Discretion versus Algorithms: Bureaucrats and Tax Equity in Senegal

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Dakar by Jeff Attaway

Motivation

- ▶ A government's ability to gather accurate individual-level information is a crucial component of state capacity
  Lee and Zhang (2017)

- ▶ Success and fairness of many policies imply accurate registrations and evaluations Hanna and Olken (2018)

- ▶ Examples: anti-poverty programs, taxation and audits, enforcing regulations, etc.

- ▶ Building these policy registers is a challenge when administrative capacity is low
  Banerjee et al (2019): social registers more than 10 years old

- ▶ Two possible approaches:
  - ▶ **Discretionary** Reliance on bureaucrats to generate required information Basurto et al (2020), Khan et al (2016)
  - ▶ **Rule-based** Made easier with digitalization

Motivation

- ▶ Administration's objective: maximize coverage and accuracy

- ▶ **How does bureaucrats' discretion affect the policy's outcomes and its equity?**

- ▶ **Is a rule-based process preferable?**
  - ▶ More accurate and fair

- ▶ Discretionary bureaucrats may have local information, but could have different incentives or vary in performance

This project

- We leverage the roll-out of the first digital property tax census in Dakar

- Experimental variation of the extent to which bureaucrats have discretion to value properties

  - Option (1): **Fully discretionary**. Bureaucrats rely on their judgment and interactions with occupants. *Arm 1 in the field.*

  - Option (2): **Rule-based** with some **bureaucrat inputs**. They enter observable characteristics & prediction is automatically computed. *Arm 2 in the field.*

  - Option (3): **Pure rule**. Predictions with zero bureaucrat discretion. *Computed remotely.*

- **Benchmark**:
  - Market valuations by certified real estate assessors.

Preview of results

- ▶ Full discretion of bureaucrats:
  - ▶ Inaccurate: strongly below market values
  - ▶ Regressive ($\neq$ vertical equity)
  - ▶ Strong dispersion ($\neq$ horizontal equity)

- ▶ Rule-based process:
  - ▶ Improves tax equity
  - ▶ Share of bureaucrat-induced variation in accuracy reduced from 40% to 14%

- ▶ Overall: Discretion $\prec$ Rule-based $\prec$ Pure rule

- ▶ Mechanisms:
  - ▶ Screening by long higher education may help but $\preceq$ rule
  - ▶ Knowledge channel identified through lab-in-the-field
  - ▶ Suggestive evidence used to rule out collusion channel
  - ▶ Bureaucrats' biases and perceptions of fairness

Related Literature

- ▶ **Rules vs discretion in organizations** Aghion & Tirole (1997), Duflo et al (2018), Bandiera et al (2021), Pouliquen & Okunogbe (2022), Bachas et al (2022)

- ▶ **Data-driven policymaking & algorithms in government** Browne et al (2023), Greenstone et al (2022), Haseeb & Vyborny (2022), Avenancio-León & Howard (2022), Björkegren (2021)
    - ▶ First rule vs discretion experimental variation for tax base
    - ▶ Setting allows to compare algorithm with different degrees of discretion

- ▶ **State capacity: bureaucrats** Besley et al (2021), Khan et al (2016,2019), Bandieira et al (2009), Rogger & Somani (2023)

- ▶ **State capacity: property taxation** Weigel (2020), Balan et al (2020), Brockmeyer et al (2021), Okunogbe (2020), Dzansi et al (2022)
    - ▶ Setting allows to measure influence of individual bureaucrats
    - ▶ Scarce evidence on technology adoption at scale for urban public finance

Outline

Outline

Property taxation in Dakar

- **Tax base**: *Market rental value*. Value that is or could be obtained from the property rented at market prices

- **Tax rate**: $8.6\% \approx 1$ monthly rent
  - Abatement: reduction for owner-occupied properties

- The system is under-performing:
  - Registration Gap: $\approx$50,000 properties on tax roll – 15% of total.
  - Collection Gap: 6.3 bn FCFA (10 million USD) of revenues – 16% of emissions

- No data on real estate prices.
  - Pre-program: administration relies on declarations or bureaucrats' discretion
  - We hire licensed real estate assessors to have benchmark values
  - Too expensive to have them value all properties · $x10$ daily fee of bureaucrat

Properties in Dakar: Illustration

Bottom 10%. 100,000 FCFA (163 USD) per month.

Median. 520,000 FCFA (845 USD) per month.

Top 10%. 2.3 mn FCFA (3,740 USD) per month.

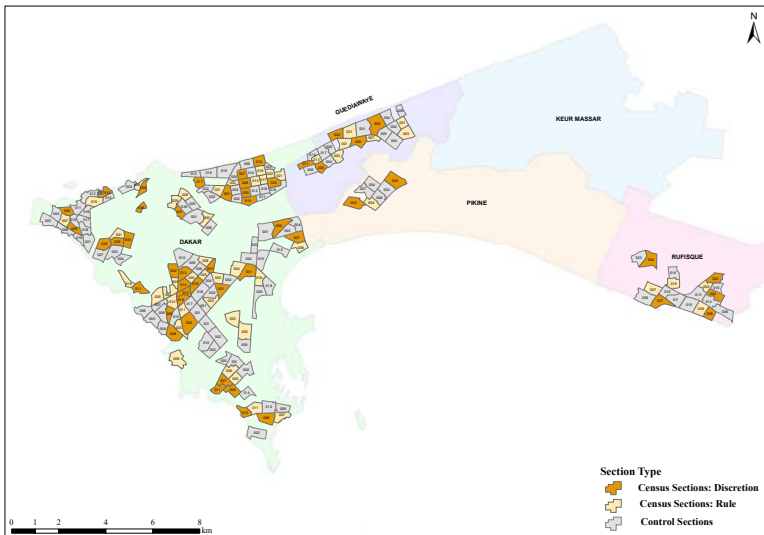# Outline

Program description

We worked with the administration and an IT firm to create a tailored digital tool

The application on tablets allows to conduct a geocoded property tax census

The data collected generates the new tax roll

Randomization at the section level in the Dakar region

Tax census: 96 sections. 41,600 plots.

Discretionary

► Try to speak to owner/tenants

► Ask about identification information and monthly rental values

► And/or use own judgment to estimate

Rule-based

► Enter property characteristics visible from the outside ≈ 4min

► Predicted value computed based on these & pre-loaded built area and location

► Try to speak to owner/tenants to recover identification information

Total duration: around 10-15min. No difference in advancement across arms.

Rule-based valuation

- ▶ In the spirit of Computer Assisted Mass Appraisal (CAMA) systems

- ▶ Policy constraints: external characteristics

- ▶ 18 characteristics + built area (satellite) + Section FE
  - ▶ Usage, Fence, Garage, Wall, Balcony, Floors...
  - ▶ Drop-down selection of type and quality

▸ Details

Repr. sample of 4,900 Market values by assessors
Elastic net regression with cross-validation
All covariates (rule) : $R^2 = 0.90$
Remote covariates (pure rule): $R^2 = 0.87$

Bureaucrats

▶ 267 bureaucrats hired, trained and managed by the administration

▶ Their deployment is orthogonal to treatment arms

▶ Quasi-random assignment to plots

▶ The average bureaucrat worked 32 days, covered 142 plots, worked in both arms.

▶ We verify that bureaucrat characteristics:
  ▶ are balanced across arms
  ▶ do not correlate with market values of properties

Outline

Conceptual framework

Objective: Accurate tax roll $+$ horizontal and vertical tax equity

- ▶ Discretion may be preferable if bureaucrats:
    - ▶ Have local knowledge
    - ▶ Recover private information (eg, rents paid by tenants)
    - ▶ Generate more equity and welfare than a systematic process
    - ▶ Outperform rule for some segments of the real estate market

- ▶ Rule may be preferable if bureaucrats:
    - ▶ Have objectives misaligned with administration
    - ▶ Try to collude with owners
    - ▶ Lack skills to value correctly
    - ▶ Are biased towards or against certain types of occupants
    - ▶ Are heterogeneous and hard to screen

Outline

Data

Property tax census data from the digital tool
- ▶ 21,902 plots in Discretion arm, 19,881 plots in Rule arm

Market values by licensed real estate assessors (▶ Details)
- ▶ 2,361 plots in Discretion + Rule arms

Bureaucrat survey w/ lab-in-the-field

Property owner baseline survey

Outline

Under Discretion: Regressivity and Dispersion

Assessment Ratio = Bureaucrat Value/Market Value
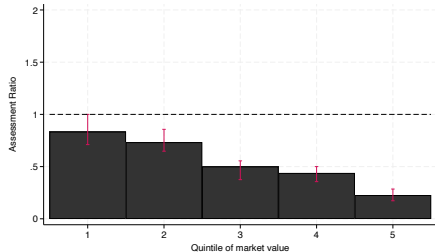
The AR is 0.83 in Q1 and 0.23 in Q5

Under Discretion: Regressivity and Dispersion

Removing Discretion Increases Accuracy and Tax Equity
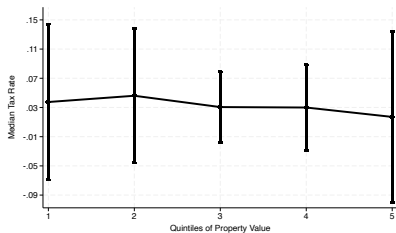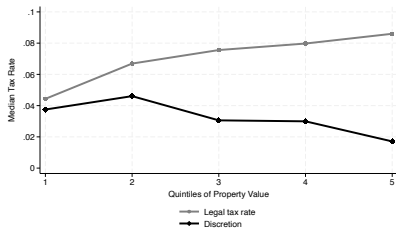
Discretion Increases the Tax Base Gap by 82%

$$Gap = Bureaucrat\ Value - Market\ Value$$

$$|Gap|_{ijk} = \alpha + \beta Discretion_{jk} + S_k + \epsilon_{ijk}$$

	|Gap|
Panel A: Discretion	
Mean (sd)	8.94 (16.88)
Panel B: Rule-based	
Mean (sd)	4.70 (12.05)
$\hat{\beta}_{Discretion}$	3.87***
	(1.38)
N plots: 2290	
N Sections: 94	
Mean (sd) property value: 77.00 (15.80)	
Median property value: 5.60	

Bureaucrat Fixed-Effects

$$|Gap|_{ijb} = \alpha_b + Val_j + \epsilon_{ijb}$$

α_b bureaucrat fixed-effect

Empirical Bayes shrinkage procedure

Chandra et al (2016), Kane & Steiger (2008), Bergeron et al (2022)

| | (1) | (2) |
	Discretion	Rule-based
N obs	1,055	1,063
N Bur FE	198	190
Mean of Outcome (mil. of FCFA)	8.02	3.84
Var of Outcome	217.57	101.72
Var($\alpha_{b,EB}$)	87.24	13.91
Share Variance	0.40	0.14

Outline

Mechanisms

- ▶ Skills and knowledge channel:
  - ▶ Longer higher education predicts being a top bureaucrat
  - ▶ Bureaucrats undervalue high-end property by 75% (from top to 3rd quintile) `▶ Lab-in-the-field results`
  - ▶ Bureaucrats' implicit formula `▶ Details`
  - ▶ No learning `▶ Details` `▶ Info. treatment`

- ▶ Ruling out Collusion channel
  - ▶ No difference in undervaluation gradient whether owner is met or not met `▶ Results`
  - ▶ Strong undervaluation in lab-in-the-field when no stakes

- ▶ Under the rule: large effects of small degree of discretion `▶ Details`

- ▶ Behavioral biases based on owner status and perceptions of fairness `▶ Lab-in-the-field arms`

- ▶ Heterogeneity depending on how the field visit goes `▶ Details`

Outline

Optimal Policy

- Trade-off for low value properties (bottom two quintiles)
    - Discretion reduces the risk of over-valuation (more vertical equity)
    - .. but increases dispersion (less horizontal equity)

- Other than that: Removing discretion always better in this context

- Also more cost-effective ▸ Details

- No costs in terms of job satisfaction

Outline

Conclusion

- ▶ Bureaucrats strongly shape the tax roll and determine tax equity

- ▶ Status quo discretionary process is extremely regressive
    - ▶ Passive waste Bandiera et al (2009), knowledge Rogger & Somani (2023)

- ▶ Using an algorithm increases accuracy, tax liabilities, vertical and horizontal equity

- ▶ Exception: may want keep some discretion for lowest values if prioritizes vertical equity over horizontal equity

- ▶ Policy take-up: working on scale-up with the administration

- ▶ Next step: tax payments & owner survey asking about perceptions of the tax system and government

Thank you!

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Calibration of Rule

Elastic net regression with x5 cross-validation. Performance assessed on test sample.

	All covariates	**Remote covariates (pure rule)**
	18 vars + Section FE + built area	Section FE + built area
R^2	0.90	0.87
MAPE	33.8%	41%
Share within 30%	60%	54%

▶ McCluskey et al (2013), Davis et al (2012), Franzsen & McCluskey (2017), Ali et al (2018), IAAO (2022) **Satisfactory wrt similar contexts**[1]

▶ Robustness:
  ▶ random forest (R2 0.83; MAPE 43%)
  ▶ model calibrated on baseline survey values (R2 0.44; MAPE 33%)

[1]R2 56% in Rwanda (Ali et al); R2 85% in Ethiopia (Franklin); 50% predictions within 25% of value in Uganda (Manwaring & Regan)

Assessment Ratio by Quintile
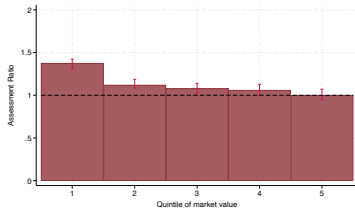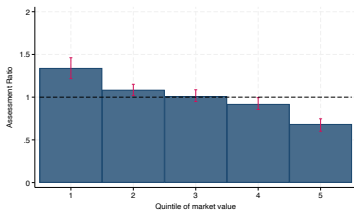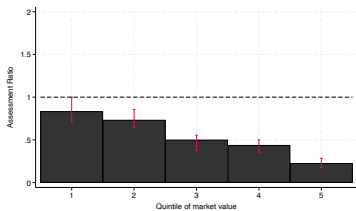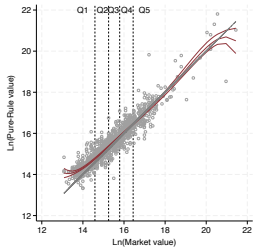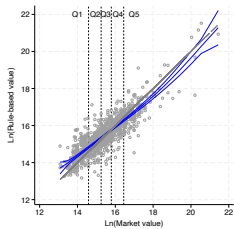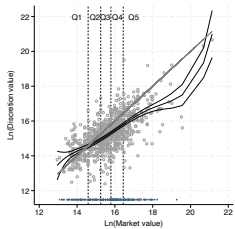
Effective tax rates
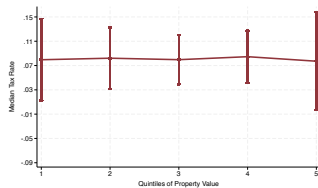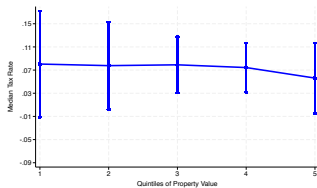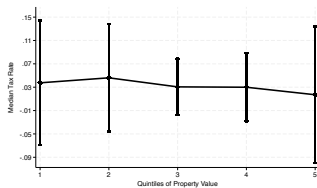
Removing discretion improves rank preservation
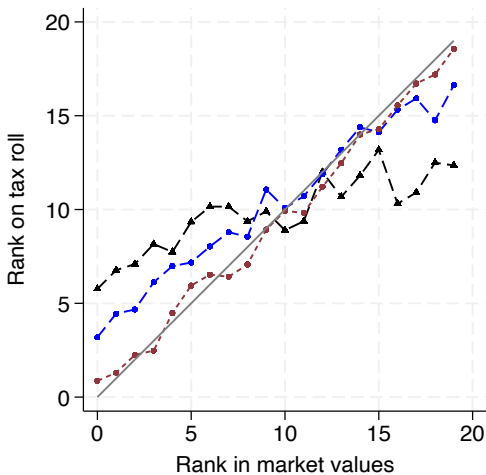
– ◆ – Discretion. Slope:	0.28.
– ◆ – Rule-based. Slope:	0.69.
·–◆–· Pure Rule. Slope:	0.94.

Tax liabilities

	Total	Share bottom 10%	Share top 10%
Discretion	8 bn	1.1%	49.6 %
Rule	12 bn	0.95 %	62.9 %
Pure Rule	15 bn	0.64 %	69.4 %

Assessment Ratio and its Dispersion

Dispersion: average percentage variation of the ass. ratio around its median

	Median Ass. Ratio	Dispersion
Discretion	0.50	115%
Rule	1.02	53%
Pure Rule	1.13	31%

Bureaucrat Fixed-Effects

Density plotted against Bureaucrat Fixed Effect, with legend:
Discretion: Raw FE — Discretion: EB adj. FE — Rule: Raw FE — Rule: EB adj. FE
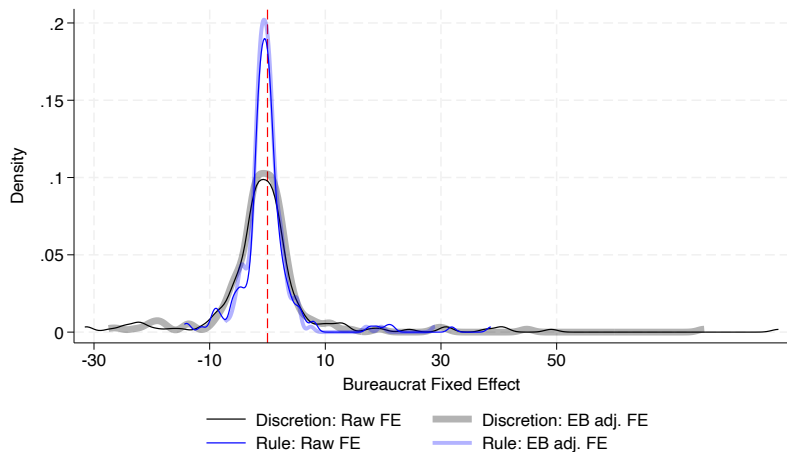
What to Top Bureaucrats do differently?

Depedent Variable (0,1)	Positive value (1)	Owner Met (2)	Owner Details (3)	Contract (4)	Comment (5)	Conflict (6)	Bureaucrat estimate (7)
Top bureaucrat	0.129***	0.045**	0.056***	0.004	0.108***	-0.006	0.058**
	(0.026)	(0.018)	(0.016)	(0.005)	(0.038)	(0.011)	(0.025)
Strata FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	22314	22314	22314	20086	22314	10932	10932
R2	0.13	0.03	0.09	0.02	0.29	0.02	0.18
Adj. R2	0.13	0.03	0.09	0.01	0.29	0.02	0.18
Mean of dependent	0.58	0.23	0.31	0.03	0.49	0.09	0.18

Correlates of Top Bureaucrat
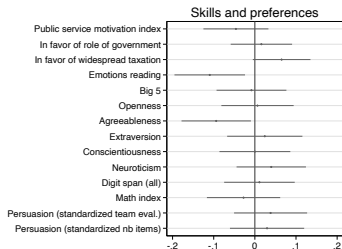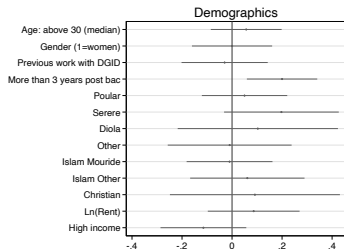
+3 yrs higher education is associated with 35% higher proba. of being a top bureaucrat

top bureaucrats are more likely to be in favor of widespread taxation

lower emotions reading and agreeableness scores ▶ Back

Removing worst bureaucrats: at best as good as the rule
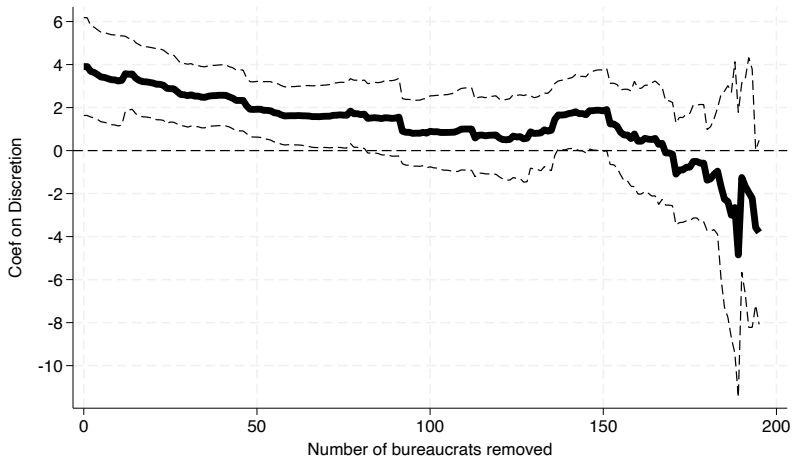
Correlation between discretion and rule FE

Coefficient: -.05

Survey: Information treatment

All the properties of the Dakar region

20% of properties — Group 1 — Lowest rental values

20% of properties — Group 2 — 2nd lowest rental values

20% of properties — Group 3 — Intermediate rental values

20% of properties — Group 4 — 2nd highest rental values

20% of properties — Group 5 — Highest rental values

The 20% **cheapest properties** are worth on average **120,000 F** per month

The 20% **most expensive properties** are worth on average **2.5 million F** per month

Average: **120,000 F** monthly	Average: **300,000 F** monthly	Average: **550,000 F** monthly	Average: **950,000 F** monthly	Average: **2.5 million F** monthly
[30,000 F to 200,000 F]	[200,000 F to 400,000 F]	[400,000 F to 720,000 F]	[720,000 F to 1.4 million F]	[1.4 million F to 200 million F]

▸ Back

Survey: Experimental valuations

Consider you are covering this property (located in Commune ... Quartier ...) during the census. There is no occupant to talk to, a neighbor tells you the owner is M. Ba, a retired [employed] man. What is your best estimate of the monthly rental value you would write down on your tablet?

Photo	Expensive	Cheap
Owner Employed		
Owner Retired		

Survey: Experimental questions

Depedent Variable	Ass. Ratio (1)	Ass. Ratio (2)	Ln(Value) (3)	Ln(Value) (4)
High value property	-1.419*** (0.112)	-1.491*** (0.109)		1.232*** (0.091)
Info treatment		-0.085 (0.150)		
Info X High value		0.127 (0.150)		
Retired owner			-0.378*** (0.091)	-0.241*** (0.091)
Retired X High value				0.090 (0.133)
Strata FE	No	Yes	Yes	Yes
Bureaucrat FE	Yes	No	No	No
N	280	280	280	280
R2	0.83	0.62	0.07	0.57
Adj R2	0.60	0.61	0.01	0.54
Mean in reference	1.74	1.78	12.84	12.08

Bureaucrats' implicit formula

- ▶ Using the same methodology as for our main algorithm

- ▶ $R^2 = 0.25$. Coef = 0 for 15/34 characteristics and 18/48 section FEs

- ▶ against 3/34 and 22/193 in main model

- ▶ Coefficient on $ln()$ built area is 0.43 against 0.57

- ▶ $\rightarrow$ bureaucrat values are poorly explained by objective property characteristics

Learning over time

Dependent Variable	Discretion			Rule		
	|Gap|	|Gap|	Value	|Gap|	|Gap|	Value
	(1)	(2)	(3)	(4)	(5)	(6)
Numb. properties	0.050*			-0.026*		
	(0.026)			(0.014)		
(Numb. properties)^2	-0.000			0.000**		
	(0.000)			(0.000)		
Numb. days		0.342**	0.011		-0.208**	-0.028
		(0.152)	(0.021)		(0.085)	(0.029)
(Numb. days)^2		-0.004	-0.001***		0.001**	0.000
		(0.003)	(0.000)		(0.001)	(0.000)
Section control for Market Value	Yes	Yes	Yes	Yes	Yes	Yes
Bureaucrat FE	Yes	Yes	Yes	Yes	Yes	Yes
N	1055	1055	20086	1063	1063	17458
Mean	8.02	8.02	3.98	3.84	3.84	5.88
R2	0.51	0.51	0.15	0.44	0.44	0.33
Adj R2	0.39	0.39	0.14	0.30	0.31	0.33

Undervaluation gradient doesn't change when owner is met

$$AR_{ij} = \alpha + \sum_{n=1}^{5} \beta_n Q(n)_{ij} + \sum_{n=1}^{5} \gamma_n M_{ij} \cdot Q(n)_{ij} + \epsilon_{ij}$$
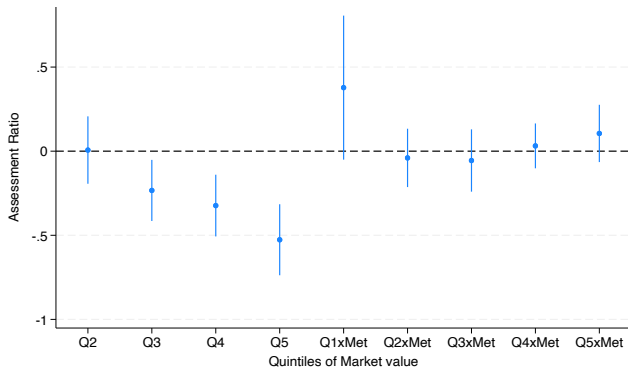
Effects of small degree of discretion

Rule implemented by bureaucrats increases tax base gap by ..

- ▶ 59% compared to pure rule
- ▶ 63% compared to rule with calibration inputs

Heterogeneity depending on how field visit goes

	No Bureaucrat FE			with Bureaucrat FE		
	(1)	(2)	(3)	(4)	(5)	(6)
	Value	|Gap|	Ass. Ratio	Value	|Gap|	Ass. Ratio
Panel A: Bureaucrats' estimate						
$\hat{\beta}_{Discretion}$	-2.50^{*}	2.56	-0.33^{***}	-1.81	4.15^{***}	-0.32^{***}
Mean (sd) in Rule	7.97 (8.58)	3.84 (10.09)	1.24 (0.82)	7.97 (8.58)	3.84 (10.09)	1.24 (0.82)
N	1,195	1,195	1,195	1,195	1,195	1,195
Panel B: Owner Met						
$\hat{\beta}_{Discretion}$	-3.22^{***}	1.85	-0.55^{***}	-4.18^{***}	1.11	-0.51^{***}
Mean (sd) in Rule	7.67 (7.61)	4.15 (13.21)	1.25 (0.83)	7.67 (7.61)	4.15 (13.21)	1.25 (0.83)
N	597	597	597	597	597	597
Panel C: Rented						
$\hat{\beta}_{Discretion}$	-1.72^{*}	3.38^{**}	-0.24^{***}	-2.25^{*}	4.78^{**}	-0.28^{**}
Mean (sd) in Rule	9.53 (9.17)	4.36 (10.31)	1.26 (0.93)	9.53 (9.17)	4.36 (10.31)	1.26 (0.93)
N	977	977	977	977	977	977
Panel D: Conflict						
$\hat{\beta}_{Discretion}$	-3.39	-0.23	-0.58^{***}	-6.19	-3.29	-0.72^{***}
Mean (sd) in Rule	8.64 (8.67)	5.75 (15.80)	1.04 (0.59)	8.64 (8.67)	5.75 (15.80)	1.04 (0.59)
N	112	112	112	112	112	112

Cost-benefit analysis

- ▶ Field costs (bureaucrats, supervisors)
- ▶ Rule-Specific costs (assessors, GIS experts)

	Costs	Tax liabilities	Ratio
Discretion	118.1 mn	15.7 bn	x129
Rule	134.7 mn	25 bn	x188
Pure Rule	16.6 mn	61 bn	x3674
Assessors	503.3 mn	43 bn	x85

	(1) Gap *mil.FCFA*	(2) Gap (median) *mil.FCFA*	(3) |Gap| *mil.FCFA*	(4) Ass. Ratio
Panel A: Discretion				
Mean[1] (sd)	−7.12 (17.72)	−2.41	8.94 (16.88)	0.71
Panel B: Rule-based				
Overall				
Mean[1] (sd)	−1.87 (12.80)	0.05	4.70 (12.05)	1.13
$\hat{\beta}_{Discretion}$	−5.07***	−2.12***	3.87***	−0.42***
	(1.27)	(0.42)	(1.38)	(0.05)
Low Value				
Mean[1] (sd)	0.63 (2.20)	0.34	1.36 (1.84)	1.36
$\hat{\beta}_{Discretion}$	−0.71***	−0.73***	0.22	−0.33***
	(0.20)	(0.12)	(0.16)	(0.10)
High Value				
Mean[1] (sd)	−4.12 (17.21)	−1.08	7.70 (15.93)	0.93
$\hat{\beta}_{Discretion}$	−7.19***	−4.91***	5.57***	−0.40***
	(1.76)	(0.68)	(1.88)	(0.05)
Panel C: Pure Rule				
Overall				
Mean[1] (sd)	0.50 (7.36)	0.43	2.96 (6.76)	1.24
$\hat{\beta}_{Discretion}$	−6.21***	−2.76***	4.56***	−0.49***
	(0.91)	(0.46)	(0.91)	(0.04)
Low Value				
Mean[1] (sd)	0.65 (1.23)	0.43	0.87 (1.09)	1.35
$\hat{\beta}_{Discretion}$	−0.53***	−0.75***	0.75***	−0.25***
	(0.20)	(0.14)	(0.14)	(0.09)
High Value				
Mean[1] (sd)	0.37 (10.08)	0.44	4.83 (8.85)	1.13
$\hat{\beta}_{Discretion}$	−9.51***	−6.43***	6.73***	−0.57***
	(1.28)	(0.55)	(1.24)	(0.05)

N plots: 2290
N Sections: 94
Mean (sd) market value: 77.00 (15.80)
Median market value: 5.60

	(1) Gap *mil.FCFA*	(2) Gap (median) *mil.FCFA*	(3) |Gap| *mil.FCFA*	(4) Ass. Ratio
Panel A: Rule-based (with bur. FEs)				
Mean[1] (sd)	−0.74 (10.77)	0.24	3.84 (10.09)	1.24
$\hat{\beta}_{Discretion}$	−6.08***		4.48***	−0.46***
	(1.30)		(1.24)	(0.06)
Mean[1] (sd) Discretion	−6.09 (15.65)	−2.40	8.02 (14.75)	0.76
N plots: 2118				
N Bureaucrats: 234				
Panel C: Rule-based (calibrated on owner survey)				
Mean[1] (sd)	−5.87 (18.02)	−1.13	6.65 (17.74)	0.91
$\hat{\beta}_{Discretion}$	−1.16	−1.30***	1.81	−0.20***
	(1.93)	(0.35)	(1.92)	(0.05)
Mean[1] (sd) Discretion	−7.51 (19.00)	−2.41	8.99 (18.35)	0.71
N plots: 2290				

	(1) Gap *mil.FCFA*	(2) Gap (median) *mil.FCFA*	(3) |Gap| *mil.FCFA*	(4) Ass. Ratio
Panel A: Discretion				
Mean[1] (sd)	−4.43 (15.43)	−1.32	6.91 (14.49)	0.97
Panel B: Rule-based				
Mean[1] (sd)	−0.74 (10.77)	0.24	3.84 (10.09)	1.24
$\hat{\beta}_{Discretion}$	−3.48***	−1.38***	2.64**	−0.29***
	(1.08)	(0.27)	(1.12)	(0.05)
Panel C: Pure Rule				
Mean[1] (sd)	0.70 (6.65)	0.44	2.77 (6.09)	1.24
$\hat{\beta}_{Discretion}$	−4.59***	−1.82***	3.55***	−0.29***
	(0.90)	(0.37)	(0.87)	(0.05)
Panel D: Lee bounds				
Lower bound	−6.25		2.05	−0.46
Upper bound	−1.83		5.69	0.04
CI for $\hat{\beta}_{Discretion}$	[−7.17;−0.72]		[0.99;6.53]	[−0.55;0.11]
N plots:	1885			
N Sections:	94			
Mean (sd) market value: 73.90 (14.40)				
Median market value:	5.40			

Panel A: Details on assessors' field work

N sections	193
- per assessor	24.1
Info. from Office (%)	97.4
Info. from Agencies (%)	55.4
Info. from Occupants (%)	67.4

Panel B: Correlation with other sources of rental values

Owner survey	0.39 (N=1,310)
Owner survey (rented)	0.49 (N=394)
Owner survey (fully rented)	0.62 (N=52)
Census (fully rented, met tenant)	0.50 (N=212)
Census (fully rented, met tenant, contract)	0.59 (N=48)
Census (full contract)	0.72 (N=63)
Census (full contract, met tenant)	0.83 (N=19)