between Realized Upgrades and Link-level Costs and Benefits

$$\underbrace{\Delta(R_{kl} \times l_{kl})}_{\text{length of realized upgrades along } kl} = \alpha + \beta \times \underbrace{\Delta_{kl} W}_{\text{link-level } \Delta \text{welfare (pctile)}} + e_{kl}$$

- ▶ More improvements along links w/
  - ▶ high worker + owner welfare gains (gross)
  - ▶ high ↓ commuting time
  - ▶ low land costs

	<i>Dependent variable:</i>			
	Log Length of Upgraded Roads (m)			
	(1)	(2)	(3)	(4)
Average Tau (commuting costs)	5.412 (5.426)		9.430* (5.444)	
Log Worker Welfare		1.428 (1.432)		2.489* (1.437)
Log Share Owners Bargaining	-1.077 (1.048)	-1.077 (1.048)	-1.789* (1.051)	-1.789* (1.051)
Log Market Value Payments	-0.970 (1.042)	-0.970 (1.042)	-2.726** (1.045)	-2.726** (1.045)
Observation level: link between parish				
Road Upgrades	All	All	Ext. funds	Ext. funds
Control for road length	Y	Y	Y	Y
Observations	94	94	94	94
R <sup>2</sup>	0.021	0.021	0.102	0.102

Note:

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

# Robustness

	Avg Change (%)	Land Costs	Tax	Welfare Gains (USD)	Net of Construct.	Costs	
	Commuting	Property	(USD)	Rate	Per	Per	
	Time	Values	(million)	$\phi$	Resident	Resident	
					Total	Total	
					(million)	(million)	
<b>Panel A. Realized Road Improvements - Main</b>							
A1. VLT	-6.62	1.36	15.18	0.022	209	119	103.57
A2. Market Value	-6.62	1.36	63.1	0.091	-380	-470	-407.34
A3. No Payment	-6.62	1.36	0	0	395	306	265.12
<b>Panel B. Alternative Discount Rates</b>							
B1.1. - A1 & 3%	-6.62	1.36	15.18	0.022	348	259	224.37
B1.2. - A1 & 7%	-6.62	1.36	15.18	0.022	149	60	51.8
B2.1. - A2 & 3%	-6.62	1.36	63.1	0.091	-634	-723	-627.14
B2.2. - A2 & 7%	-6.62	1.36	63.1	0.091	-272	-361	-313.14
B3.1. - A3 & 3%	-6.62	1.36	0	0	659	569	493.63
B3.2. - A3 & 7%	-6.62	1.36	0	0	282	193	167.19
<b>Panel C. Alternative Model Parameters</b>							
C1. - A1 & $\eta = 0.5$	-6.62	1.36	15.18	0.017	250	160	139.12
C2. - A1 & $\eta = 0.7$	-6.62	1.36	15.18	0.028	153	64	55.08
C3. - A1 & $\theta = 3.0$	-6.8	1.41	15.18	0.021	240	151	130.5
C4. - A1 & $\theta = 3.6$	-6.44	1.32	15.18	0.022	182	92	79.98
C5. - A1 & $\kappa = 0.008$	-7.61	1.22	15.18	0.021	136	47	40.61
C6. - A1 & $\kappa = 0.012$	-5.99	1.49	15.18	0.023	281	192	166.36
C7. - A1 & $\xi = 0.34$	-5.5	1.24	15.18	0.022	156	66	57.27
C8. - A1 & $\xi = 0.44$	-7.85	1.47	15.18	0.021	255	166	143.6
<b>Panel D. Owner Log Utility</b>							
D1. - A1 & log U	-6.62	1.36	60.71	0.022	158	69	59.47
D2. - A2 & log U	-6.62	1.36	252.38	0.091	-265	-355	-307.53
D3. - A3 & log U	-6.62	1.36	0	0	287	197	170.88

# Robustness

	Avg Change (%)		Land Costs (USD) (million)	Tax Rate $\phi$	Welfare Gains (USD)		Net of Construct. Costs	
	Commuting Time	Property Values			Per Resident	Total (million)	Per Resident	Total (million)
<b>Panel A. Optimal Road Improvements - Main</b>								
A1. VLT	-10.14	2.86	16.61	0.024	590	511.33	500	433.7
A2. Market Value	-9.9	2.74	62.16	0.088	242	209.89	153	132.31
A3. No Payment	-10.38	3.07	0	0	724	627.36	634	549.73
<b>Panel B. Alternative Discount Rates</b>								
B1.1. - A1 & 3%	-10.14	2.86	16.61	0.024	983	852.22	893	774.59
B1.2. - A1 & 7%	-10.14	2.86	16.61	0.024	421	365.24	332	287.61
B2.1. - A2 & 3%	-9.9	2.74	62.16	0.088	403	349.81	314	272.24
B2.2. - A2 & 7%	-9.9	2.74	62.16	0.088	173	149.92	83	72.34
B3.1. - A3 & 3%	-10.38	3.07	0	0	1206	1045.59	1116	967.96
B3.2. - A3 & 7%	-10.38	3.07	0	0	517	448.11	427	370.48
<b>Panel C. Alternative Model Parameters</b>								
C1. - A1 & $\eta = 0.5$	-10.17	2.91	17.04	0.019	635	550.43	545	472.8
C2. - A1 & $\eta = 0.7$	-10.1	2.8	16.03	0.03	529	459.06	440	381.43
C3. - A1 & $\theta = 3.0$	-10.53	2.99	16.91	0.023	636	551.7	547	474.07
C4. - A1 & $\theta = 3.6$	-9.78	2.77	16.44	0.024	549	475.87	459	398.24
C5. - A1 & $\kappa = 0.008$	-11.53	2.4	15.83	0.021	454	393.85	365	316.22
C6. - A1 & $\kappa = 0.012$	-9.23	3.27	17.02	0.025	726	629.42	636	551.79
C7. - A1 & $\xi = 0.34$	-8.34	2.6	16.21	0.023	505	437.53	415	359.9
C8. - A1 & $\xi = 0.44$	-12.14	3.02	16.39	0.023	662	573.81	572	496.18
<b>Panel D. Owner Log Utility</b>								
D1. - A1 & log U	-8.3	5.65	16.88	0.024	1166	1010.71	1076	933.08
D2. - A2 & log U	-6.52	4.61	66.07	0.095	763	661.48	674	583.97
D3. - A3 & log U	-8.64	6	0	0	1211	1049.72	1121	972.09
<b>Panel E. No Opportunity Cost of Land</b>								
E1. VLT	-11.39	3.12	18.34	0.026	966	837.11	876	759.48
E2. Market Value Acquisition	-10.86	2.84	66.89	0.095	557	483.07	468	405.44
E3. No Land Payment	-11.39	3.14	0	0	1098	952.03	1009	874.4

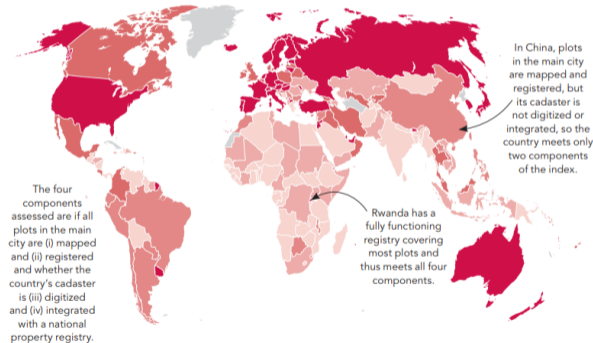
# Uganda Is a Typical SSA Country w.r.t. Property Rights

Land rights provide security of tenure and are important for reducing poverty. But many countries lack a comprehensive land registry that records ownership.

Number of components related to property registration from Doing Business Index (0–4, higher is better)

SDG 1.4

0 1 2 3 4 No data

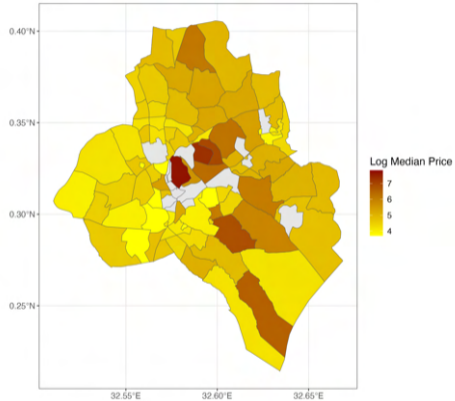


Source: World Bank Doing Business (database). <http://www.doingbusiness.org>

# Additional Administrative and Public Data

- ▶ **Road network**
  - ▶ Open Street Map (OSM)
- ▶ **Traffic Flows**
  - ▶ Local Ride hailing App
- ▶ **Population + Business Censuses**
  - ▶ Uganda Bureau of Statistics (UBOS)
- ▶ **Road Improvements:**
  - ▶ Kampala Capital City Authority (KCCA)
  - ▶ African Development Bank (AfDB)

# Property Values Data: Novel Broker Survey



Log Median Rental Price Residential Property

# Increase in Local Property Values - Appraisal

	<i>Dependent variable:</i>			
	Log Price			
	(1)	(2)	(3)	(4)
Post road upgrade	0.224*** (0.028)	0.237*** (0.036)	0.452*** (0.024)	0.435*** (0.046)
Survey	Broker	Broker	Owner	Owner
Property Type	Res	Bus		
Variation			Panel	Panel
FE	Respondent	Respondent	Respondent	Respondent
Sample			Affected+NotAffected	NotAffected
Observations	354	304	1,185	355
R <sup>2</sup>	0.978	0.962	0.947	0.950
Adjusted R <sup>2</sup>	0.955	0.923	0.891	0.896

► By design: only varying characteristics = whether (before/after) the road is upgraded or not

Main

Pre model

Post model

# Increase in Local Property Values - Past Transactions

$$\log \text{price}_{i,b,r,p,t} = \alpha + \beta^{\text{post}} \mathbf{1}\{\text{post}_{t,r}\} + \mathbf{X}'_i \boldsymbol{\eta}^X + \gamma_p + \gamma_t + e_{i,b,r,p}$$

- ▶ price = sales (rental) price of property  $i$  sold by broker  $b$  on road  $r$  in parish  $p$  in year  $t$  (survey data)
  - ▶ Sample: properties on the side of roads  $\Rightarrow \mathbf{1}\{\text{post}_{t,r}\}$  a dummy = 1 if road  $r$  was upgraded by year  $t$
- ▶  $\mathbf{X}_i$  property characteristics,  $\gamma_t$  year and month FE
- ▶  $\gamma_p$  parish FE  $\Rightarrow$  compare upgraded / not upgraded road within parish
- ▶ standard errors clustered at parish + broker level
- ▶ identification assumptions
  - ▶ no road selection based on baseline property value or unobservables + no OVB + SUTVA

Main

Pre model

Post model

# Increase in Local Property Values - Past Transactions

	<i>Dependent variable:</i>	
	Log Transaction Price	
	(1)	(2)
Post Upgrade (d)	0.372* (0.223)	0.399*** (0.151)
Treatment Level	Road	Road
Type	Sales	Rental
Within X minutes walk from road	0	0
Year FE	Y	Y
FE	Parish	Parish
Observations	285	319
R <sup>2</sup>	0.690	0.730
Adjusted R <sup>2</sup>	0.470	0.586

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

Pre model

Post model

# Road Upgrade Increased Local Speed

$$\text{speed}_{h,d,r} = \alpha + \beta^{\text{policy}} \text{upgraded}_{d,r} + \underbrace{\mathbf{X}'_r \beta^x}_{\text{roads controls or FE}} + \underbrace{\gamma_h + \gamma_d}_{\text{time FE}} + \varepsilon_{h,d,r}$$

- ▶ Sample: road-level Googlemaps trips
- ▶ roads upgraded early (done) or late (in progress / do to)
- ▶ Identification assumptions
  - ▶ **no road FE**: no road selection into early / late wave
  - ▶ **road FE**: no selection on timing
- ▶ Standard errors clustered at the road + day level

Main   Pre model   Post model

	<i>Dependent variable:</i>	
	Traffic Speed at time of query in km/h	
	(1)	(2)
Upgraded (d)	4.449*** (0.859)	4.351** (1.598)
Construction (d)	-1.319 (1.264)	-1.112 (1.267)
Mean dep var	22.39	22.39
Time of Day	Non-rush	Non-rush
Hour + Day FE	Y	Y
Road Controls	Y	
Road FE		Y
Sample	Policy	Policy
Observations	682	682
R <sup>2</sup>	0.473	0.641
Adjusted R <sup>2</sup>	0.434	0.592

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

# Road Upgrade Increased Local Speed

	<i>Dependent variable:</i>						
	Traffic Speed at time of query in km/h						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Upgraded (dummy)	4.804*** (1.151)	4.504*** (1.105)	4.449*** (0.859)	4.351** (1.598)	1.735** (0.884)	2.616*** (0.612)	1.957 (2.167)
Construction (dummy)	0.771 (1.368)	0.395 (1.585)	-1.319 (1.264)	-1.112 (1.267)	-1.173 (0.888)	-1.283 (0.907)	-1.523* (0.751)
Mean dep var (km/h)	22.39	22.39	22.39	22.39	22.85	20.21	20.21
Time of Day	Non-rush	Non-rush	Non-rush	Non-rush	Non-rush	Rush	Rush
Hour + Day FE	Y	Y	Y	Y	Y	Y	Y
Control for road class		Y	Y		Y	Y	
Flexible geo controls			Y		Y	Y	
Road FE				Y			Y
Sample	Policy	Policy	Policy	Policy	Policy + Mentioned	Policy	Policy
Observations	682	682	682	682	1,663	426	426
R <sup>2</sup>	0.311	0.323	0.473	0.641	0.331	0.407	0.613
Adjusted R <sup>2</sup>	0.267	0.276	0.434	0.592	0.310	0.362	0.544

*Note:*

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

# Local Impact of Road Improvements: Appraisal

$$\log P_{b,k,t} = \alpha + \beta 1 \{ \text{nearby upgrade}_{k,t} \} + \mu_b + e_{b,k,t}$$

	<i>Dependent variable:</i>			
	Log Price			
	(1)	(2)	(3)	(4)
Post road upgrade	0.224*** (0.028)	0.237*** (0.036)	0.452*** (0.024)	0.435*** (0.046)
Survey	Broker	Broker	Owner	Owner
Property Type	Res	Bus		
Variation			Panel	Panel
FE	Respondent	Respondent	Respondent	Respondent
Sample			Affected+NotAffected	NotAffected
Observations	354	304	1,185	355
R <sup>2</sup>	0.978	0.962	0.947	0.950
Adjusted R <sup>2</sup>	0.955	0.923	0.891	0.896

- By design: only varying characteristics = whether (before/after) the road is upgraded or not

# Local Impact of Road Improvements: Past Transactions

$$\log P_{k,i,t} = \alpha + \beta 1 \{\text{upgrade in parish}_i\} + \mathbf{Z}'_k \cdot \gamma + \eta_t + \mu_i + e_{i,t}$$

**Table:** Property Values Increased In Response to Local Road Improvement

	<i>Dependent variable:</i>			
	Log Sales Price (USD)			
	(1)	(2)	(3)	(4)
Post Road Upgrade (dummy)	0.157*** (0.006)	0.142*** (0.007)	0.156*** (0.003)	0.188*** (0.019)
Division FE			Y	Y
Parish controls		Y	Y	Y
Sample	All	All	All	Ever-treated
Mean Sales Price (USD)	77,500	77,500	77,500	75,884
Observations	1184	988	952	234
R2	0.43	0.44	0.49	0.58

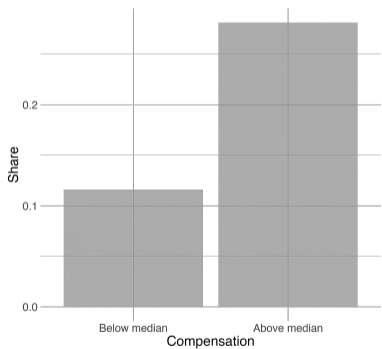
# Benefits: GoogleMaps Data API

- ▶ GoogleMaps Direction API
  - ▶ traffic speed + average speed
  - ▶ itinerary (approximate mapping to OSM)
- ▶ March 2023 to August 2024
- ▶ > 180,000 queries
  - ▶ 96×96 unique parish-to-parish trips
  - ▶ 148 unique roads
- ▶ Avg speed = 24.5km/h  $\approx$  25<sup>th</sup> ptile world cities



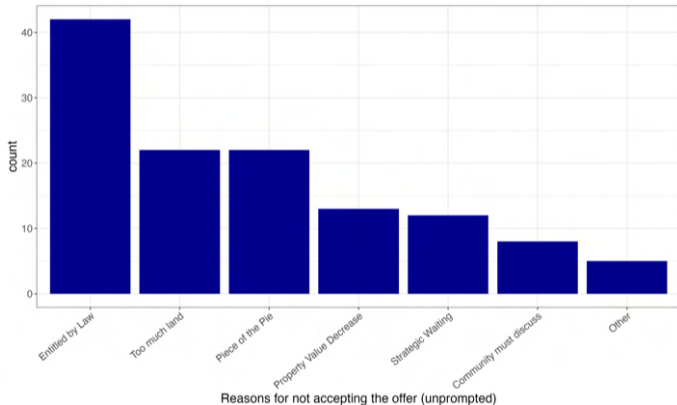
# Claim Probability Increases in the Potential Compensation

Share of owners claiming the compensation

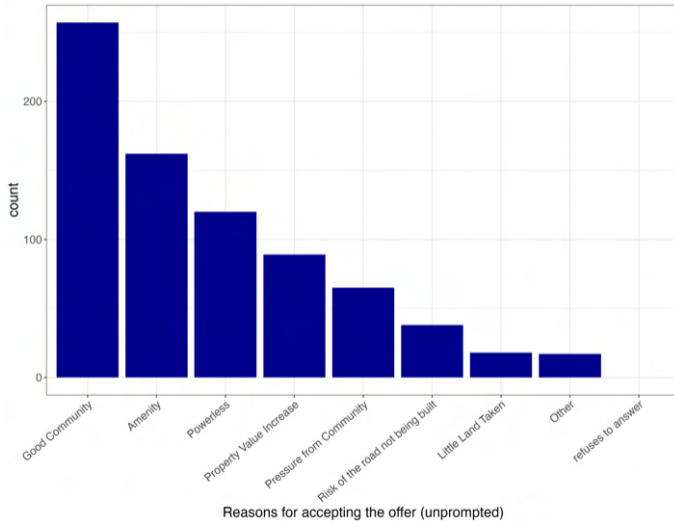


▶ 1 sd ↑ compensation amount (\$ 7,558) ⇒ ↑ probability of claiming the compensation by 27 pp

# Reasons to Claim the Compensation



# Reasons to Not Claim the Compensation



# Negotiation and Property Right Regimes

	<i>Dependent variable:</i>			
	Above Median Cost Ownership Doc (1)	Nego ↓ Affected (2)	Nego ↑ Money (3)	Negotiate (d) (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 <sup>2</sup>	0.073	0.180	0.075	0.013
Adjusted R <sup>2</sup>	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.

# Road-Level Heterogeneity By Property Right Regime

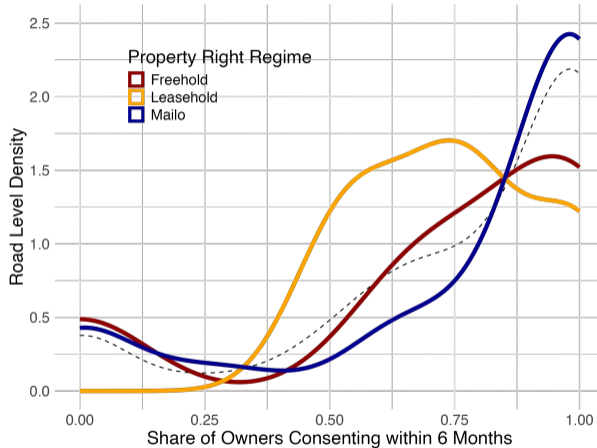


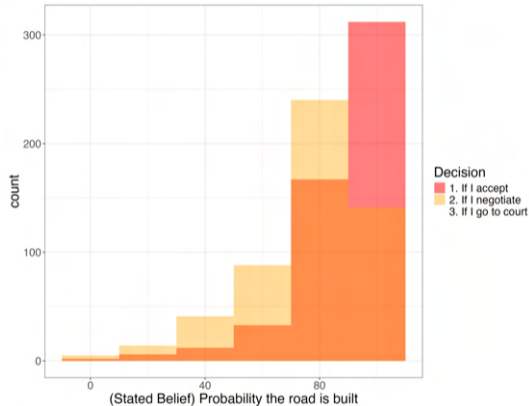
Figure: Share of Consents Obtained within 6 Months By Road

# Mechanisms Behind The Impact of Land Tenure on Negotiation

	<i>Dependent variable:</i>			
	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*** (0.031)	-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 <sup>2</sup>	0.108	0.206	0.105	0.075
Adjusted R <sup>2</sup>	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

# Assumption: No individual pivotality



Owner Data

Stylized Owner

Model Owner

# Recovering $A_j, B_i, H_i^{\text{res}}, L_{ij}$

Parameters

1. Recover  $\tau_{ij}$  at baseline given  $\kappa$ 
  - ▶ assign each road segment a speed based on road category + GoogleMaps
  - ▶ shortest path (Dijkstra's algorithm)  $\Rightarrow \tau_{ij}$
2. Invert the model  $\Rightarrow A_j, \beta_i$ , given the parameters  $\{\beta, \theta\}$  & data on  $q_i^R, L_i^R, L_j^F, \tau_{ij}$ 
  - ▶ standard inversion approach (Redding and Rossi-Hansberg 2017)
3. Recover  $L_{ij}$  given  $A_j, B_i$ , parameters & data
4. Recover  $H_i^{\text{res}}$  given  $q_i^R, L_{ij}$ , parameters & data

# Road Amount: From Data to Model

- ▶ Roads matter for commuting costs on a link  $kl$

$$d_{kl} = \exp \left( \kappa \cdot \underbrace{\frac{\bar{\text{time}}_{kl}}{R_{kl}^{\xi}}}_{\equiv \text{time}_{kl}} \right)$$

- ▶ I define  $kl$  as two neighboring location (parish or grid) centroids

- ▶ I observe (or recover):  $\text{time}_{kl}$  & road area around link  $kl : H_{kl}^R$

- ▶ I need

- ▶ **road production function:**  $R_{kl} \approx$  average road width = lane width  $\times$  nb of lanes that can be used for  $k \leftrightarrow l$

$$R_{kl} \equiv \frac{H_{kl}^R}{\text{dist}_{kl}}$$

where  $\text{dist}_{kl}$  is the straight-line distance between the centroids of  $k$  and  $l$

- ▶  $\bar{\text{time}}_{kl}$

$$\bar{\text{time}}_{kl} = \text{time}_{kl} \times R_{kl}^{\xi}$$

- ▶ Gov takes into account the **road production function:**  $dH_{kl}^R = 1 \Rightarrow dR_{kl} = \frac{1}{\text{dist}_{kl}}$