Are Tax Rates too High in Developing Countries? Evidence from Randomized Property Tax Rates

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Raising Tax Revenues in Developing Countries

- Tax capacity is key for public good provision and development (Kaldor 1967; Besley and Persson 2009, 2014)
  - LICs collect 10% GDP in tax vs. 30-40% in HICs
  - Local governments in LICs have relatively lower tax take
- Tax policy tools:
  1. Tax rates
  2. Tax enforcement
     - Audits and monitoring - Kleven et al. 2011; Pomeranz et al. 2019
     - Third-party info - Kleven et al. 2011; Pomeranz 2015; Naritomi 2016
     - Effects of change in rate endogenous to enforcement - Kopczuk and Slemord 2002; Kleven 2014; Keen and Slemrod 2017; Jensen 2019
- This paper studies how to set tax rates and how they interact with enforcement in low-capacity settings

Questions and Empirical Strategy

1. Are tax rates above or below the Laffer rate in settings with low state capacity and tax compliance?
2. Can governments in LICs shift the Laffer rate?
3. Can governments in LICs exploit heterogeneity in the Laffer rate?

- **Empirical strategy:** Randomized property tax rates
  - Property tax key source of revenue for local governments (Slack, 2013)
  - Partnership with provincial government of Kasai-Central, DRC
  - Property tax rates were randomized on property level during 2018 tax campaign in the city of Kananga

Preview of Findings

1. Tax rate on wrong side of Laffer curve:
   - Elasticity of **tax revenue** wrt tax rates: $e_{revenue}$ =**-0.26**
   - Elasticity of **tax compliance** wrt tax rates: $e_{compliance}$ =**-1.19**
2. Beyond higher revenue, lowering rates also:
   - Lowers **bribes** collected
   - Improves **view of government**
3. Governments can shift the Laffer rate:
   - Analyze tax collector heterogeneity
   - Collectors with high **enforcement capacity** have $e_{revenue} > 0$
     $\Rightarrow$ Increasing enforcement capacity permits higher tax rates
   - **Collectors' characteristics**: policy tool to shift the Laffer rate
4. Governments can use heterogeneity in Laffer rates:
   - Analyze heterogeneous treatment effects
   - A **progressive** tax schedule would maximize revenue

Related Literature

- Elasticity of taxable income

  Elasticity of taxable income - Feldstein (1995); Gruber and Saez (2002); Saez (2004); Saez, Slemrod and Giertz (2012); Kleven and Waseem (2013); Waseem (2018)

  Elasticity of taxable income and enforcement - Kopczuk and Slemord (2002); Keen and Slemrod (2017)

  Elasticity of tax compliance - Fisman and Wei (2004)

- Increasing tax compliance

  Tax Reporting Margin - Slemrod et al. (2001); Kleven et al. (2011); Carrillo et al. (2014); Pomeranz (2015); Naritomi (2016)

  Tax Compliance Margin - Fisman and Wei (2004); Kleven et al. (2011); Brockmeyer et al. (2019)

- Property taxation in developing countries

  Del Carpio (2017); Khan, Khwaja and Olken (2015); Okunogbe (2019); Brockmeyer et al. (2019)

Outline

1. Context
2. Experimental Design and Data Collection
3. Effects on Tax Compliance and Revenue
   - Reduced Form Results
   - Marginal Value of Public Funds
   - Resulting Elasticities
   - Robustness Checks
4. Secondary Outcomes
   - Bribe Payments
   - Compliance with Other Taxes
   - View of the Government
5. Tax Collectors: Can Governments Shift the Laffer Rate?
6. HTE: Can Governments use Heterogeneity in Laffer Rate?

Kananga, D.R. Congo

- Sixth most populated city in the DRC
  - Population $\approx 500,000$
- Capital of Kasai-Central Province
- Average income: $\approx \$1.5$ per person per day

Tax Revenues in Kananga

- Provincial **revenues** are extremely low: $\approx$ \$0.3 per person
- Majority comes from national transfers and resource rents
- One of many local governments trying to raise revenue through **property tax**:
  - Tax revenue stays local
  - Efficient form of taxation

Property Tax Collection in Kananga

- Door-to-door property **tax collection** is new:
  - First door-to-door collection the year before in 2/3 of the city but...
  - $\leq$ 10 % of owners paid the property tax despite tax collectors' visits
  - Only 2.6 % of owners know of the official tax liability at baseline
- Low level of property **tax enforcement**:
  - In theory: fine for tax evasion = 2.5 x liability to pay within 30 days and if unpaid the case goes to court
  - In practice: sanctions very rarely implemented

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Design of the Property Tax Campaign

Door-to-door tax collection is done in **two stages** in each neighborhood:

1. **Registration**: First day of the month. Property owners receive a *tax letter* with information about the property tax and their tax liability.
   - Randomized assignment of tax rate embedded in tax letter
2. **Tax collection:** Rest of the month. Taxpayers receive a *printed receipt*.

Stage	**Period**	**Collectors**	**Enumerators**
Registration	First days of the month	Yes	Yes
Tax collection	Rest of the month	Yes	No

Randomized Property Tax Rates

- Tax liability: fixed annual fee (common in developing countries in the absence of a property valuation roll) Examples
- **Control:**
  - Status quo liability decided ex ante by building materials
    - Low value properties (95% of properties): 3,000 FC (≈$2)
    - High value properties (5% of properties): 13,200 FC (≈$9)
  - Rate: ≈ 0.22% of property value (USA 0.27% – 2.35%)
- **Treatments:**
  - 17% reduction in tax liability
  - 33% reduction in tax liability
  - 50% reduction in tax liability
- Treatment is randomized at the property level and stratified at the neighborhood (polygon) level.

Example of Tax Letters

REPUBLIQUE DEMOCRATIQUE DU CONGO
PROVINCE DU KASAÏ OCCIDENTAL
DIRECTION GENERALE DES RECETTES DU KASAÏ OCCIDENTAL
DGRKOC

Pour la campagne de collecte de l'Impôt Foncier 2018 :

La parcelle, No. 595013,

appartenant à _____,

est assujettie à un taux de : 3000 FC*

à payer au percepteur de la DGRKOC une fois par année.
Comme preuve de paiement, vous recevrez un reçu imprimé sur place (voir l'exemple du reçu à droite).

Il est important de payer l'impôt foncier.

DIRECTION GENERALE DES RECETTES DU KASAÏ CENTRAL

RÉPUBLIQUE DÉMOCRATIQUE DU CONGO
KANANGA

IMPOT SUR LA SUPERFICIE DES PROPRIÉTÉS FONCIERES BATIES ET NON BATIES

Premiere Copie
Date et Heure : 22-FEB-2018 11 :54 :35
No : KGA20180200000000001-0000016

Nom du contribuable : Mutombo Dikembe Jean-Jacques
Licence d'Exploitation : 202005

Type de taxe :	Perif 3.000
Unite :	Terrain
Quantite/Base :	1
Taux :	1.5
Montant (CDF) :	3000

Nom de l'agent : Kabeya Kabeya Jean (KN20180000000000)

* D'autres montants s'appliquent si vous habitez dans une maison en matériaux durables.
Si vous avez des questions ou des plaintes, veuillez contacter 0974982998 ou 0811439515. Ce sont les coordonnées téléphoniques d'Harvard-RDC, une organisation indépendante de chercheurs scientifiques réalisant une évaluation de la campagne de l'impôt foncier. Ils garderont votre identité confidentielle.

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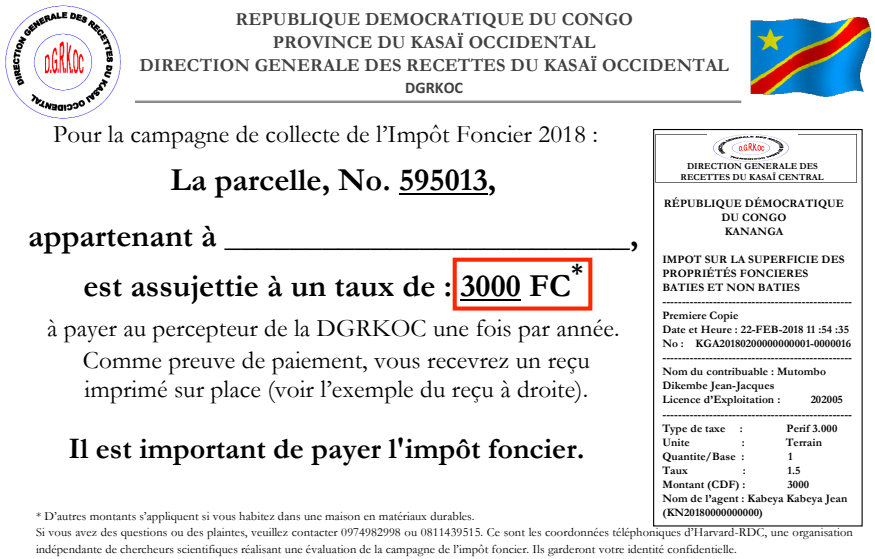

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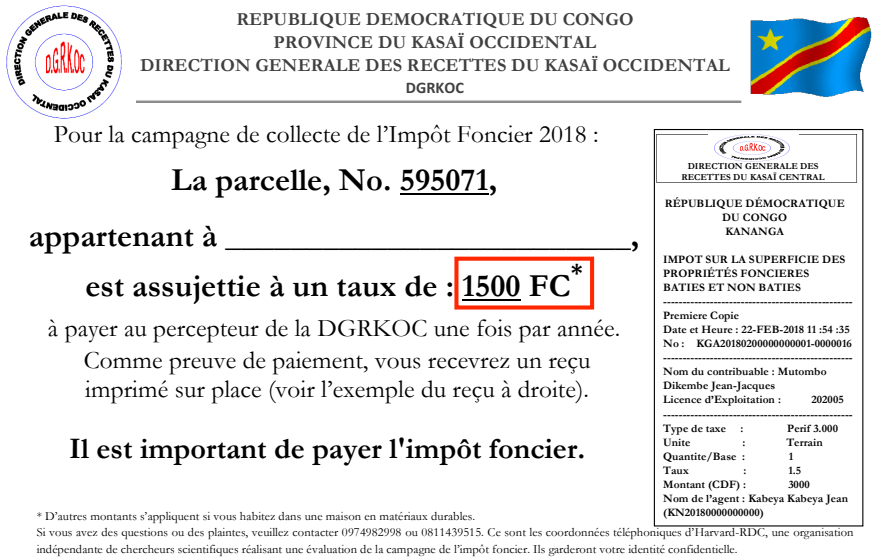
Status quo Tax Liability



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50% **Reduction in Tax Liability**

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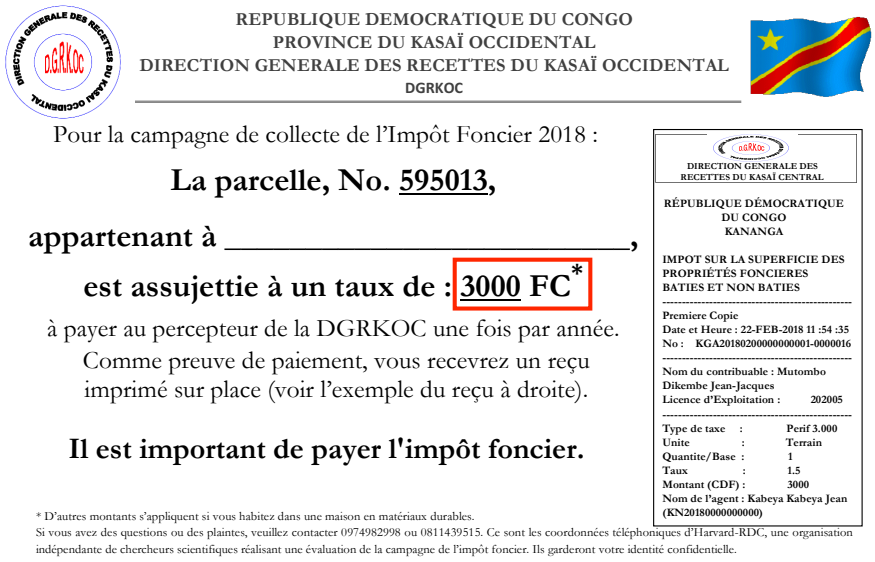

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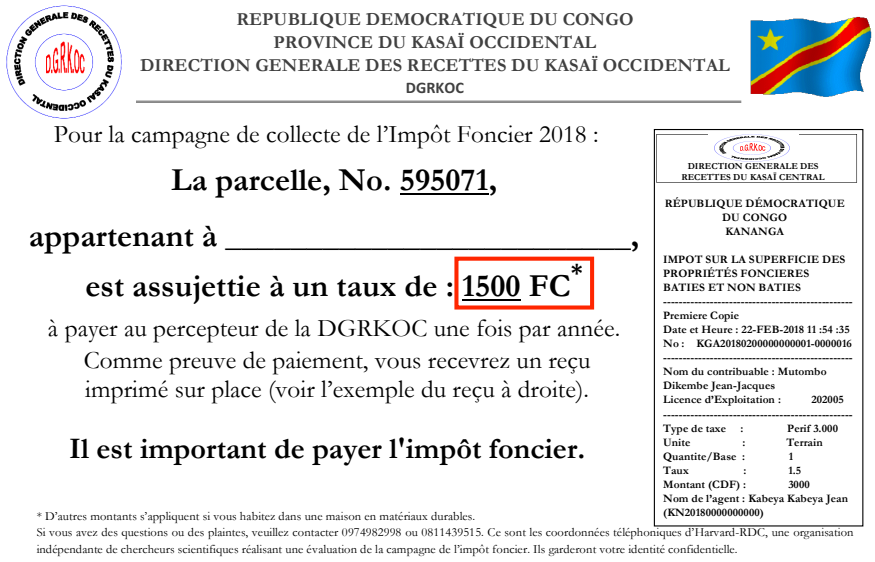

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Status quo Tax Liability | 50% **Reduction in Tax Liability**

- Avoid transaction utility effects: Tax liability directly written on the tax letter without reference to a tax reduction

Low Value vs High Value Properties

Low Value Property

High Value Property

Low Value vs High Value Properties

Low Value Property

Status quo tax liability: 3,000 CF

17% reduction: 2,500 CF

33% reduction: 2,000 CF

50% reduction: 1,500 CF

High Value Property

Status quo tax liability: 13,200 CF

17% reduction: 11,000 CF

33% reduction: 8,800 CF

50% reduction: 6,600 CF

Data Collection

- **Universe of Property Owners:** $N = 48,000$
  - Census Survey: Implemented during property registration
  - Midline Survey: Takes place 2 weeks after tax collection ends in nbhd
  - Administrative Data: Property tax data from the receipt printers
- **Subsample of Property Owners:** $N = 4,332$
  - Baseline and Endline Survey: Administered to a random sample of property owners (12 per neighborhood)
- **Tax Collectors:** $N = 50$
  - Baseline and Endline Survey: Administered to all tax collectors

Data Collection Timeline

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Reduced Form Specification

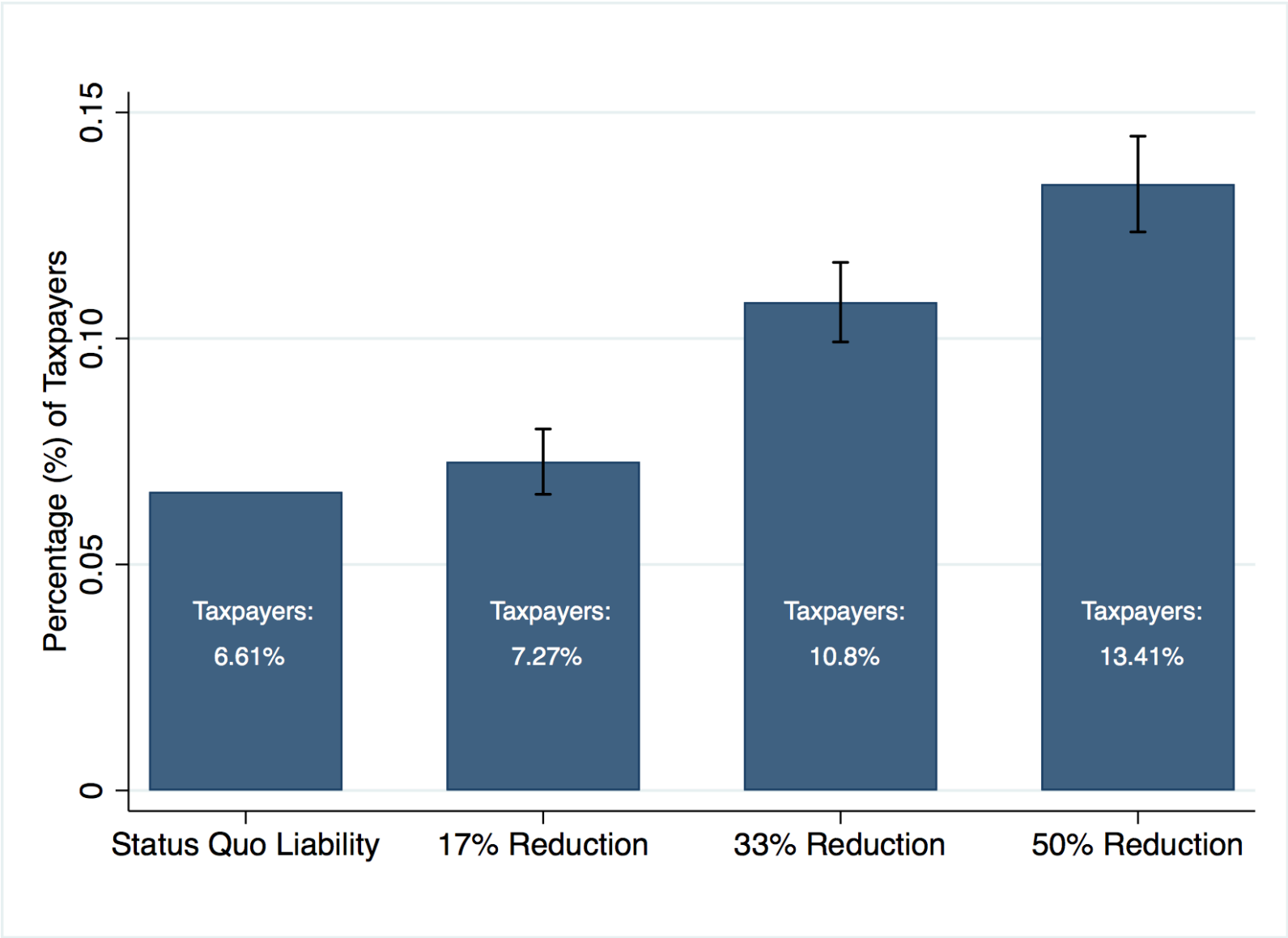
We estimate the following regression:

$$y_{ip} = \beta_0 + \beta_1 Reduction17\%_{ip} + \beta_2 Reduction33\%_{ip} + \beta_3 Reduction50\%_{ip} + \gamma_{ip} + \delta_p + \epsilon_{ip}$$

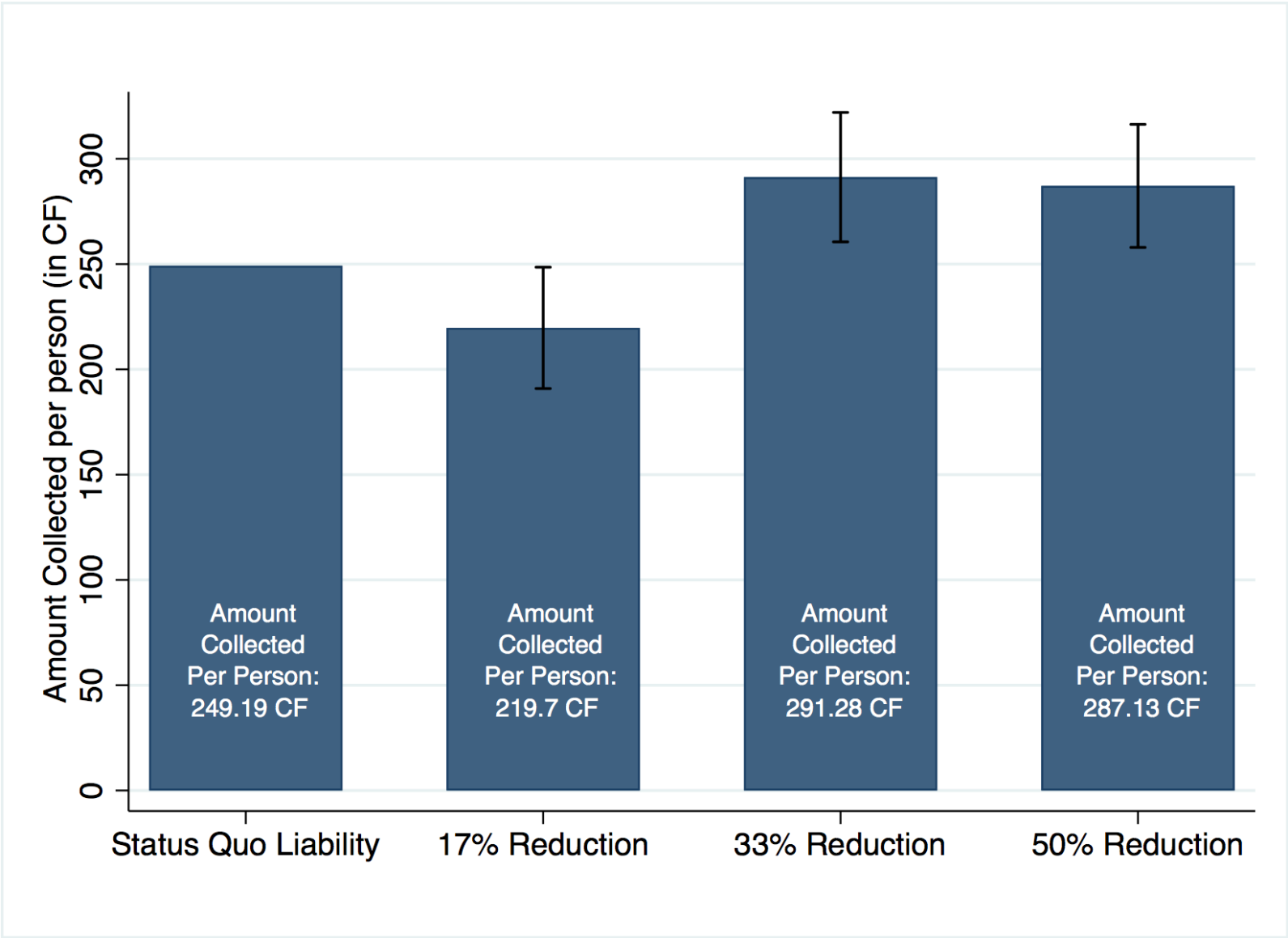
- y_{ip} = outcome for individual i in polygon p.
- $Reduction17\%_{ip}$ = indicator for being assigned to 17% reduction in annual tax liability. Likewise for $Reduction33\%_{ip}$ and $Reduction50\%_{ip}$.
- γ_{ip} = type of house (low or high value) indicator.
- δ_p = polygon ($\sim$130 properties) fixed effects.
- ϵ_{ip} = error term.

Balance Tests and Omnibus Tests show balance on characteristics of the property and of the property owner Balance

Reduced Form Tax Compliance Results



Reduced Form Tax Revenue Results



Marginal Value of Public Funds

- Should tax rates be reduced in low-income countries?
- **Marginal Value of Public Funds** (MVPF) of reducing τ (Hendren 2016; Hendren and Sprung-Keyser 2019):

$$MVPF = \frac{WTP}{dR/d(-\tau)} = \frac{WTP}{Net\,Cost}$$

  - $WTP_{17\%} = 0.17x249$, $WTP_{33\%} = 0.33x249$, $WTP_{50\%} = 0.5x249$
  - Net Cost $< 0 \Rightarrow MVPF = \infty$

- Reducing property tax rates produces a "Laffer effect", raising total revenue (Werning 2007; Hendren and Sprung-Keyser 2019)

The Elasticity of Tax Compliance and Tax Revenue

- To estimate the elasticity of tax compliance and revenue, we use the following 2SLS regressions framework:

$$y_{ip} = \alpha + \beta log(\tau_{i,p}) + \gamma_{ip} + \delta_p + \nu_{ip} \quad (1)$$

$$log(\tau_{i,p}) = \beta_0 + \beta_1 Reduction17\%_{ip} + \beta_2 Reduction33\%_{ip} + \beta_3 Reduction50\%_{ip} + \gamma_{ip} + \delta_p + \epsilon_{ip} \quad (2)$$

y_{ip} is the outcome (tax compliance or tax revenue) and the mean tax rate is $\tau_{i,p} = \frac{TaxLiability_{ip}}{Prop.Value_{ip}}$ for property i in neighborhood p.

- Eq (2) is the first stage of the IV model, and Eq (1) the second stage.
- From marginal effect β to elasticity e :

$$e_{ip} = \frac{\partial y_{ip}}{\partial \tau_{i,p}} \times \frac{\tau_{i,p}}{y_{ip}} \quad \Rightarrow \quad e = \frac{\beta}{mean(y_{ip})}$$

Predicting Property Values using Machine Learning

To compute $\tau_{i,p} = \frac{TaxLiability_{ip}}{Prop.Value_{ip}}$ we need to estimate the value of every property in Kananga:

- We use **Supervised Machine Learning** to predict the conditional mean of property value given a set of features.

$$\mathbb{E}[Y_i|X_i = x]$$

- As a **training sample** we use the value of 1,500 properties from our baseline sample estimated by a team of 6 professional land surveyors in July-Nov 2019. Density

Predicting Property Values using Machine Learning

Low Value Property

Property value: $1,000

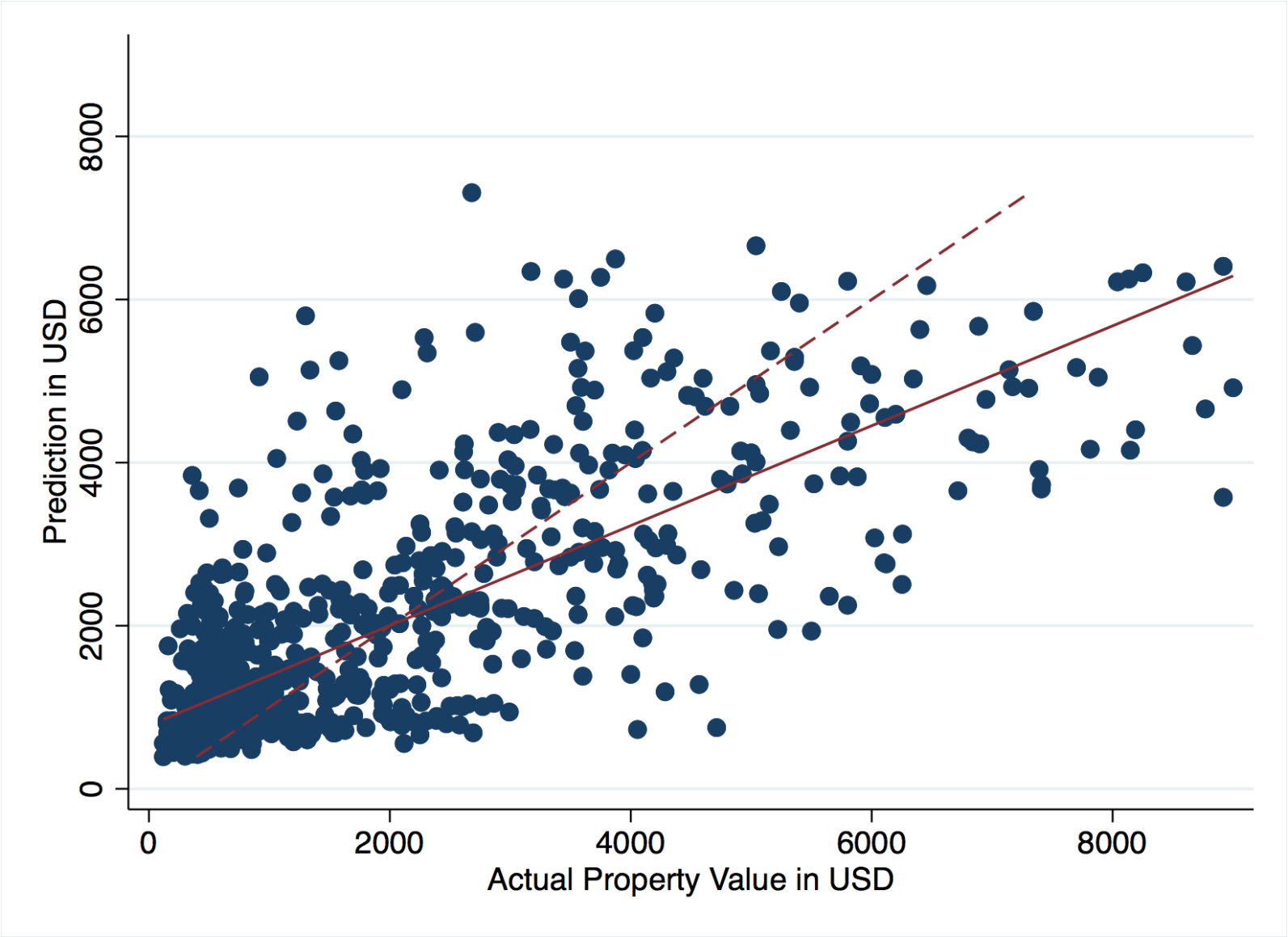
High Value Property

Property value: $8,134

Predicting Property Values using Machine Learning

- Most performant algorithm is a **Gradient Boosting Decision Tree Model** (LightGBM). All Trained Algorithms
- Avoid **overfitting**: only include 15 most important property and neighborhood features. Feature Importance
- **Mean Absolute Percentage Error (MAPE)** using 10-fold cross validation is 42%.
- Work in progress: Data collection ongoing (70% done).

Predicting Property Values using Machine Learning



The Elasticity of Tax Compliance and Tax Revenue

	Compliance 2SLS (1)	Revenue 2SLS (2)
ln(Tax Rate in %)	-0.105***	-61.816**
	(0.008)	(28.769)
Observations	38379	38379
Sample	All	All
House	Pooled	Pooled
Strata	363	363
Mean	.09	234.11
Elasticity	-1.19	-.26

- **Tax rates** $>$ **Laffer rate**: The government can increase revenues by lowering tax rates
  - Elasticity of tax compliance wrt tax rates: -1.19
  - Elasticity of tax revenue wrt tax rates: -0.26
- Similar elasticities wrt total tax liability Specification & Results

Robustness Checks: Information Spillovers

- Property owners might know that their tax rate differs from their neighbor's tax rate and from past tax rates
  - Could affect tax compliance through taxpayers' preferences for a fair tax system (Besley and Persson, 2009; Jensen and Persson, 2015)
  - Could affect tax compliance through taxpayers' transaction utility (Thaler, 1983)

- The elasticity of tax compliance and revenue are not affected by
  1. Controlling for neighbors' tax rate $\tau_{-i,p}$ Based on Distance Based on Tax ID
  2. Whether the owner knows her neighbors' tax rate $\tau_{-i,p}$ or not Results
  3. Whether the owner knows the official tax liability at baseline Results

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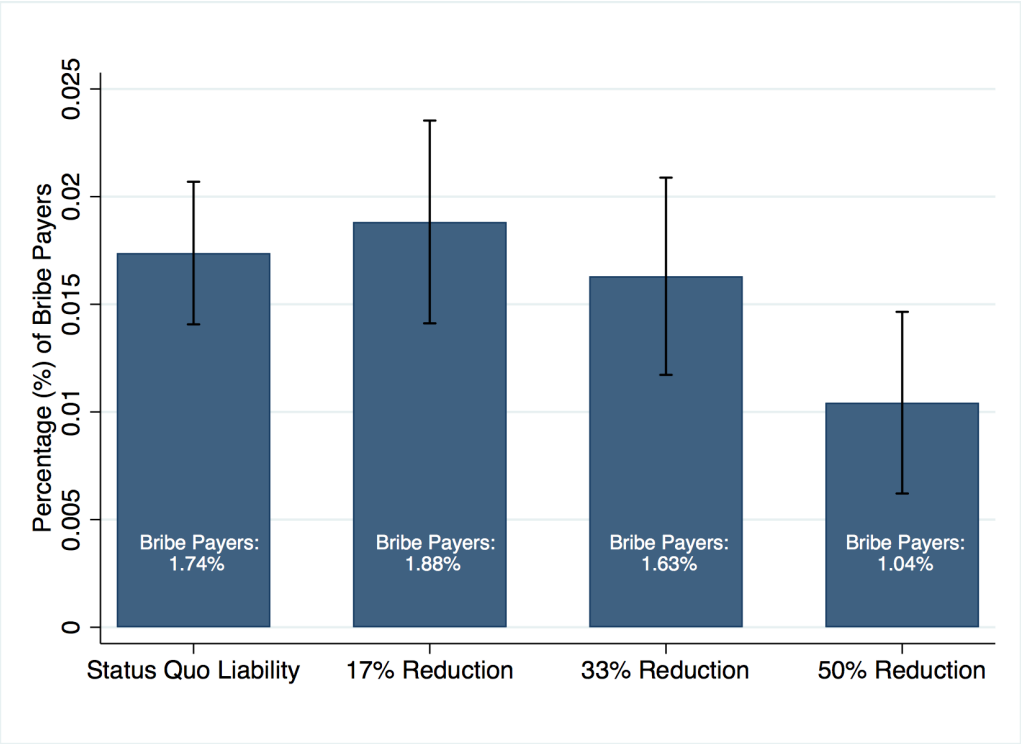
Reduced from Effects of Bribe Payments

- Bribe payments are a first-order issue when taxation is door-to-door due to principal-agent problem (Khan, khwaja and Olken 2016)

  Extensive Margin - "Did you pay the *transport* of the collectors?"



Validity

Reduced from Effects of Bribe Payments

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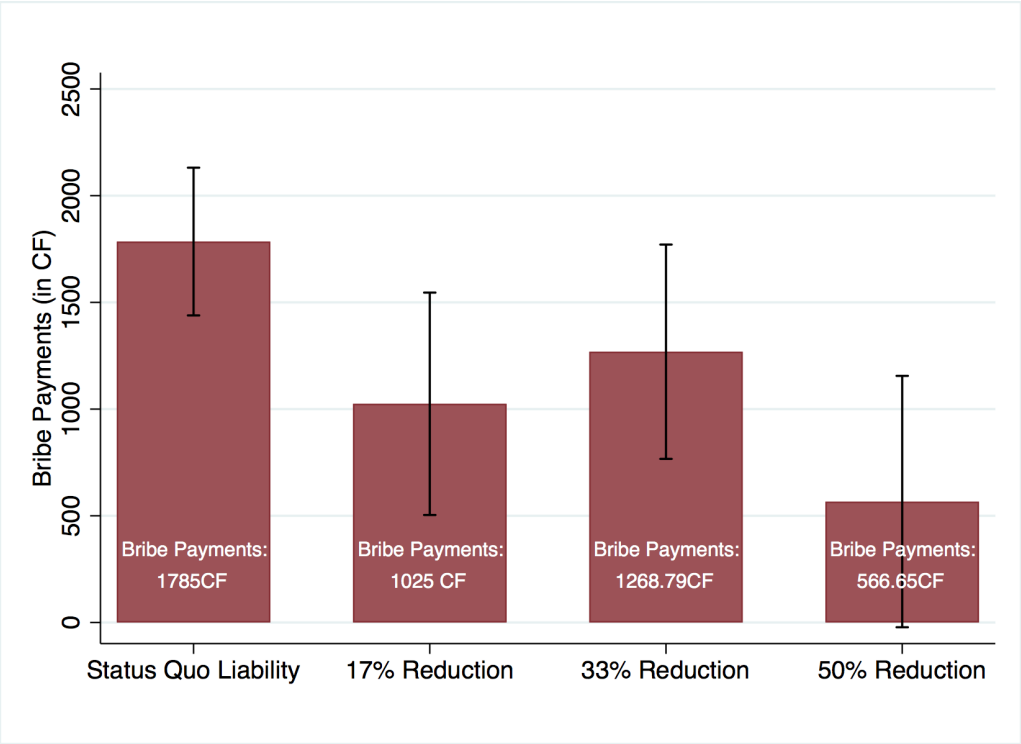
  Intensive Margin - "How much did you pay for their *transport* ?"



Validity

Elasticity of Bribe Payments

	Bribe Payment	Bribe Amount
	2SLS	2SLS
	(1)	(2)
ln(Tax Rate in %)	0.021***	27.290***
	(0.003)	(4.261)
Observations	26757	26757
Sample	Endline	Endline
House	Pooled	Pooled
Strata	363	363
Mean	.02	21.18
Elasticity	.98	1.94

- Beyond higher revenues, lowering tax rates also lowers bribes:
  - Elasticity of bribe payment wrt tax rates: 0.98
  - Elasticity of bribe amounts wrt tax rates: 1.94
- Suggests higher tax rates increase collector's bargaining power

Elasticity of Bribe Payments

	Bribe Payment	Bribe Amount
	2SLS	2SLS
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- Beyond higher revenues, lowering tax rates also lowers bribes:
  - Elasticity of bribe payment wrt tax rates: 0.98
  - Elasticity of bribe amounts wrt tax rates: 1.94
- Another motive for lowering tax rates in low capacity settings: Set bargaining power of tax collector low and minimize bribes

Compliance with Other Taxes

- Changes in property tax rates do not crowd out or crowd in **informal taxes** (weekly labor contributions) Informal Taxes
  - Informal taxes have a high burden in developing countries (Olken and Singhal, 2011; Walker, 2018)
  - Especially high burden in the DRC (Paler et al., 2017)

- Changes in property tax rates do not crowd out or crowd in **other formal taxes** Other Formal Taxes
  - Market tax
  - Firm tax
  - Vehicle tax
  - Income tax

Perceptions of the Government

- Changes in property tax rates do not affect **attitudes** toward the provincial government Legitimacy
  - Trust in provincial government
  - Perceived performance
  - Perceived corruption

- But evidence that lowering tax rates increases perceptions that the provincial government should **provide public goods** Provision
  - "Who should provide?" $\rightarrow$ With lower tax rates shift from other providers to provincial government
  - Public goods: schools, water, health, safety, helping the poor, development, roads

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6. HTE: Can Governments use Heterogeneity in Laffer Rate?

Can Governments Shift the Laffer Rate?

- Low tax capacity but tax rates already **above the Laffer rate**
- Limits ability to raise tax revenue and contributes to
  - Low public good provision (Besley and Persson, 2014)
  - Low government accountability (Besley and Persson, 2009)
- Can the government **shift the Laffer rate**?
- To answer this question we analyze **tax collector heterogeneity**

Tax Collector Analysis

Tax Rates and Enforcement Capacity

- Estimate tax collectors' **enforcement capacity** and **elasticity**
- **Random Assignments** of tax collectors:
  - Random assignment of collectors to another collector
  - Random assignment of collector pairs to neighborhoods (polygon)
- **Sample**: 50 tax collectors from provincial tax ministry randomly assigned to work in pairs in 250 neighborhoods

Tax Collector Analysis

Raw Estimates

- Outcome y_i is **tax revenue** collected from owner i
- Tax collectors' **enforcement capacity** $\mu = (\mu_1, ..., \mu_{50})$:

$$y_i = \mu_{c_1} 1[c(i) = c_1] + \mu_{c_2} 1[c(i) = c_2] + \epsilon_{ip}$$

- Tax collectors' **elasticity** $\nu = (\nu_1, ..., \nu_{50})$:

$$y_i = \nu_{c_1} log(\tau_{i,p}) 1[c(i) = c_1] + \nu_{c_2} log(\tau_{i,p}) 1[c(i) = c_2] + \alpha_1 1[c(i) = c_1] + \alpha_2 1[c(i) = c_2] + \epsilon_{ip}$$

- **Problem:** Estimates of μ_c and ν_c are unbiased but have high variance because of the small sample size ($N \approx 1000$) for each collector.

Raw Collector Enforcement | Raw Collector Elasticity

Tax Collector Analysis

Shrunk Estimates

- **Empirical Bayes** shrinkage estimator (Morris, 1983)

$$\mu_c^{EB} = \rho_{1,c}\hat{\mu}_c + \rho_{2,c}\bar{\mu}_c$$

with $\hat{\mu}_c$ estimated value of μ_c and $\bar{\mu}_c$ mean of $\hat{\mu}_c$

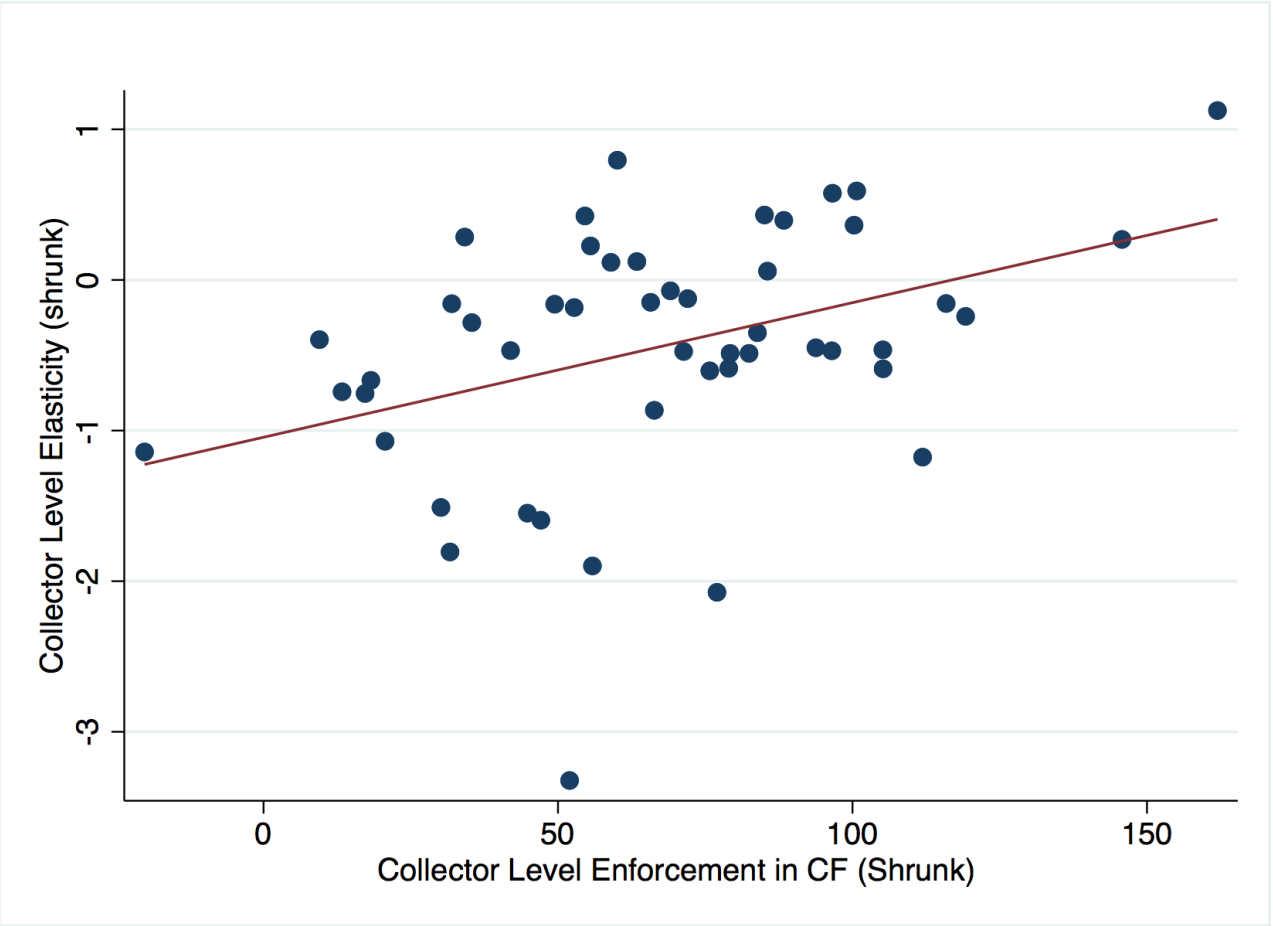
$$\rho_{1,c} = \frac{\sigma^2}{\pi_c^2 + \sigma^2} \qquad \rho_{2,c} = \frac{\pi_c^2}{\pi_c^2 + \sigma^2}$$

with π_c^2 variance of measurement error and σ^2 signal variance

- Optimal forecast shrinks noisy estimates of $\hat{\mu}_c$ towards the mean $\bar{\mu}_c$
- Average signal variance to total variance ratio $\rho_{1,c}$:
  - 0.70 for tax collectors' enforcement capacity μ_c
  - 0.84 for tax collectors' elasticity ν_c

Shrunk Collector Enforcement | Shrunk Collector Elasticity

Elasticity of Tax Revenue Increases with Enforcement



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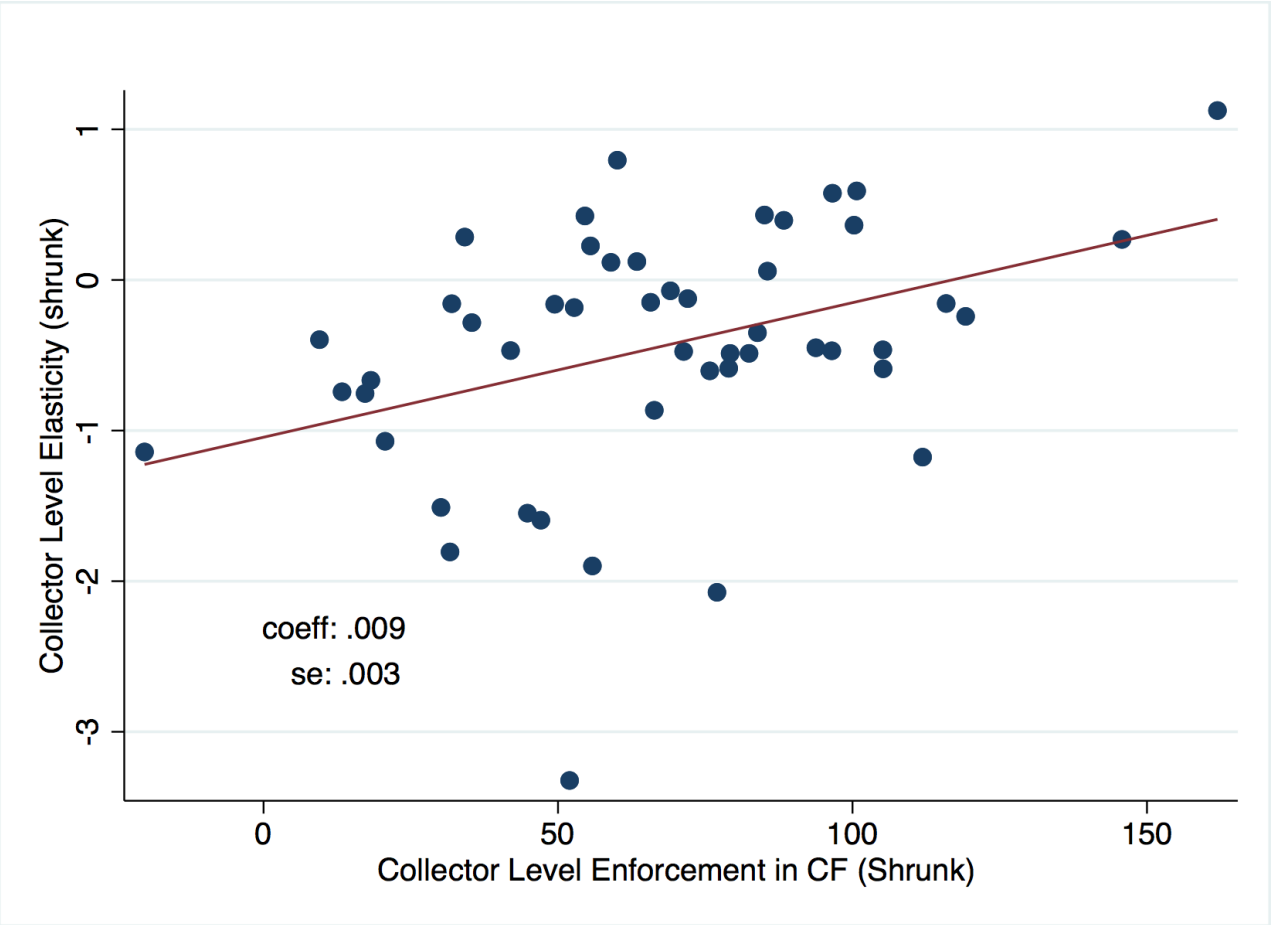

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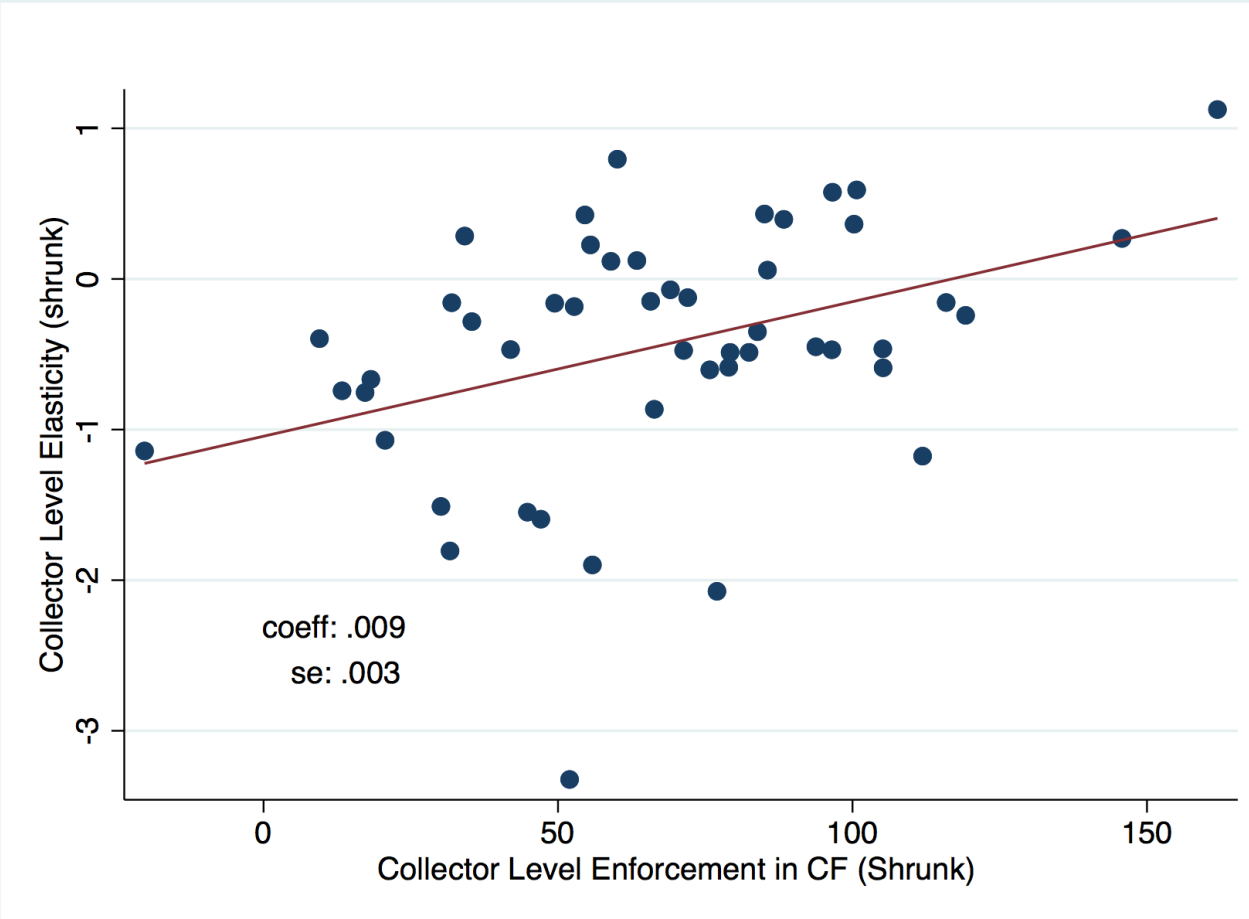
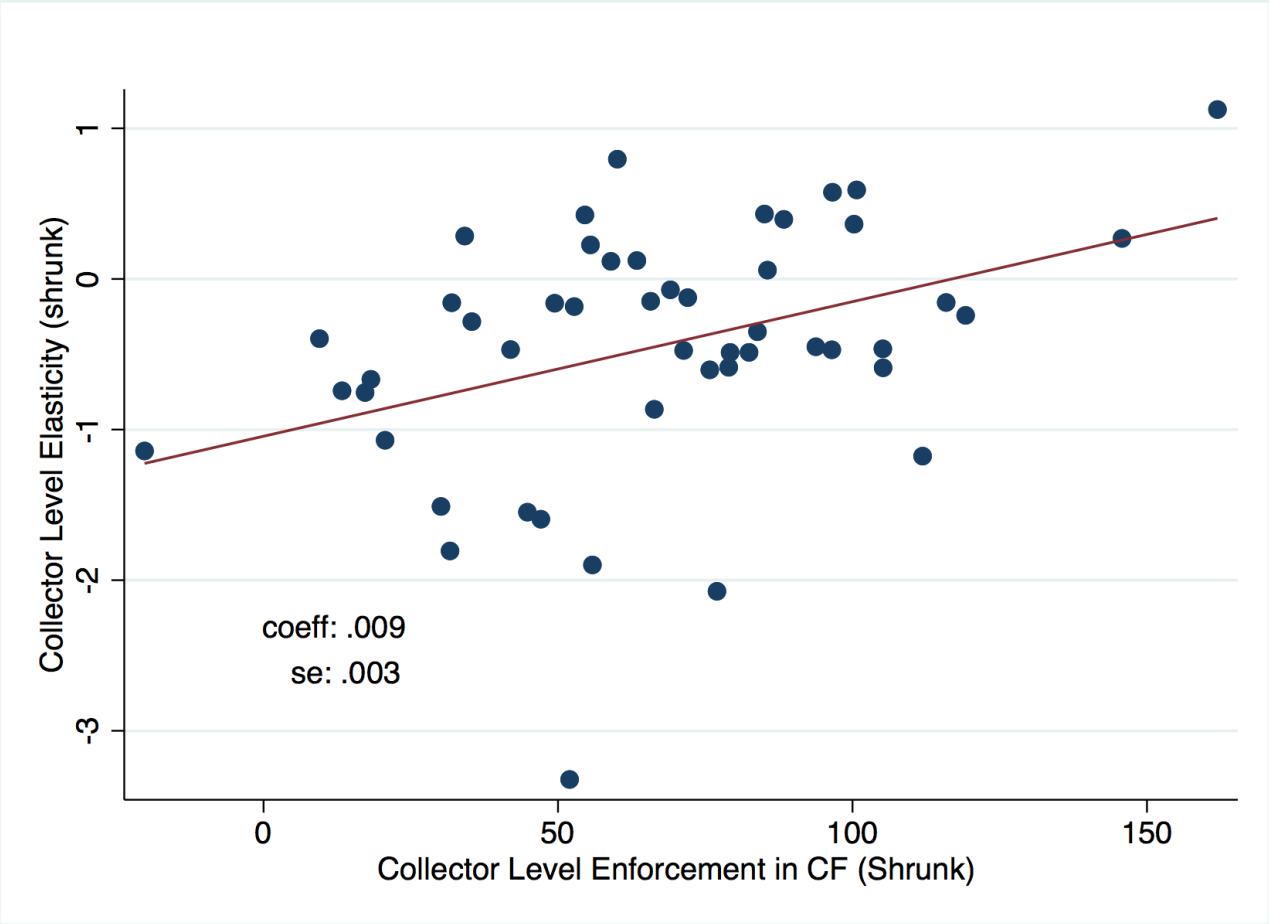


Collectors who are more effective at getting people to pay can also overcome citizens' low WTP at higher rates

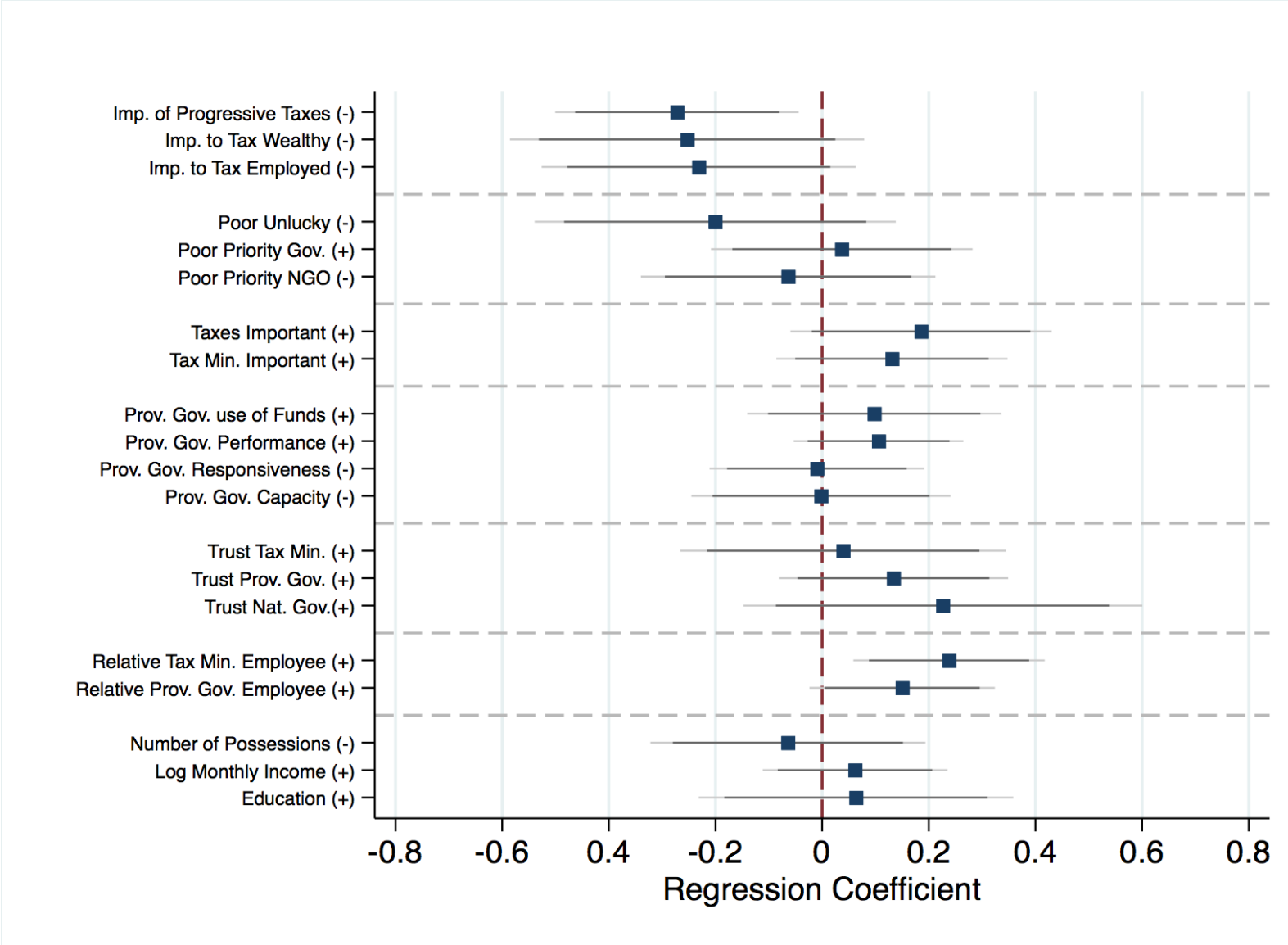
Elasticity of Tax Revenue Increases with Enforcement



Collectors who are more effective at getting people to pay can also overcome citizens' low WTP at higher rates

$\Rightarrow$ **Increasing enforcement capacity permits higher tax rates**

Can Collectors' Characterisitcs Shift the Laffer Rate?



Tax Collector's Characteristics Matter

- Tax collectors' characteristics can help **shift the Laffer rate**
- **Static perspective**:
  - At **rate** $>$ **Laffer rate** (e.g. *low levels of enforcement capacity*) the government should lower tax rates and hire tax collectors who:
    - Have stronger preferences for progressive taxes (e.g. through training)
  - If **rate** $<$ **Laffer rate** (e.g. *high levels of enforcement capacity*) the government should increase tax rates and hire tax collectors who:
    - Have stronger tax morale (e.g. through selection or training)
    - Have more positive views of the government (e.g. through selection)
    - Are more connected to the government (e.g. through selection)

Tax Collector's Characteristics Matter

- Tax collectors' characteristics can also **shift the Laffer rate**:
- **Dynamic perspective**:
  - Governments can hire collector with certain characteristics to increase the **Laffer rate** and permit higher rates (i.e. get to rate $<$ Laffer rate)
    - Have stronger tax morale (e.g. through selection or training)
    - Have more positive views of the government (e.g. through selection)
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- Limits ability to raise tax revenue and contributes to
  - Low public good provision (Besley and Persson, 2014)
  - Low government accountability (Besley and Persson, 2009)
- Can the government exploit **heterogeneity in the Laffer rate** ?
- To answer this question we analyze **heterogeneous treatment effect**

Heterogeneous Treatment Effects

- We use **Machine Learning** to guide predictions instead of pre-registering every hypothesis
- Interested in the **Conditional Average Treatment Effect**:

$$s_0(Z) = \mathbb{E}[Y|D = 1, Z] - \mathbb{E}[Y|D = 0, Z]$$

where Y is tax revenue and $D = 1$ if owner assigned to 50% reduction in tax liability, $D = 0$ if owner assigned to status quo tax liability

- Use Chernozhukov et al. (2007) which relies on **data splitting** into a main sample and an auxiliary sample to avoid overfitting and achieve validity.

GATES and CLAN

- **Group Average Treatment Effects (GATEs)**: $\gamma_k = \mathbb{E}[S_0(Z)|G_k]$ where $G_k = S \in I_k$ explain as much variation in $s_0(Z)$ as possible
  - Substantial heterogeneity in the effect of assignment to lower tax rates on tax revenue GATEs - Graph
  - For the 20% most affected reducing tax rates increases revenues for the 20% least affected it decreases revenue
- **Classification Analysis (CLAN)**: $\delta_k = \mathbb{E}[g(Y_i, Z_i)|S_i \in I_k]$
  - Revenue maximization enough to justify a progressive tax schedule
    - Lower tax rates for low value properties and cash constrained individuals
    - Keep status quo tax rates for high value properties and unconstrained individuals

Classification Analysis (CLAN)

	LASSO		
	20 % Most Affected	20 % Least Affected	Difference
Walls Quality	2.042 (1.982,2.101)	2.450 (2.391,2.508)	-0.413 (-0.499,-0.328) [0.000]
Roof Quality	6.918 (6.885,6.951)	6.955 (6.922,6.985)	-0.029 (-0.079,0.016) [0.421]
Erosion Threat	0.530 (0.491,0.569)	0.416 (0.378,0.454)	0.144 (0.091,0.197) [0.000]
Employed	0.786 (0.764,0.809)	0.816 (0.794,0.839)	-0.038 (-0.070,-0.007) [0.035]
Salaried	0.256 (0.231,0.281)	0.345 (0.320,0.370)	-0.089 (-0.124,-0.053) [0.000]
Work for Gov. Self	0.119 (0.098,0.140)	0.251 (0.231,0.271)	-0.132 (-0.161,-0.103) [0.000]
Work for Gov. Self or Relatives	0.229 (0.204,0.254)	0.334 (0.309,0.359)	-0.104 (-0.139,-0.068) [0.000]
Ethnic Majority	0.724 (0.701,0.746)	0.829 (0.806,0.852)	-0.111 (-0.142,-0.079) [0.000]

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Conclusion

- Study how governments should set tax rates using a unique case of randomized property tax rates in Kananga, DRC
- Tax rate on wrong side of Laffer curve:
  - Elasticity of **tax revenue** wrt tax rates: **-0.26**
  - Elasticity of **tax compliance** wrt tax rates: **-1.19**
  - Beyond higher revenue, lowering rates also:
    - Lowers **bribes** collected
    - Improves **view of government**
- Policies can exploit heterogeneity in the Laffer rate
  - Increasing enforcement capacity permits higher tax rates
  - Progressive tax schedule would maximize revenue

Conclusion

THANK YOU!

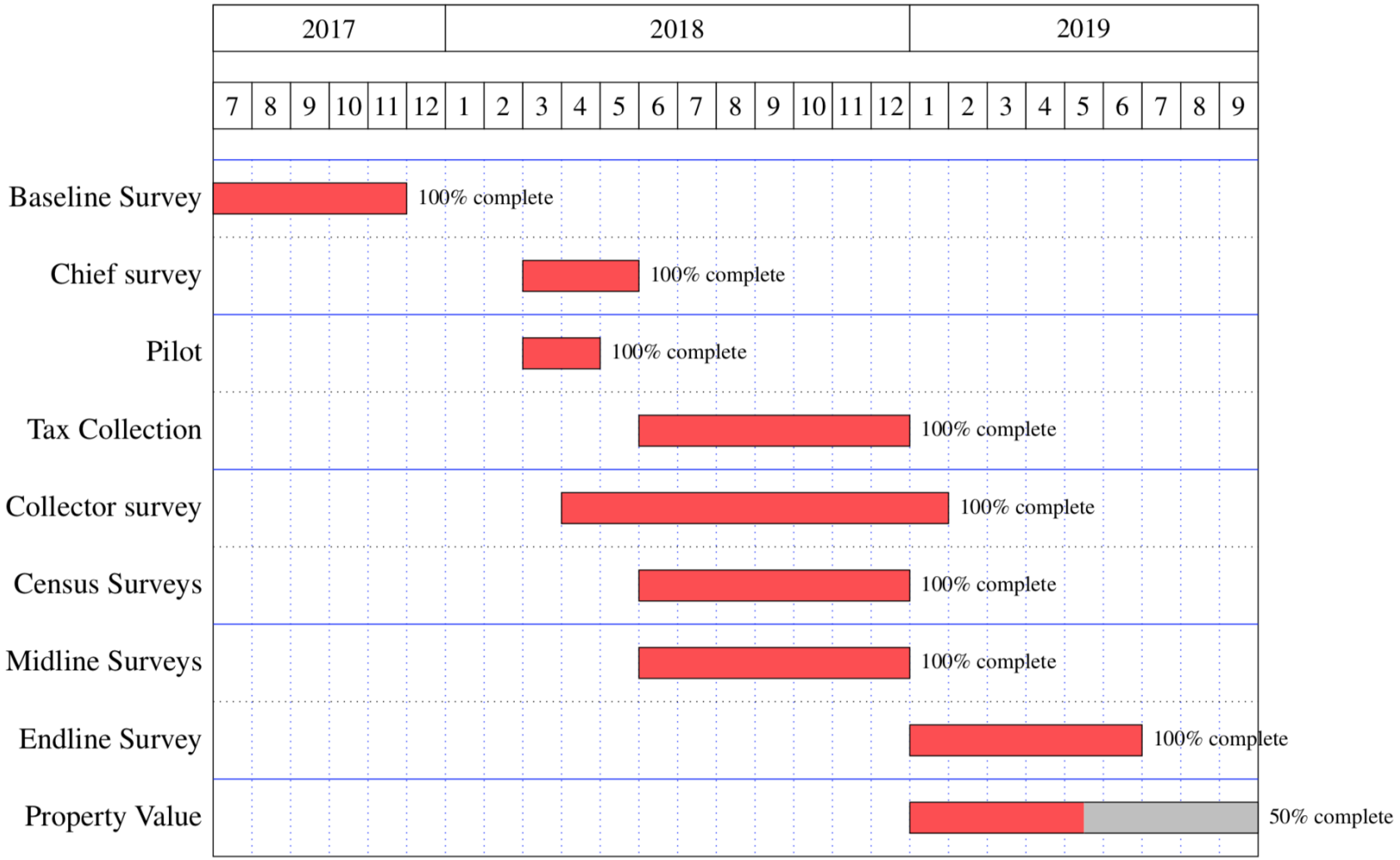
Similar property tax schemes in other countries

Similar property tax schemes in other countries (Franzsen and McCluskey, 2017):

- Common in developed countries until recently:
  - *United Kingdom*: Introduced a flat charge (the Community Charge or "Poll Tax") between 1989 and 1993.
  - *Republic of Ireland*: Property owners had to pay a flat rate charge (Household Charge and Residence Charge) until the implementation of the local property tax in 2013.
- Still common in developing countries:
  - *India*: Major Indian cities (e.g. New Delhi, Bangalore, Kolkata) have adopted flat rates by unit-area category in 2008.
  - *Tanzania*: All properties that are not included on the valuation roll are liable for flat rates.
  - *Sierra Leone*, *Liberia* and *Malawi*: Overall tax simplification agenda implies piloting flat rates for properties not on the valuation roll.

Back

Data Collection Timeline



Back - Data

Balance Table

	Erosion	House Quality Walls	Roof	Age	Gender	Employed	Salaried	Gov Employee	Relatives Gov Employee	Tribe Majority
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
17 % Reduction	0.000	-0.009	-0.001	0.211	-0.007	0.005	0.004	0.007	0.009	0.002
	(0.008)	(0.014)	(0.010)	(0.290)	(0.008)	(0.008)	(0.009)	(0.007)	(0.008)	(0.008)
33 % Reduction	-0.004	-0.018	-0.015	-0.030	0.004	0.001	-0.004	-0.002	-0.003	0.006
	(0.008)	(0.014)	(0.010)	(0.294)	(0.008)	(0.008)	(0.009)	(0.007)	(0.008)	(0.008)
50 % Reduction	0.004	-0.035**	-0.010	-0.091	-0.002	0.011	-0.003	0.005	0.012	-0.007
	(0.008)	(0.014)	(0.010)	(0.291)	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
Observations	30574	24888	24885	16972	19154	21120	21125	21123	20155	19571
Sample	Midline	Midline	Midline	Midline	Midline	Midline	Midline	Midline	Midline	Midline
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Strata	358	358	358	358	358	358	358	358	358	358
Mean	.4	2.18	6.94	52.05	.82	.79	.26	.16	.1	.79

- **Omnibus Tests** of joint orthogonality fail to reject the null
  - Status quo tax liability vs 17% reduction: $F = 0.44$ and $p = 0.93$
  - Status quo tax liability vs 33% reduction: $F = 0.87$ and $p = 0.55$
  - Status quo tax liability vs 50% reduction: $F = 1.51$ and $p = 0.13$

Back

Robustness Checks

Tax Collector Effort Level

- **Concern:** Tax collectors earn a percentage (usually 30%) of the amount of tax collected. Different tax rates might affect *collectors' effort level* through tax collectors' compensation.
- **Strategy #1:** We randomized tax collectors' compensation at the property level: 30 % of the amount collected vs fixed compensation (equal to 25% of the full liability). We can estimate η_{ip} for each compensation scheme as well as controlling for compensation level.

Compensation

- **Strategy #2:** Estimate η_{ip} using tax collector visit indicator (extensive margin) and number of visits by tax collectors (intensive margin) as the outcome.

Robustness Checks

Tax Collector Effort Level

Tax Compliance	Tax Compliance	Tax Compliance	Tax Compliance	Tax Compliance	Visit Indicator	Nb visits
	Main Spec.	Compensation Proportional	Compensation Flat	Compensation Control	Main Spec.	Main Spec.
	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
ln(Tax Liability)	-0.094***	-0.084***	-0.090***	-0.106***	-0.003	-0.028
	(0.006)	(0.008)	(0.007)	(0.008)	(0.009)	(0.020)
Observations	39219	16979	21078	38385	39219	24581
Sample	All	All	All	All	All	All
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Strata	363	363	363	363	363	363
Mean	.09	.09	.08	.09	.62	1.63
Elasticity	-1.06	-.98	-1.1	-1.16	0	-.02

Back

Randomized Compensation for Tax Collectors

Property Type	Tax Liability (CF)	30% Bonus (CF)	Constant Bonus (CF)
Low Value Property	1,500	450	750
	2,000	600	750
	2,500	750	750
	3,000	900	750
High Value Property	All rates		2,000

Back

Controlling for Neighbor's Tax Rates

Neighbor Defined by Geographic Distance

	No Nbr Ctrls (1)	1 Nearest Nbr Ctrls (2)	2 Nearest Nbrs Ctrls (3)	3 Nearest Nbrs Ctrls (4)	4 Nearest Nbrs Ctrls (5)	5 Nearest Nbrs Ctrls (6)	6 Nearest Nbrs Ctrls (7)	7 Nearest Nbrs Ctrls (8)	8 Nearest Nbrs Ctrls (9)	9 Nearest Nbrs Ctrls (10)	10 Nearest Nbrs Ctrls (11)
ln(tax liability)	-0.104***	-0.104***	-0.104***	-0.104***	-0.104***	-0.104***	-0.104***	-0.104***	-0.104***	-0.104***	-0.104***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
ln(tax liability) Nearest Nbr		0.001	0.001	0.001	0.000	0.000	0.000	-0.000	-0.000	0.000	-0.000
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln(tax liability) 2nd Nearest Nbr			0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003
			(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln(tax liability) 3rd Nearest Nbr				0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003
				(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln(tax liability) 4th Nearest Nbr					0.003	0.002	0.002	0.002	0.002	0.002	0.002
					(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln(tax liability) 5th Nearest Nbr						0.006*	0.006*	0.006*	0.006*	0.006*	0.006
						(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln(tax liability) 6th Nearest Nbr							-0.000	-0.001	-0.001	-0.000	-0.001
							(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
ln(tax liability) 7th Nearest Nbr								0.002	0.002	0.002	0.002
								(0.004)	(0.004)	(0.004)	(0.004)
ln(tax liability) 8th Nearest Nbr									0.000	0.001	0.000
									(0.004)	(0.004)	(0.004)
ln(tax liability) 9th Nearest Nbr										-0.003	-0.003
										(0.003)	(0.003)
ln(tax liability) 10th Nearest Nbr											0.007*
											(0.004)
Observations	34567	34567	34567	34567	34567	34567	34567	34567	34567	34567	34567
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Mean	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09	.09
Elasticity	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19	-1.19

Back

Controlling for Neighbor's Tax Rates

Neighbor Defined by Successive compound Codes

	No neighbor Ctrls	2 neighbor Ctrls	4 neighbor Ctrls	6 neighbor Ctrls	8 neighbor Ctrls	10 neighbor Ctrls
	(1)	(2)	(3)	(4)	(5)	(6)
ln(tax liability)	-0.099***	-0.099***	-0.099***	-0.099***	-0.099***	-0.099***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
ln(Tax Rate in %) neighbor -1		0.001	0.002	0.002	0.002	0.001
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln(Tax Rate in %) neighbor -2			-0.005	-0.005	-0.005	-0.005
			(0.004)	(0.004)	(0.004)	(0.004)
ln(Tax Rate in %) neighbor -3				-0.001	-0.002	-0.002
				(0.004)	(0.004)	(0.004)
ln(Tax Rate in %) neighbor -4					0.003	0.003
					(0.004)	(0.004)
ln(Tax Rate in %) neighbor -5						0.004
						(0.004)
ln(Tax Rate in %) neighbor +1		0.003	0.003	0.003	0.003	0.003
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ln(Tax Rate in %) neighbor +2			0.000	-0.000	-0.000	-0.001
			(0.004)	(0.004)	(0.004)	(0.004)
ln(Tax Rate in %) neighbor +3				0.006	0.006	0.005
				(0.004)	(0.004)	(0.004)
ln(Tax Rate in %) neighbor +4					-0.001	-0.002
					(0.004)	(0.004)
ln(Tax Rate in %) neighbor +5						0.009**
						(0.004)
Observations	32725	32725	32725	32725	32725	32725
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Mean	.09	.09	.09	.09	.09	.09
Elasticity	-1.15	-1.15	-1.15	-1.15	-1.15	-1.15

Back

By Knowledge of Neighbor's Tax Rates

	Main Spec Spec (1)	Knows Nbr Rate (2)	Doesn't Know Nbr Rate (3)	Main Spec (4)	Knows Nbr Rate (5)	Doesn't Know Nbr Rate (6)
ln(tax liability)	-0.136***	-0.151***	-0.137***	-70.843	5.926	-86.293*
	(0.013)	(0.045)	(0.014)	(46.232)	(117.514)	(51.544)
Observations	15637	1811	13355	15637	1811	13355
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Mean	.11	.14	.11	284.11	318.11	282.23
Elasticity	-1.2	-1.11	-1.23	-.25	.02	-.31

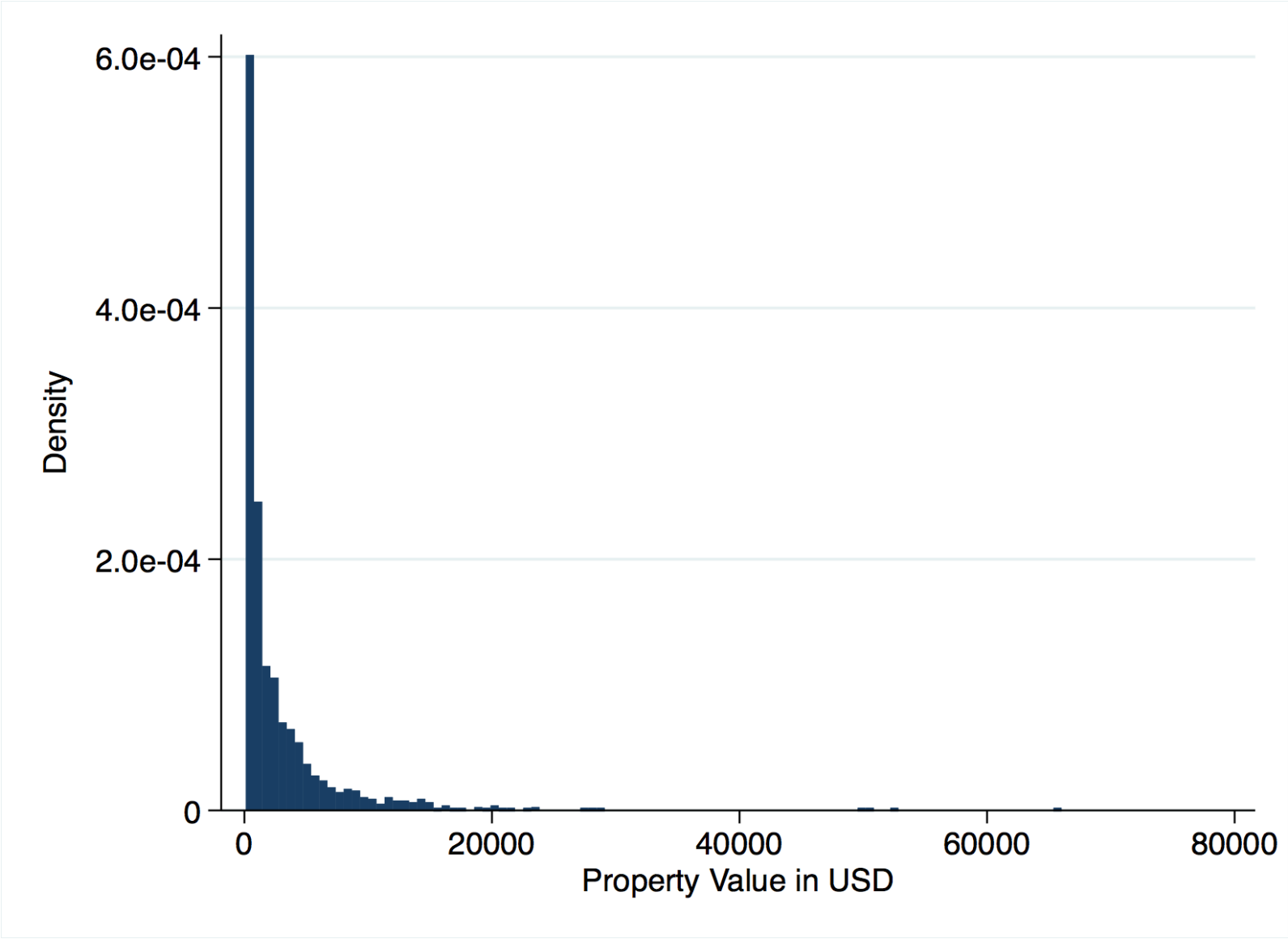
Back

By Past Tax Collection Status

	Main Spec (1)	Past Campaign (2)	No Past Campaign (3)	Main Spec (4)	Past Campaign (5)	No Past Campaign (6)
ln(tax liability)	-0.106***	-0.095***	-0.123***	-62.532**	-41.875	-94.251*
	(0.008)	(0.010)	(0.012)	(28.868)	(35.174)	(49.376)
Observations	38238	23433	14805	38238	23433	14805
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Mean	.09	.09	.09	239.25	234.26	247.14
Elasticity	-1.16	-1.04	-1.35	-.26	-.18	-.38

Back

Distribution of Property Value in Training Sample

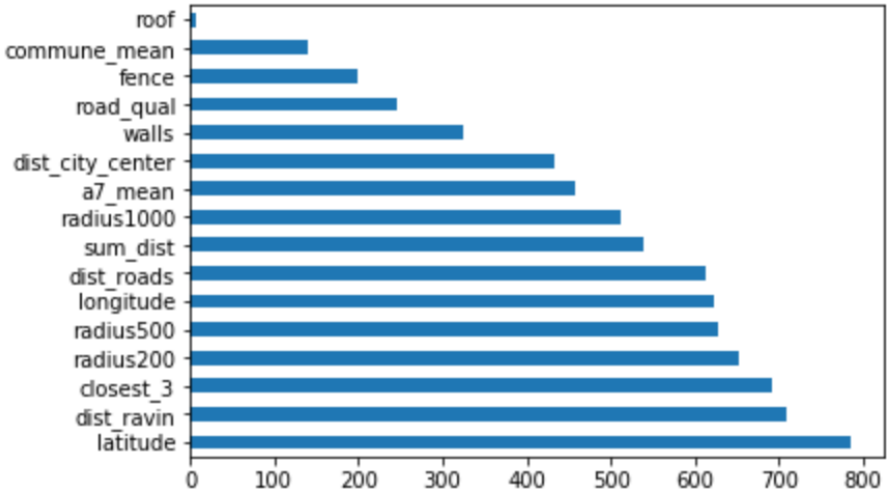


Accuracy of all Trained Algorithms

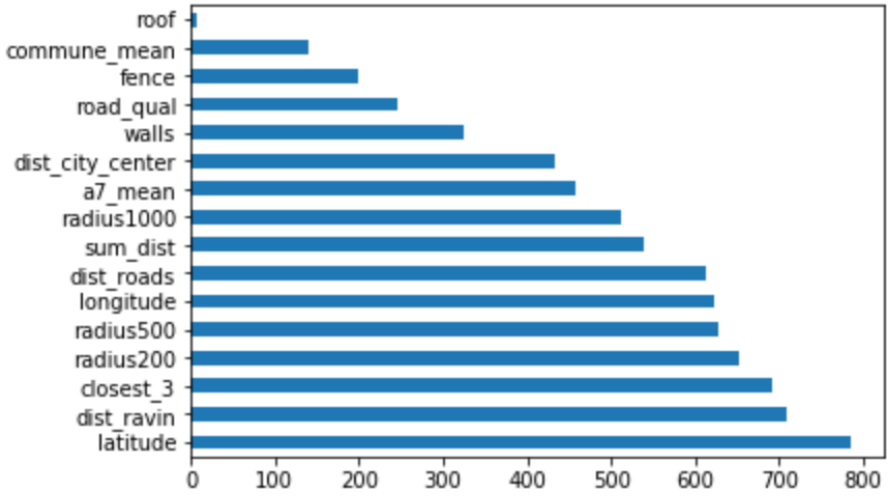
Model	**Accuracy (MAPE)**
Ridge	142 %
SVR - Linear Kernel	120 %
SVR - RBF Kernel	83 %
KNN	167 %
Random Forest	99 %
Boosting - LGBM (MAPE loss)	58 %
Boosting - LGBM (MAPE and APE loss)	42 %

Back

Feature Importance



Gain from Feature Split



Number of Splits

Back

The Elasticity of Tax Compliance

- To estimate the elasticity of tax compliance η_{ip} we run the following OLS regressions :

$$C_{ip} = \alpha + \beta ln(T_{ip}) + \gamma_{ip} + \delta_p + \nu_{ip}$$

  - C_{ip} = tax compliance status of owner of property i in neighborhood p.
  - T_{ip} = tax liability for property i in neighborhood p.
  - γ_{ip} = type of house indicator.
  - δ_p = polygon fixed effects.

- The marginal effect β is not an elasticity but can be easily transformed into $\eta_{1,ip}$ using the standard formula:

$$\eta_{1,ip} = \frac{\partial C_{ip}}{\partial T_{ip}} \times \frac{T_{ip}}{C_{ip}} \quad \Rightarrow \quad \eta_{1,ip} = \frac{\beta}{mean(C_{ip})}$$

The Elasticity of Tax Compliance and Tax Revenue

	Tax Compliance ($\eta_{1,ip}$)		
	OLS	OLS	OLS
	(1)	(2)	(3)
ln(Tax Liability)	-0.094***	-0.095***	-0.087***
	(0.006)	(0.006)	(0.016))
Observations	39219	35012	4207
Sample	All	All	All
House	Pooled	Low Value	High Value
Strata	363	363	363
Mean	.09	.09	.07
Elasticity	-1.06	-1.04	-1.28

Back

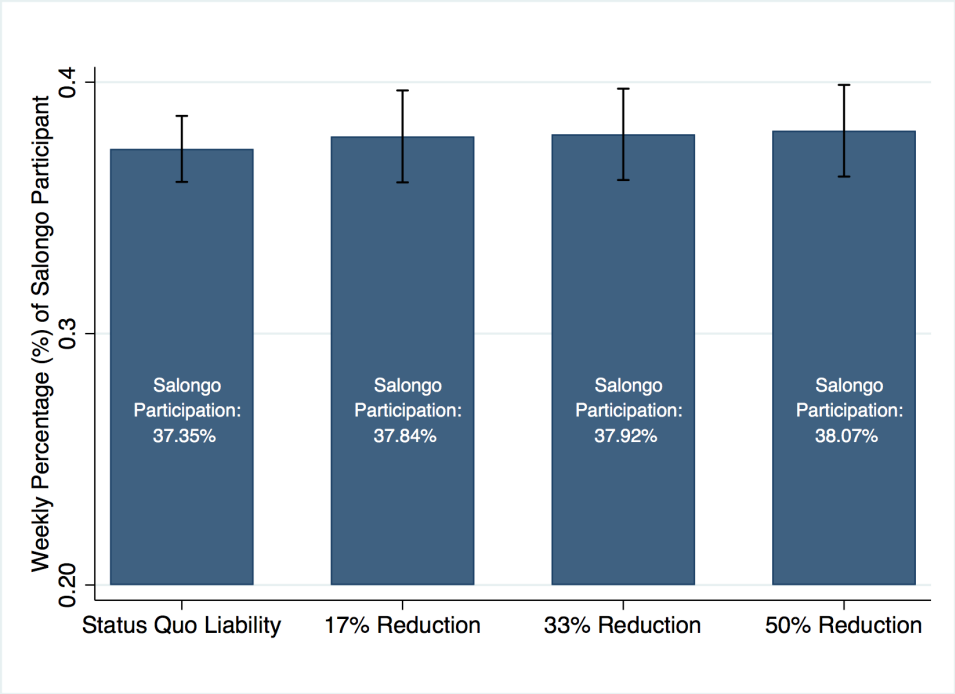
Measuring Bribe Payments

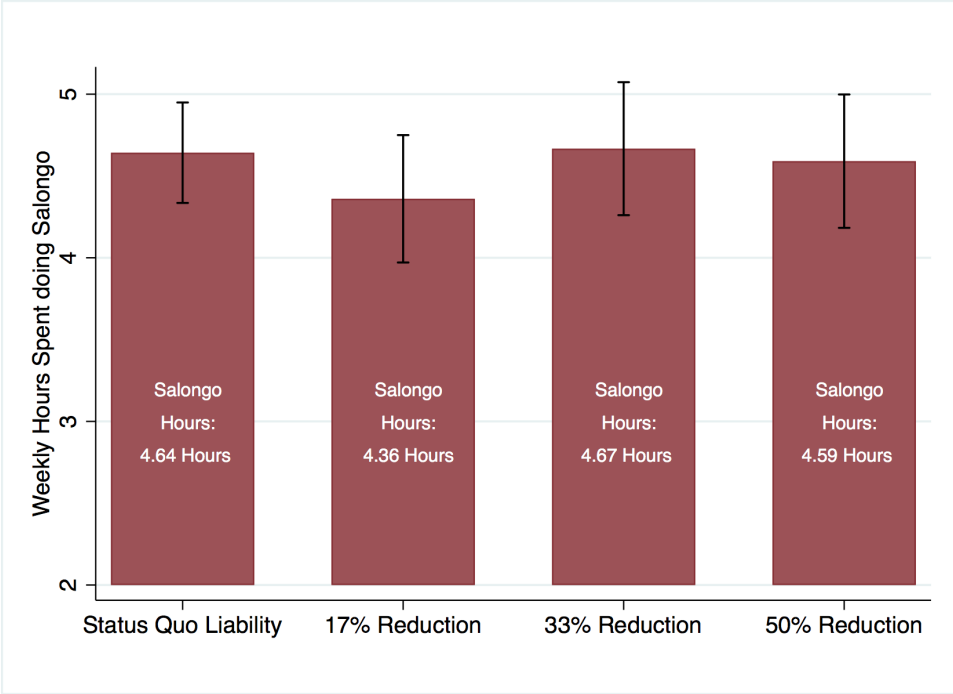
Can **survey questions** reliably measure bribes?

1. In high bribe settings 50% of citizens openly admit paying bribes (Reid and Weigel 2018)
2. High correlation between more and less overt bribe elicitation strategies (Reid and Weigel 2018; Weigel 2019)

Back

Informal Taxes - Reduced Form





Extensive margin

Intensive margin

- *Extensive Margin* - "Did you participate in *Salongo* in the past week?"
- *Intensive Margin* - "For how many hours did you participate?"

Back - Secondary Outcomes

Informal Taxes and other Formal Taxes

	Salongo IV (1)	Salongo Hours IV (2)	Paid Market Tax IV (3)	Paid Firm Tax IV (4)	Paid Vehicle Tax IV (5)
ln(Tax Rate in %)	0.026	2.124*	-0.020	0.001	0.001
	(0.036)	(1.101)	(0.013)	(0.005)	(0.006)
Observations	2745	1414	1677	2099	2262
Sample	Endline	Endline	Endline	Endline	Endline
House	Pooled	Pooled	Pooled	Pooled	Pooled
Strata	360	360	360	360	360
Mean	.43	7.63	.44	.22	.19
Elasticity	.06	.28	-.05	.01	0

Back - Secondary Outcomes

Government Legitimacy

	Prov. Gov.			Tax Ministry				Fair Prop. Tax	
	Trust	Performance	Perceived USD Stolen	Trust	Performance	Perceived USD Stolen	Collection	Rates	Collectors
	IV	IV	IV	IV	IV	IV	IV	IV	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln(Tax Rate in %)	0.073	0.000	2.183	0.044	0.175*	-33.107	0.051	-0.140**	-0.007
	(0.065)	(0.084)	(24.666)	(0.074)	(0.090)	(22.703)	(0.043)	(0.063)	(0.053)
Observations	2783	2732	2806	2787	2735	2789	2790	2554	2509
Sample	Endline	Endline	Endline	Endline	Endline	Endline	All	All	All
House	Pooled	Periphery	Midrange	Pooled	Periphery	Midrange	Pooled	Pooled	Pooled
Strata	363	363	363	363	363	363	363	363	363
Mean	1.77	3.91	576.4	2.04	4.07	426.99	2	1.38	1.69
Elasticity	.04	0	0	.02	.04	-.08	.03	-.1	0

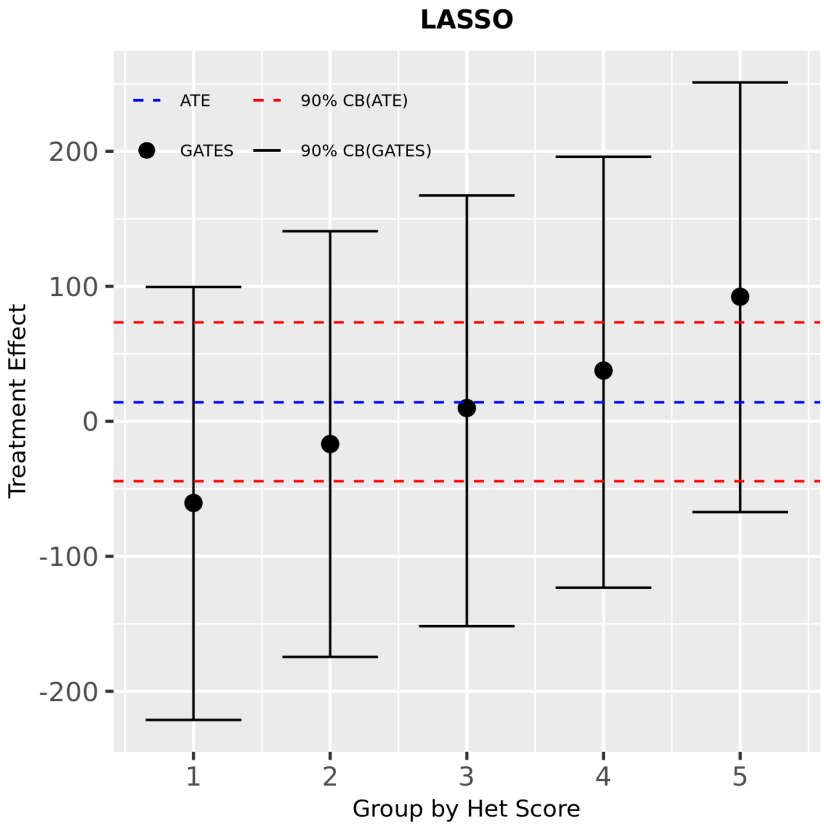
Back - Secondary Outcomes

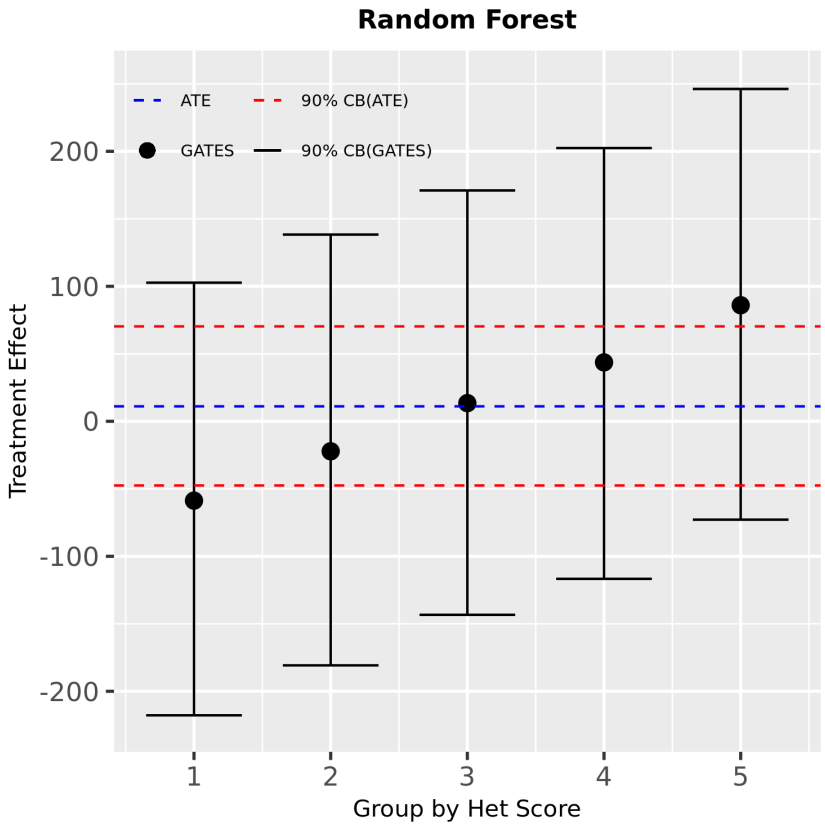
Government Accountability

	Schools IV (1)	Water IV (2)	Health IV (3)	Safety IV (4)	Help the poor IV (5)	Development IV (6)	Roads IV (7)	All IV (8)
ln(Tax Rate in %)	-0.078**	-0.068*	-0.065*	-0.075**	-0.044	-0.069*	-0.059*	-0.458*
	(0.036)	(0.036)	(0.036)	(0.036)	(0.035)	(0.036)	(0.036)	(0.236)
Observations	2806	2806	2806	2806	2806	2806	2806	2806
Sample	Endline	Endline	Endline	Endline	Endline	Endline	Endline	Endline
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Strata	363	363	363	363	363	363	363	363
Mean	.42	.4	.42	.44	.36	.42	.44	2.89
Elasticity	-.19	-.17	-.16	-.17	-.12	-.16	-.14	-.16

Back - Secondary Outcomes

Group Average Treatment Effects (GATES)

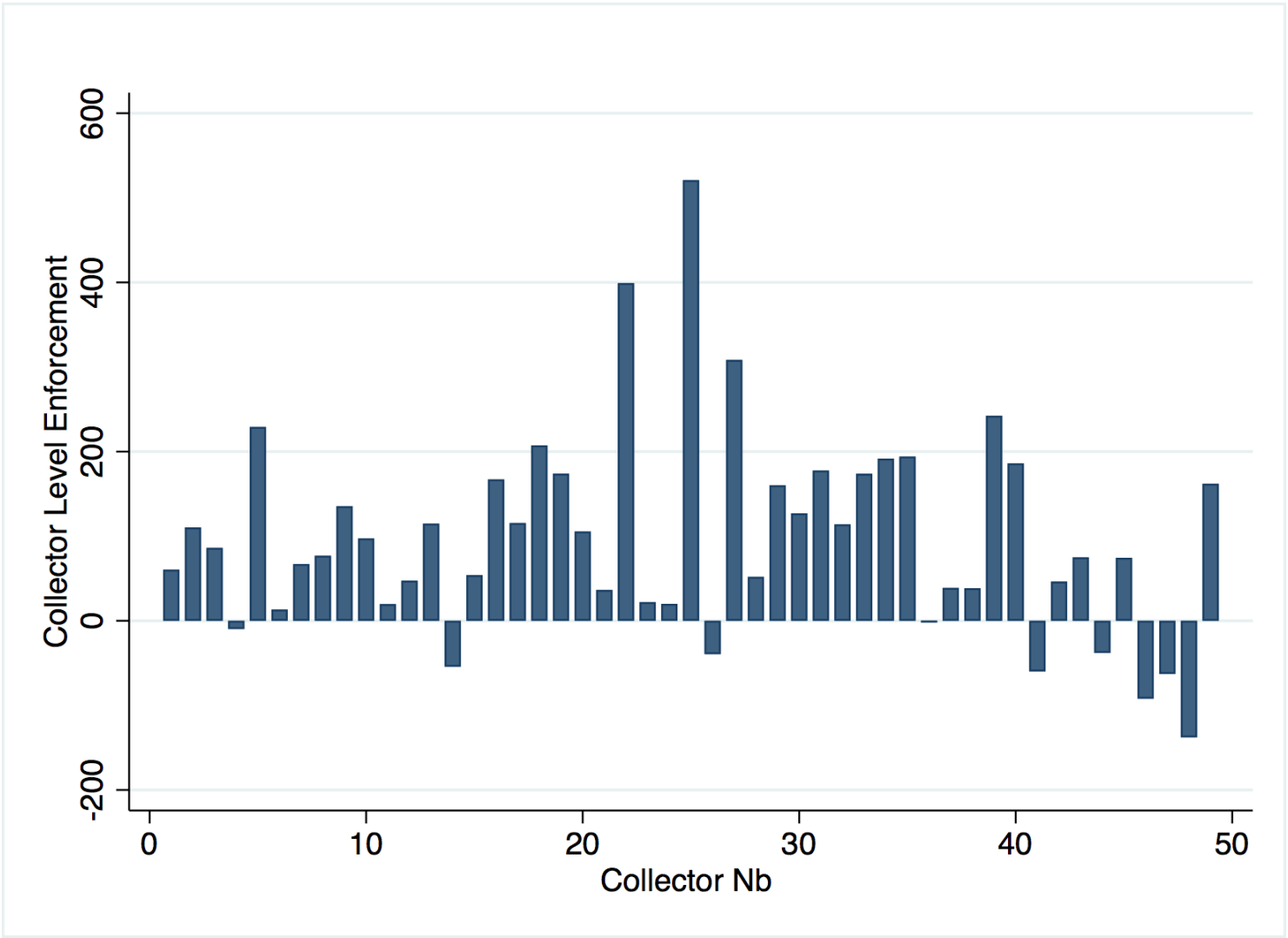




Back - Heterogeneity

Tax Collector Enforcement Capacity

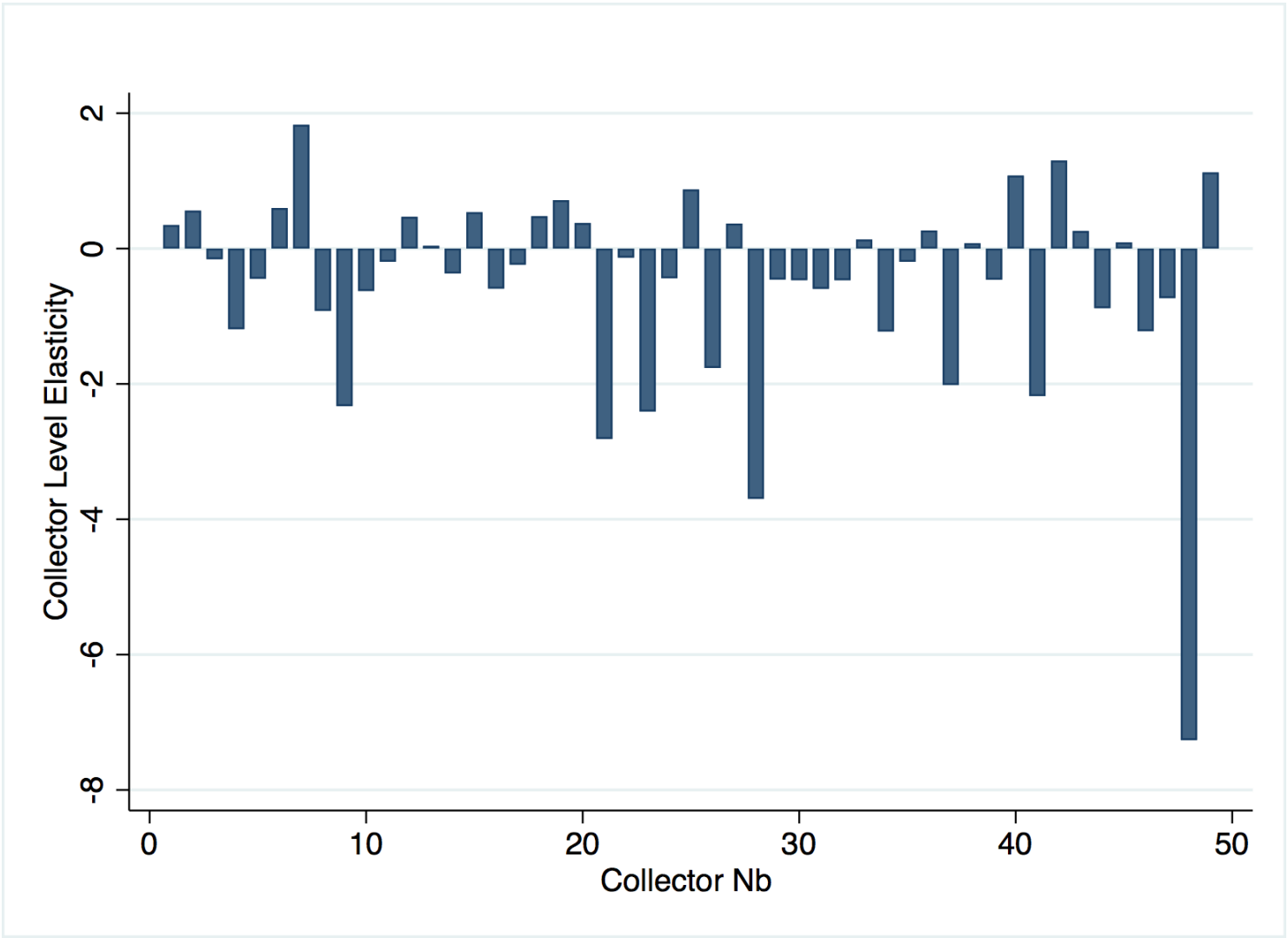
Raw Estimates



Back - Collector Elasticity

Tax Collector Elasticity

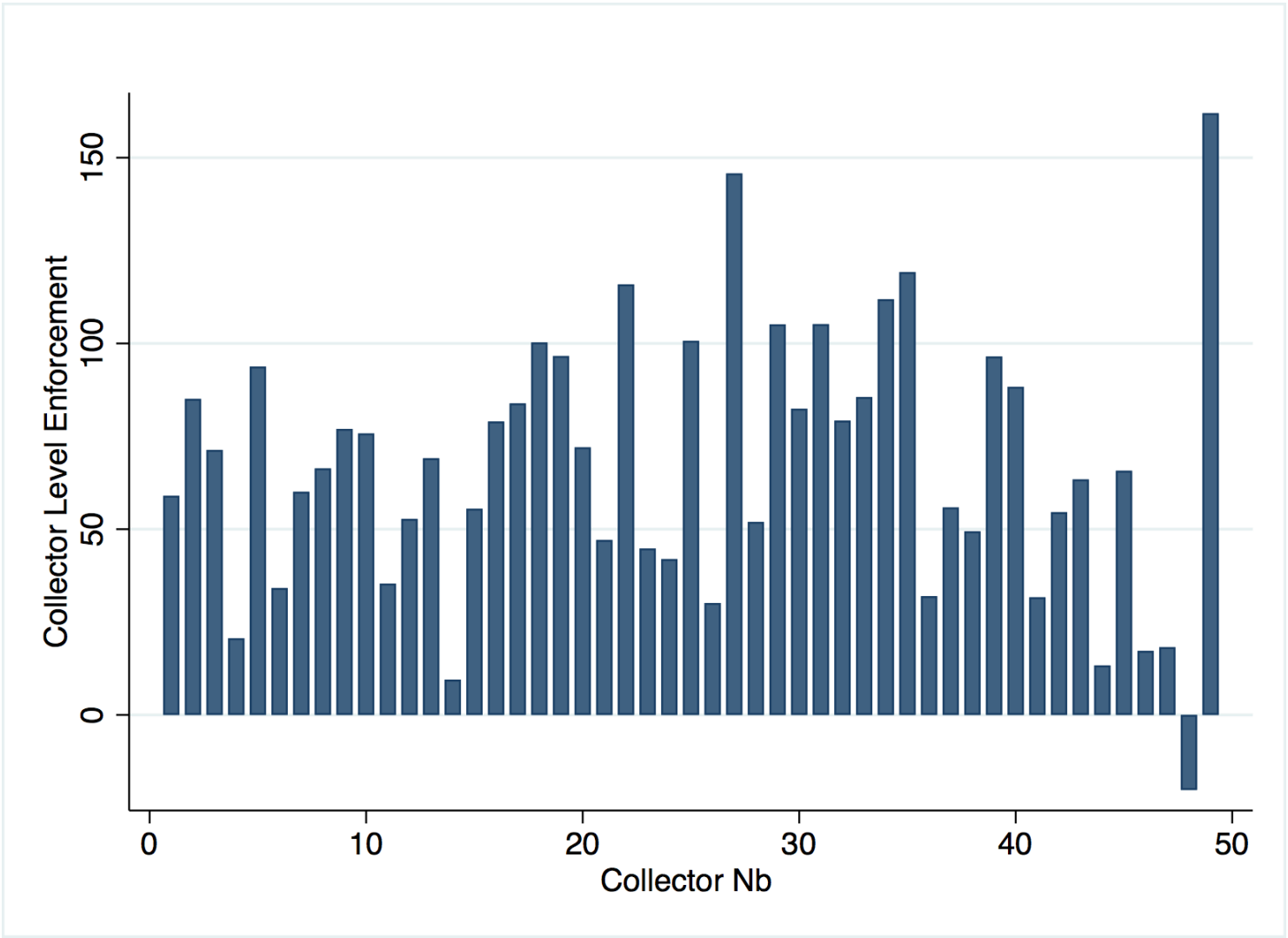
Raw Estimates



Back - Collector Elasticity

Tax Collector Enforcement Capacity

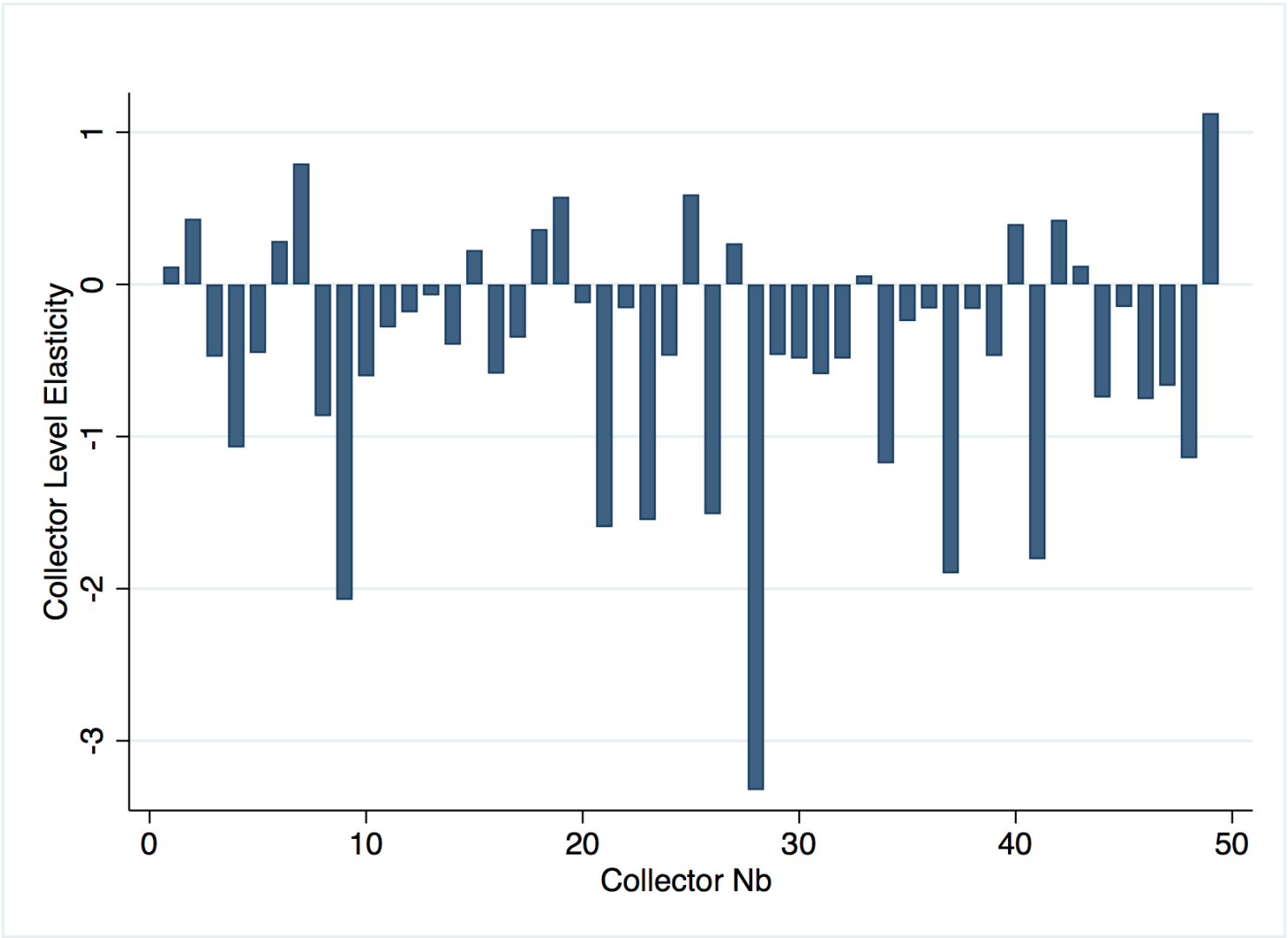
Shrunk Estimates



Back - Collector Elasticity

Tax Collector Elasticity

Shrunk Estimates



Back - Collector Elasticity