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

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Abstract

How should tax rates be set in developing countries? This project estimates the elasticity of property tax compliance and tax revenue in a field experiment in Kananga, D.R. Congo, a setting with very low tax compliance. In collaboration with the provincial government, we randomly assign four tax rates at the household level as part of a door-to-door city-wide property tax campaign covering 48,000 properties. Property owners randomly face the status quo tax liability or a reduction of 17%, 33% or 50% in their tax liability. We find that the elasticity of tax compliance with respect to the tax rate is -1.19 and the elasticity of tax revenue with respect to the tax rate is -0.26, suggesting that tax rates are on the wrong side of the Laffer curve and that the government could increase revenues by lowering tax rates. We also find that beyond higher revenues, lowering tax rates results in lower amounts of bribes being collected and improves citizens' view of the government. Finally, we document further policy implications resulting from the substantial heterogeneity in the elasticity of tax revenue with respect to the tax rate. First, we use heterogeneous treatment effects to show that a progressive tax schedule would maximize revenue. Second, we use tax collector heterogeneity to show that an increase in government's enforcement capacity would permit higher tax rates. [1]

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[1]Note to the conference conveners: This draft was written as a submission to the 2019 NEUDC conference *before endline survey enumeration is completed*. Current results reflect outcomes from administrative data, midline survey and initial endline survey data. The endline survey will be complete by September 2019. If selected, a completed draft will be available before the 2019 NEUDC conference. This study has been approved by the Harvard Institutional Review Board (Protocol IRB17-0724) and is funded by the J-PAL Governance Initiative as well as the EGAP Metaketa II Taxation Initiative. A Pre-Analysis Plan was submitted to the American Economic Association's registry for randomized controlled trials (AEA RCT Registry) on January 28th 2019.

1 Introduction

A rudimentary level of state capacity is thought to be a precondition for economic development (**??**). Tax capacity, in particular, enables states to provide public goods and is associated with more accountable, responsive governance (**???**). But the transition to becoming a "tax state" is perhaps the greatest challenge of state building (**?**). Many developing countries have narrow tax bases that may be particularly distortionary (**?**). Broadening the tax base is a priority in such settings, and a key input is the rates taxpayers face. The public finance literature has a long history of estimating responses to tax rate variation, chiefly focusing on labor supply responses (**????**) and taxable income elasticities (see **?** for a review). However, in many developing countries, tax evasion or the refusal to pay taxes are the relevant margins given low rates of compliance. Capacity-constrained governments in information-poor environments may set tax rates suboptimally, and perhaps lie on the right of the Laffer rate if evading taxpayers would be willing to comply at lower rates (**?**). Understanding how tax rates affect the extensive margin of the tax base can help governments select the rates that will maximize revenues in settings where public funds are direly needed. This paper seeks to answer the question: what is the elasticity of tax compliance with the respect to the rate in a low-capacity, low-compliance context?

We examine how lowering tax rates affects tax compliance and government revenues in Kananga, DRC. Although there are many taxes in the books, formal tax compliance is very low – fewer than 5% of citizens reported paying any formal taxes – and the tax base is mainly composed of a small set of firms downtown. As a consequence, in a province of over 6 million inhabitant, total provincial tax receipts were less than $2 million in 2015. Even when tax collectors went door to door collecting the property tax in 2016, only a small fraction of citizens ended up paying (**?**). Could lowering the property tax rates promote compliance and increase revenues? In partnership with the Provincial Government of Kasai Central, we introduced random variations in the property tax rates faced by the 46,000 property owners in the city of Kananga. Specifically, property owners were randomly assigned to 100%, 88%, 66% or 50% of the full annual tax rate. These treatments apply to two categories of properties – "*periphery*" houses, which typically face an annual liability of 3,000 CF ($2 USD) and represent about 90% of the properties in Kananga, and "*midrange*" houses, which face an annual liability of 13,200 CF ($9 USD) and represent the remaining 10% of properties. The randomization is embedded in the official tax letters handed out by tax collectors and occurs at the property level, stratified at the neighborhood level.

We find that lowering the property tax rate increases property tax compliance considerably. Only 6.56% of households paid when assigned to the full annual tax rate, compared to 12.69% of households in the 50% tax rate treatment. This random variation in tax rates allow us to estimate the elasticity of tax compliance with respect to the tax rate. To calculate this elasticity, we compare changes in compliance to changes in tax rates as a percentage of the full annual tax rate. We estimate an elasticity of -0.49: a 1% increase in the tax rate relative to the full rate is associated with a 0.49% decrease in tax compliance.

We rule out alternative explanations for the observed increases in compliance. First, we show that

the results are not biased by different levels of effort exerted by tax collectors. Importantly, households assigned to lower tax rates do not receive more visits from tax collectors. As an additional test, we randomize tax collectors' compensation at the property level. Half of the "*periphery*" properties are assigned a fixed compensation and the other half a proportional compensation. Our main results are unchanged when holding tax collectors' compensation fixed, suggesting that tax collectors' effort levels are unlikely to drive our results. Second, we show that the results are not biased by property owners' knowledge of their neighbor's tax rate, which could affect compliance if citizens exhibit fairness considerations (**?**). To rule out this interpretation, we show that the elasticity of tax compliance is unchanged when directly controlling for neighbor's tax rates as well as when estimated separately for the subsamples of citizens who report knowing and not knowing their neighbors' rate. Third, we show that the results are not biased by awareness of tax cuts among property owners, which could affect compliance by increasing transaction utility (i.e. the sense of getting a 'good deal') (**?**). To rule this out, we use survey questions and show that only a few property owners report knowing that they received a tax reduction.

We also examine key behavioral responses noted in the literature on taxation in developing countries. First, bribery is a first-order problem, due to principal-agent problems associated with door-to-door tax assessment and collection (**?**). We find that changes in tax rates affect bribe payments on the extensive and on the intensive margin. 1.89% of property owners paid bribes when assigned to the full annual tax rate, compared to 1.11% in the 50% tax rate treatment. Similarly, the average bribe paid decreases monotonically from 2000 CF ($1.25 USD) in the full annual tax rate treatment to 900 CF ($0.5 USD) in the 50% tax rate treatment. The corresponding elasticity of bribes with respect to the full annual tax rate are high at 0.64 on the extensive margin and 1.21 on the intensive margin.

A second key behavioral response is citizens' contributions to 'informal taxes,' which have a high burden in many developing countries (**?**), including the DRC (**?**). Contribution to informal taxation may be impacted by the size of formal tax liability if formal and informal taxes are substitutes or complements. To examine this issue, we estimate the effects of changes in tax rates on informal tax contributions. We do not find evidence that reduction in the property tax rates affect contributions to informal taxation, neither on the extensive nor on the intensive margin. This suggests that formal and informal taxation are neither substitutes nor complements in this setting.

Changes in the size of liability may also affect how citizens view and trust the state. Using our ongoing endline data we find preliminary evidence that lowering the property tax rate has mixed effects on trust in the provincial government. On the one hand assignment to a lower tax rates results in beliefs that more of the money will be spent on public goods. On the other hand it is also associated with respondents reporting that a higher fraction of the tax revenues will be stolen by the provincial government. While these two simultaneous results are puzzling, both could possibly be generated by the increase in compliance that results from lower tax rates. We do not find any effects of assignment to lower tax rates when using trust in the provincial tax ministry as the outcome. Finally, reducing tax

rates has a positive effect on the perceived fairness of the tax rate but no effect of perceived fairness of tax collection or tax collectors. These mixed results contribute to the nascent literature that studies the relationship between taxation and governance (**??**).

Taken together, our results suggest that tax rates in this low capacity setting might be on the wrong side of the Laffer curve. By decreasing tax rates, the provincial government could increase its revenue and decrease the amount of bribes paid to tax collectors. The effects of lower property tax rates on trust in the state might attenuate this conclusion but they are still preliminary and should be taken with a grain of salt. Our findings are therefore similar in spirit to **?**, who estimates the elasticity of reporting goods to the customs authority in Mozambique and finds that reducing tariffs increases the reported quantities and reduces corruption.

We then turn to investigating why citizens respond so strongly to reductions in their tax rate. The increase in tax compliance in response to decreases in tax rate could be consistent with several hypotheses. We first investigate the role of liquidity constraints, showing that the elasticity decreases monotonically with the amount of time tax collectors spend collecting taxes in each neighborhood. The elasticity is -0.56 on the first day of tax collection and decreases to -0.49 by the end of the tax collection period. This decreasing pattern is likely to be due to cash constraints. To understand the extent to which the liquidity constraints mechanism can explain our results, in comparison to other factors operating at the level of property owner, we next turn to studying the characteristics of property owners that result in higher treatment effects. To do this we follow **?** and use machine learning to guide the analysis of heterogeneous treatment effects. Our results are very preliminary but they suggest that there is a lot of heterogeneity in responses to lower tax rates. Moreover, we find that lowering the property tax rates has a stronger effect on the poorest and most cash constrained property owners as well as on the least socially and politically connected property owners. These preliminary results suggest that cash constraints might explain part of the strong effect of changes in tax rates on compliance and bribe payments, a result that is consistent with the elasticity of tax compliance decreasing with time spent collection taxes as previously mentioned. In future work, we will use our baseline and endline surveys to study other characteristics that might explain our treatment effects including more precise measures of cash constraints but also measures of tax morale and trust in the provincial government and tax ministry.

Overall, our findings shed light on the determinants of tax compliance and the design of revenue-optimal rates in settings where state capacity and formal tax payments are very low. Moreover, while most papers on the public finance of developing countries focus on middle-income countries, such as Brazil, Chile, and Pakistan, this paper presents evidence on the determinants of tax compliance from one of the poorest countries in the world.

The rest of this paper reviews the setting (Section 2), the experimental design (Section 3) and data, estimation, and balance (Section 4), before turning to the main results (Section 5), the secondary results (Section 6), the effects on government revenues (Section 7) and heterogeneous treatment effects and

mechanisms (Section 8).

2 Setting

The DRC is the fourth most populous country in Africa, and one of the five poorest in the world[2]. Median monthly income in the study site is roughly $60, PPP $95 (**?**). The country is often termed a 'kleptocracy' due to the corrupt rule of long-time president Joseph Kabila or a 'failed state', due to its history of civil conflict (**?**). It has low state capacity across all dimensions, and especially in terms of tax capacity (**?**). In tax revenue as a percent of GDP, the DRC ranks 186 out of 200 countries for the period 2000 to 2018[3].

Kananga, our study site, is a city of roughly 1 million inhabitants and is the seat of the Provincial Government of Kasa-Central. With nearly 6 million people in the province, the total provincial tax receipts are around $2 million per year, less than $0.30 per person per year. Although there are many taxes on the books, few are enforced among private citizens in Kananga. The great majority of government revenues come from mineral rents and national transfers.

In this low tax capacity context, property taxes are thought to be efficient and progressive (**?**). Because valuations can be difficult for low-capacity governments, many developing countries have simplified property valuations to size-based assessments of fixed amounts levied on properties under a certain threshold (**?**)[4]. The Provincial Government of Kasai has followed suit. Out of the total 46,000 properties in Kananga, roughly 41,000 properties are considered "*periphery*" properties and must pay a fixed annual property tax or 3,000 Congolese Francs (CF), about USD $2, which is the median household's total daily income. There are also 5,000 larger "*midrange*" properties built of modern materials (i.e. not mudbricks). These properties face a fixed annual tax rate of 13,200 CF (about USD $9). Finally, there are less than 300 'villas' in Kananga, Belgian-built compounds with a terrace or a garage. To be taxed, these 'villas' must be measured and their owner face a rate increasing in the size of the property. Because the systematic collection of the property tax only ever happened once and only took place in some parts of the city, overall knowledge of the property tax is still very low (**?**). When surveyed in late 2017, 18% of property owners knew of the property tax and only 2.6% of property owners in the sample knew of the property tax liability corresponding to their property type.

[2] data available at http://wdi.worldbank.org/table/1.2

[3] data available at https://data.worldbank.org/indicator/gc.tax.totl.gd.zs

[4] Several major Indian cities (e.g. New Delhi, Bangalore, Kolkata) adopted flat rates by unit-area category in 2008. In Tanzania, all properties that are not included on the valuation roll are liable for flat rates. In Sierra Leone, Liberia, and Malawi, the overall tax simplification agenda implies piloting flat rates for properties not on the valuation roll.

3 Design

3.1 Tax Collection

The randomization of property tax rate occurred as part of a larger tax collection effort described in details in **?**. The taxation campaign consists of three stages described below and summarized in Table 1: Training, Census and Taxation.

Training - Before the start of the campaign, tax collectors are trained by the tax ministry and by members of the research team. Training sessions, conducted at the tax ministry, introduce future collectors to the taxation campaign protocol and teach all aspects of the property tax system in Kananga (rates, exemption criteria, house types, etc.). Collectors also learn how to use the handheld receipt printers.

Census - The first stage of the campaign is the census which is implemented in each neighborhood on the first day of the tax month. During the census stage teams of two tax collectors visit every house in each neighborhood, accompanied by enumerators (who work for the research team rather than the government) trained to use tablets with GPS capabilities. The census visit serves four purposes. First, property owners are informed about the property tax campaign. Second, properties are assigned a unique code, which enables collectors to return to the neighborhood alone knowing its boundaries based on the codes. These codes effectively produces a cadastral map of the city. Third, property owners are given a tax bill in French (the official administrative language in the DRC) and Tshiluba (the most widely spoken local language). Among other informations about the property tax, this tax bill contains the assigned tax rate (see Figure 1 for an example of tax bill). Finally, enumerators fill out a short survey recording details about the transaction that we will use in the analysis.

Taxation - Upon completion of the census, the second stage of the campaign begins, which is the tax collection stage. Tax collection lasts for the rest of each tax month. During taxation, enumerators no longer accompany tax collectors.

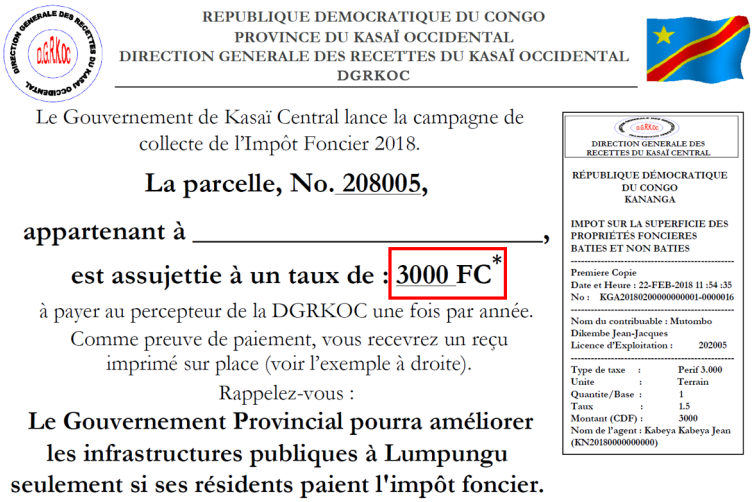
Table 1: Campaign stages

Stage	**Period**	**Collectors**	**Enumerators**
Stage 0 : Training	Before the campaign	Yes	No
Stage 1 : Census	First days of each month	Yes	Yes
Stage 2 : Tax collection	Rest of the month	Yes	No

Property owners can pay either during the census stage or during the tax collection stage. Collectors are equipped with handheld receipt printers to issue receipts for the taxpayers. Two receipts are automatically printed in the field, one for the taxpayer and one for the collector. Collectors bring the money to the provincial tax ministry, account for the money they deposit, and need to justify any discrepancy

between the total sum on their report based on the receipts and and the money they have with them.

Figure 1: Sample Tax Bill — 3,000 CF Rate


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

Le Gouvernement de Kasaï Central lance la campagne de collecte de l'Impôt Foncier 2018.

La parcelle, No. 208005,

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 à droite).
Rappelez-vous :
Le Gouvernement Provincial pourra améliorer les infrastructures publiques à Lumpungu seulement si ses résidents paient 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)

3.2 Randomly Assigned Tax Rates

The treatment is the tax rates assigned to each property during the census visits. The unit of randomization is the property, each of which was identified during the door to door census. There are 46,000 properties in total in Kananga which for tax purposes are divided in two groups: 41,000 "*periphery*" properties and 5,000 "*midrange*" properties (see Figure 2 for an example of "*periphery*" and "*midrange*" properties). During the door to door census, tax collectors randomly assigned tax rates to all the periphery and midrange properties in Kananga among the following four treatments[5].

T1 - Full Liability: Properties are assigned to the full annual tax liability: 3,000 CF for "*periphery*" properties and 13,200 CF for "*midrange*" properties[6].

T2 - 83% of the full Liability: Properties are assigned to 83% of the full annual tax liability: 2,500 CF for "*periphery*" properties and 11,000 CF for "*midrange*" properties.

T3 - 66% of the full Liability: Properties are assigned to 66% of the full annual tax liability: 2,000 CF for "*periphery*" properties and 8,800 CF for "*midrange*" properties.

T4 - 50% of the full Liability: Properties are assigned to 50% of the full annual tax liability: 1,500 CF

[5]For villas, the rate does not vary, as these comprise a small share of overall properties, and the determination of villa rates depends on many inputs that entail visits by experienced tax collectors. Tax collectors involved in the campaign will distribute special tax bills to villa properties and pass the location of villas to the tax authority for special visits. Villas will be excluded from our analysis.

[6]The nominal rate in (**?**) was 2,000 CF, which is approximately equivalent to 3,000 CF in real terms at the time of this study in 2018.

for "*periphery*" properties and 6,600 CF for "*midrange*" properties.

Figure 1 shows a sample tax bill for a "*periphery*" property randomly assigned to the full liability (treatment group **T1** with a tax liability of 3,000 CF) and Figure 2 shows an example of "*periphery*" and "*midrange*" properties. Table 2 summarizes the randomized tax rates for each property category and Table 3 describes the number of properties by property type. It is worth highlighting that citizens in the treatment groups **T2**-**T4** are not informed that they receive a reduction on their tax liability. They are simply told the rate on their tax bill without mention of the full liability as can be seen from Figure 1. This randomization is therefore only possible because overall knowledge of the property tax is very low given that the systematic collection of the property tax only ever happened once and only took place in some parts of the city (**?**). During the previous property tax campaign the full fixed annual liability of 3,000 CF for "*periphery*" properties and 13,200 CF for "*midrange*' properties was used. As mentioned above knowledge of the property tax is low and only 2.6% of individuals in the baseline sample knew of the property tax rate corresponding to their property type.

Table 2: Tax Rate Treatment Groups

	Rates by Property Type (CF)	
% Full Rate	**Periphery**	**Midrange**
100%	3,000 CF	13,200 CF
88%	2,500 CF	11,000 CF
66%	2,000 CF	8,800 CF
50%	1,500 CF	6,600 CF

Figure 2: Example of "*periphery*" and "*midrange*" Properties

(a) Example of "*periphery*" Property

(b) Example of "*midrange*" Property

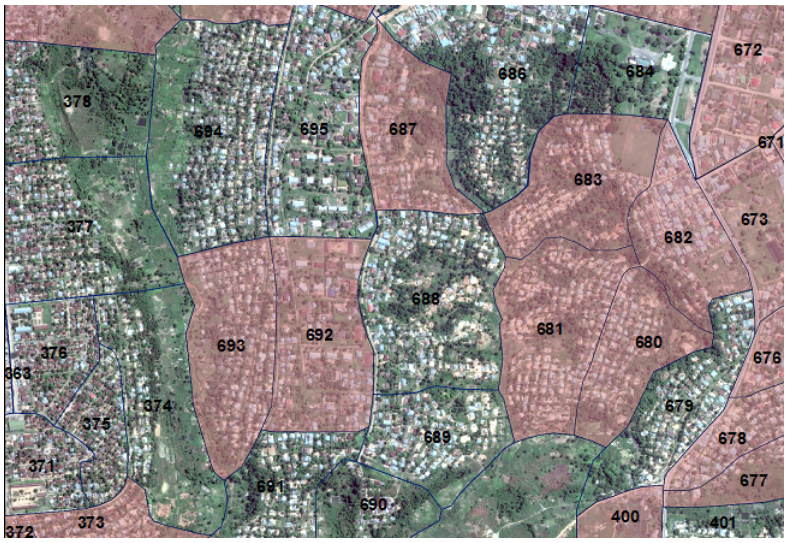
We employ a block-randomized design, stratifying on neighborhood, or polygon, each of which was identified on a satellite map with boundaries like roads, ravines, or other natural features that would be easily identifiable from the ground (see Figure 3). There are 363 neighborhoods in total in Kananga. We exclude the 5 pure control neighborhoods. In these neighborhoods, citizens were expected to pay the tax themselves at the tax ministry (as was the status quo before 2016), but very few actually did so [7]. We include the 7 neighborhoods that were part of a logistics pilot conducted prior to the experiment because the tax rate randomization and the tax bills that were distributed were the same during the pilot and the experiment [8]. For more details on the pure control and pilot neighborhoods see **?**. This leaves

[7] On average, door-to-door collection raised compliance by more than 62 times the status quo level.

[8] A logistic pilot was conducted in March-April 2018. The pilot had two main goals. First, we wanted to make sure that the tax collectors would be able to work with the handheld receipt printers used on the tax campaign. Second, we wanted to test and optimize the informational flyers that would be distributed during the census visits. The pilot was conducted in eight city polygons in Kamilabi, a remote neighborhood in northwest Kananga. This neighborhood was selected strategically due to its isolated location to minimize potential informational spillovers

358 strata for the full randomization.

Figure 3: The Unit of Stratification: Neighborhoods of Kananga



3.3 Randomly Assigned Bonuses for Tax Collectors

Following standard tax ministry protocol, tax collectors receive a performance-based compensation. Typically, collectors receive a payment proportional to the amount of tax that they collected and deposited to the state account. A concern is that compensations of varying amounts assigned to the properties in the different treatment groups **T1**, **T2**, **T3** and **T4** could result in different levels of efforts exerted by tax collectors. In particular, tax collectors could exert more effort on properties which have been randomly assigned a higher tax rate because these generate a higher compensation. If this was the case our estimates of tax compliance for the different treatment groups **T1**-**T4** would be biased by the different level of effort exerted by tax collectors for each treatment group.

To address this concern, we randomize tax collectors' compensation at the property level among the following two treatments:

Fixed Compensation: Half of the "*periphery*" properties are assigned a fixed compensation of 750 CF.

Proportional Compensation: The other half of the "*periphery*" properties are assigned a proportional compensation equal to 30% of the tax rate corresponding to that property.

For "*midrange*" properties, the compensation is a flat amount of 2,000 CF per house[9]. Overall, the size of the compensation is analogous to the incentive paid to property tax collectors in studies conducted in other developing countries (**??**). Holding the compensation constant – at a fixed amount or proportional

[9]For the 'villa' category the bonus is 5,000 CF if the villa owner paid less than or equal to 50 USD in property taxes and 10,000 CF if she pays more than that amount.

share of the tax amount – will permit us to control for tax collector incentives across rates [10]. Table 3 shows the compensation treatment groups by property type.

Table 3: Treatment allocation

		Rate Treatment (% Full Rate)			
Compensation	**Property Type**	**50%**	**66%**	**88%**	**100%**
Fixed	Periphery	5,260	5,371	5,342	5,103
	Midrange	1,036	1,108	1,047	971
Proportional	Periphery	4,306	4,130	4,302	4,242

4 Data and Empirical Methodology

4.1 Data

Data come from five sources: (1) administrative data on property tax payment, (2) a baseline survey administered before the campaign, (3) a census survey administered at the beginning of the campaign, (4) a midline survey conducted during the campaign, (5) an endline survey done after the campaign.

4.1.1 Administrative Data

Administrative data come from the government's official tax database. This database was constructed from the handheld receipt printers which store each receipt in their memory[11]. We link official tax records to survey data using the unique household tax identification numbers assigned during property registration. The sample includes about 3,600 payments.

4.1.2 Respondent Baseline Survey

Baseline survey enumeration occurred just before the property tax campaign. Independent enumerators randomly sampled households following skip patterns while walking down each avenue in a neighborhood: e.g. visit every X^{th} property, where X is determined by the estimated number of properties and a target of 12 per polygon. The baseline survey covers a wide range of topics, including but not limited

[10] If collectors tax a household during the census, the bonus is constant (750 CF for "*periphery*" properties and 2000 CF for "*midrange*" properties), in order to reduce the temptation to game the randomized order of tax bills

[11] The printers collect the collector's name and ID number, date and time stamps, neighborhood number, the house category and identification number, the tax rate, and the amount paid.

to: demographics, trust in the state, perception of state capacity, satisfaction with governance and public good provision, experience with taxation, payments to the state (formal and informal) and political beliefs and participation.This sample includes about 4,300 property owners.

4.1.3 Census Survey

This survey is conducted during the census. It records the code that is assigned to each household, its geographic coordinates, the name of the property owner, the property tax rate faced by each household (assigned on the spot during the census), and whether a property is exempt from the property tax[12]. It also contains the protocol collectors read informing respondents about the tax campaign. This sample includes about 46,000 properties.

4.1.4 Midline Survey

This survey is administered to every household in the city by enumerators on average 2-4 weeks after tax collectors had completed tax collection in a neighborhood and its goals are to measure the property owners' knowledge of the property tax, verify the work of tax collectors in a neighborhood and measure interactions between respondents and tax collectors. The midline survey covers a broad range of topics, including but not limited to: whether a household was visited by tax collectors and the number of times it was visited, whether it paid the property tax, whether the property owner knows the tax rate his neighbors were asked to pay, whether the property owner is aware of having received a tax reduction. During the midline survey we also asked property owners if they paid a bribe to the tax collectors and how much bribe they paid. We also asked property owners about households members' weekly participation in informal taxation (*Salongo*) and the total number of hours contributed in the past week. Finally, the midline survey includes information about the property such as the quality of fences, walls, roof, erosion threat and about the property owner such as age, gender, type of work, whether some of his relative works for the provincial government and tribe. This sample includes about 37,000 property owners.

4.1.5 Respondent Endline Survey

This survey is conducted after the campaign and covers a broad range of topics including questions about tax compliance with the property tax and with other provincial taxes such as the market tax, firm tax, vehicle tax and income tax. It also includes questions about the perceived performance and capacity of the provincial government as well as the tax ministry. Finally, it includes informations about engagement with the provincial government and use of formal and informal sector. The final

[12]The following cases are exempt from the property tax: 1) state-owned properties, 2) schools, churches, and scientific or philanthropic institutions, 3) houses owned by the elderly (55 years or above), widows or disabled people, 4) houses in construction or owned by foreigners or international organizations.

sample will include about 4,300 property owners but data collection is ongoing and information has been collected on 2,039 property owners to this date.Variables collected in this survey provide inputs to the preliminary analysis on secondary outcomes including other tax payments and beliefs about the government.

4.2 Estimation

The general estimation equation we use is

$$y_{ijk} = \alpha + \beta RATE\,50_{ijk} + \gamma RATE\,66_{ijk} + \delta RATE\,88_{ij} + \eta_j + \mu_k + X'_{ijk}\zeta + \epsilon_{ijk} \qquad (1)$$

where i indexes individuals, j neighborhoods (the strata used for randomization) and k indexes the house type ('periphery' or 'midrange'). $RATE50_{ijk}$ is an indicator for individuals assigned to treatment group **T4** (50% liability), $RATE66_{ijk}$ is an indicator for individuals assigned to treatment group **T3** (66% liability) and $RATE83_{ijk}$ is an indicator for individuals assigned to treatment group **T2** (83% liability). The excluded category is the treatment group **T1** (full liability). β, γ and δ estimate the causal effect of being assigned to treatment groups **T2**, **T3** and **T4** respectively on the outcome of interest y_{ijk}. We include strata fixed effect η_j and house type fixed effects μ_k. In some specifications we also include individual-level covariates X'_{ij}. Finally, we report robust standard errors since the randomization was conducted at the property level (**?**).

4.3 Balance

To check the randomization, in Table 4, we estimate Equation 1 with ten variables from the midline survey. We first consider three property level variables: an index of erosion threatening the property (column 1), an index of quality/materials of the walls (column 2) and an index of quality/materials of the roof (column 3). We also estimate Equation 1 with seven characteristics of the property owner: age (column 4), gender (column 5), employment status (column 6), an indicator for being salaried (column 7), an indicator for being a government employee (column 8) or having a relative who is a government employee (column 9) and an indicator for being from the same tribe as the majority of citizens in Kananga (column 10). In total, only one variable (quality/materials of the wall) is imbalanced at the 5% level for the **T4** indicator. Thus, as expected, 3.33% of coefficients are found to be significant at the 5% level. For all the treatment arms, an omnibus test of joint orthogonality fails to reject the null for the property level variables (**T1** vs **T2**: $F = 0.25$ and $p = 0.86$, **T1** vs **T3**: $F = 1.57$ and $p = 0.20$, **T1** vs **T4**: $F = 1.90$ and $p = 0.13$) as well as for the characteristics of the property owner (**T1** vs **T2**: $F = 0.60$ and $p = 0.75$, **T1** vs **T3**: $F = 0.44$ and $p = 0.88$, **T1** vs **T4**: $F = 0.95$ and $p = 0.46$).

Table 4: Randomization Balance

	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)
Rate 83 pct	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)
Rate 66 pct	-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)
Rate 50 pct	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

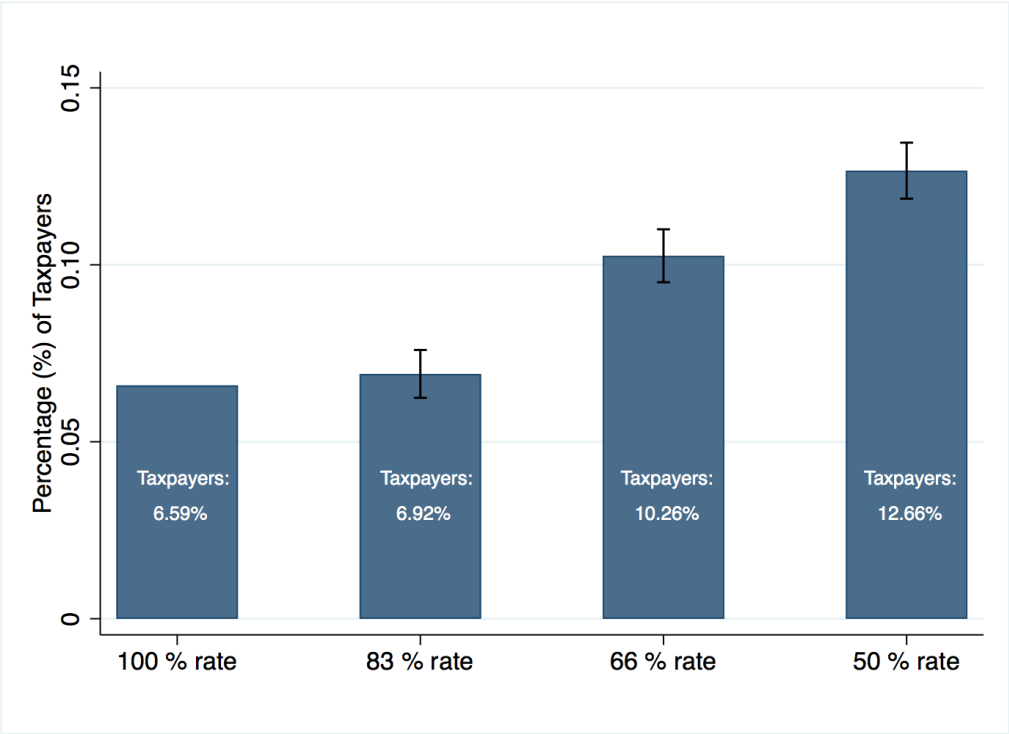
Notes: This table reports the coefficients from balance tests estimated by regressing a set of property and property owner characteristics on property tax rate treatment indicators. Each column shows the estimates from a separate regression of a property characteristic or a property owner characteristic on an indicator for each treatment arm. The number of observations, number of randomization strata and mean of the property or property owner characteristics are reported in the bottom line.

5 Effects on Tax Compliance

5.1 Main Specification

This section considers to what extent assignment to lower tax rates raised tax compliance. It is a priori not obvious that a reduction in tax liability in the DRC would lead to higher levels of compliance. Citizens have little exposure to formal tax collection and have low levels of trust in bureaucrats such as tax collectors or in the provincial government. Figure 4 summarizes the OLS estimations of Equation 1 using tax compliance as the outcome. Assignment to the full liability treatment group **T1** (full liability) is associated with 6.56% of tax compliance while assignment to 83% of the liability (treatment groups **T2**) is associated with 6.93% of tax compliance, assignment to 66% of the liability (treatment groups **T3**) is associated with 10.24% of tax compliance and assignment to 50% of the liability (treatment groups **T4**) is associated with 12.69% of tax compliance. The difference between tax compliance in treatment groups **T1** and **T3**, **T4** is statistically significant at the 1 percent level. The smallest reduction in the tax liability (a 16% reduction) does not significantly increase tax compliance.

Figure 4: Effects on Tax Compliance



5.2 The Elasticity of Tax Compliance

To put these numbers in perspective we next turn to estimating the elasticity of tax compliance with respect to the tax liability. This elasticity is defined as the percentage of property owners P who decide to pay the property tax when the tax liability R increases relative to the full liability by 1 percent. The formula for the elasticity of tax compliance with respect to the tax rate is therefore given by

$$\eta = \frac{R}{P}\frac{\partial P}{\partial R} \tag{2}$$

We can estimate the elasticity of tax compliance when the tax rate increases relative to the lowest liability (treatment group **T4**) as:

$$\bar{\eta} = \sum \frac{1}{\#N_{\{T_i \cup T_4\}}} \frac{P|Rate_{\mathbf{Ti}} - P|Rate_{\mathbf{T4}}}{P|Rate_{\mathbf{T4}}} \frac{Rate_{\mathbf{T4}}}{Rate_{\mathbf{Ti}} - Rate_{\mathbf{T4}}} \tag{3}$$

Taking the average elasticity $\bar{\eta}$ over treatment groups **T2**, **T3** and **T4** relative to treatment group **T1**

gives a good approximation of the elasticity of tax compliance when the tax rate increases because Figure 4 displays a relatively linear pattern.

Using this formula we find that the elasticity of tax compliance with respect to the tax rate is equal to -0.49, which means that wen the liability R increases by 1% relative to the full liability, tax compliance decreases by 0.49 percent. When appropriate, we will report this elasticity in the bottom row of subsequent regression tables. Note that the estimated elasticity of tax compliance when the tax rate increases relative to the lowest liability is a relevant measure in cases where fixed liabilities are used as was frequent for property taxation in developed countries until recently and is still widely used in developing countries with low state capacity (**?**).

In ongoing work, we are investigating ways to estimate property values in order to also estimate the elasticity of tax compliance with respect to the tax rate expressed as a percentage of property values to be able to provide an estimate of the elasticity of tax compliance that can talk to context where the property tax is set as a percentage of property value. Specifically, we are currently using pictures of each property taken during the census survey combined with property values that we collected for a subsample of properties in an ongoing experiment estimating the effect of randomly subsidizing access to property titles in Kananga and available (**?**). This provides us with a training sample which will then allow us to use computer vision methods to estimate property values for the entire sample of properties. This is made possible because tasks such as automatically classifying and labeling images are now much easier, thanks in part to the availability of new machine learning algorithms (**??**).

Provided with the property value estimate, we will estimate the elasticity of tax compliance with respect to the tax rate expressed as a percentage of property value using an instrumental variable model for outcome y_{ijk} of property i, in neighborhood j, of type k and mean tax rate $\tau_{ijk} = \frac{Rate_{ijk}}{Value_{ijk}}$:

$$y_{ijk} = \alpha + \beta log(\tau_{ijk}) + \gamma_j + \delta_k + \nu_{ijk} \tag{4}$$

$$\begin{aligned} log(\tau_{ijk}) = \beta_0 + \beta_1 RATE50\%_{ijk} + \beta_2 RATE66\%_{ijk} \\ + \beta_3 RATE88\%_{ijk} + \gamma_j + \delta_k + \epsilon_{ijk} \end{aligned} \tag{5}$$

where equation (4) is the first stage of the instrumental variable model and equation (5) is the second stage of the instrumental variable model.

5.3 Robustness Checks

As previously mentioned, one concern is that our results are potentially biased by the different levels of effort tax collectors could have exerted for the different treatment groups. To rule out this interpretation of our estimates we conduct several robustness checks in Table 5. Column 1 presents the main specification corresponding to figure 4. In column 2, 3 and 4 we use the randomized compensation of tax

collectors and estimate Equation 1 controlling for the tax collector's compensation level (column 2), for the constant compensation only (column 3) and for the proportional compensation only (column 4). Columns 2-4 show that taking into account tax collectors' compensation levels does not substantially affect the magnitude of the regression coefficients. Our estimates of the elasticity of tax compliance are also relatively stable: -0.52 for the constant compensation (column 3) and -0.44 for the proportional compensation (column 4) with our main specification (column 1) and controlling for compensation (column 2) lying in between at -0.49. Finally, in the last two columns, we look at two outcomes from the midline survey: an indicator for receiving a visit by tax collectors after the census visit (column 5) and number of visits by tax collectors after the census visit (column 6). None of the coefficients are significant suggesting that tax collectors do not adjust their effort level to the different tax rates.

Table 5: Robustness Checks - Collectors' Efforts

	Compliance Main Spec.	Compliance Comp. Ctrl	Compliance Const. Comp.	Compliance Prop. Comp.	Visit Indicator	Nb. Visits
	(1)	(2)	(3)	(4)	(5)	(6)
Rate 83 pct	0.003	-0.000	0.014**	-0.002	-0.000	16.467
	(0.003)	(0.004)	(0.005)	(0.005)	(0.004)	(16.347)
Rate 66 pct	0.036***	0.037***	0.037***	0.036***	0.006	-0.230
	(0.004)	(0.005)	(0.006)	(0.006)	(0.004)	(1.568)
Rate 50 pct	0.060***	0.065***	0.062***	0.053***	0.003	-1.367
	(0.004)	(0.006)	(0.006)	(0.006)	(0.004)	(2.147)
Sample	Admin	Admin	Admin	Admin	Midline	Midline
House Type	Pooled	Pooled	Periphery	Periphery	Pooled	Pooled
Observations	39222	38385	16916	16980	26297	24075
Strata	358	358	358	358	358	358
Mean	.064	.066	.06	.064	.925	1.617
Elasticity	-.49	-.49	-.51	-.45		

Notes: This table reports the tax compliance coefficients estimated by regressing tax compliance or visits by tax collectors on property level treatment indicators. Columns 1, 2, 3 and 4 show the estimates from regressions of tax compliance on indicators for each treatment arms. Column 1 includes no controls, column 2 controls for the compensation of the collector, and columns 3 and 4 show results estimated on the separate samples restricting to observations where compensation was fixed or proportional, respectively. Column 5 shows the estimates from a regression of a dummy for receiving a visit by a tax collector on indicators for each treatment arms, including no controls for compensation. Column 6 shows the estimates from a regression of the number of visits by a tax collector on indicators for each treatment arms. The number of observations, number of randomization strata and mean of the outcome considered as well as the corresponding elasticity of tax compliance are reported in the bottom rows.

Another important concern is that our estimates could be biased if property owners know that their tax rate differs from their neighbor's tax rate and if they have strong preference for a fair tax system (**??**). In Table 6 we use three strategies to assess whether property owners' knowledge of their neighbors' tax rates might bias our results. First, we use the precise GPS location of each property in Kananga to identify the four closest neighbors of each property owner. We then estimate Equation 1 using tax

compliance as the outcome without controlling for neighbors' tax rate (Column 1) and controlling for neighbors' tax rates (Column 2) and do not find any differences in the regression coefficients and the resulting elasticity of tax compliance. Second, in Column 3, we use the same specification as in Column 1 but restricting the sample to property owners whose closest two neighbors were randomly assigned to the same tax rate as them. We find that the regression coefficients are similar to the coefficients estimated in Column 1 and that the elasticity of tax compliance is left unchanged. Third, we use our midline survey question on knowledge of neighbors' tax rates to estimate the same specification as in Column 1 but separately for property owners who report not knowing their neighbor's rate (87% of property owners) (Column 4) and for property owners who report knowing their neighbor's rate (13% of property owners) (Column 5). We find that the regression coefficients and the resulting elasticity of tax compliance estimated in Column 4 and 5 are very similar. Overall, these results suggests that the treatment effects are unlikely to be biased by property owners' knowledge of their neighbors' tax rates.

Alternatively, our estimates could be biased if property owners know that their tax rate differs from past tax rates and if they have strong preference for a tax system that is stable over time. To address this concern we estimate the same specification as in Column 1 but separately for neighborhoods where the property tax campaign did not take place in the previous year (column 6) and where the tax campaign took place in the previous year (column 7). The neighborhoods where the past tax campaign did and did not take place were randomly chosen but could differ in their level of knowledge of the property tax, including the property tax liability (**?**). We see that the regression coefficients and resulting elasticity of tax compliance estimated in Columns 6 and 7 are very similar, suggesting that our estimates are unlikely to be biased by property owners' knowledge of the previous year's tax rates.

Finally, our estimates could be biased if property owners know that they received a tax reduction and if this tax reduction provides them transaction utility (**?**). To address this concern in column 7 we estimate Equation 1 with property owners in treatment groups **T2**, **T3** and **T4** who declare not knowing that they receive a tax reduction (97.2% of property owners in these treatment groups) and in column 8 we estimate Equation 1 with property owners in treatment groups **T2**, **T3** and **T4** who declare knowing that they received a tax reduction (2.8% of property owners in these treatment groups). In both specifications we include all the property owners in treatment group **T1** since they don't receive a discount. Treatments effects in column 8 are larger than in column 7, suggesting that transactional utility might affect tax compliance in our context. However, transactional utility is unlikely to affect our overall treatment effects given that only 0.73% of property owners in treatment groups **T2**, **T3** and **T4** declared knowing that they received a tax reduction.

Table 6: Robustness Checks - Spillovers

	Main Specification (1)	Nbr Rate Controls (2)	Nbr Rate Same (3)	Nbr Rate Doesn't Know (4)	Nbr Rate Knows (5)	No Previous Tax campaign (6)	Previous Tax campaign (7)	Discount Doesn't Know (8)	Discount Knows (9)
Rate 83 pct	0.003	0.004	-0.025	-0.003	-0.010	0.005	-0.000	0.008	0.022
	(0.003)	(0.004)	(0.016)	(0.007)	(0.021)	(0.004)	(0.006)	(0.007)	(0.109)
Rate 66 pct	0.037***	0.036***	0.017	0.045***	0.050**	0.039***	0.034***	0.048***	0.233
	(0.004)	(0.004)	(0.019)	(0.007)	(0.023)	(0.005)	(0.006)	(0.008)	(0.156)
Rate 50 pct	0.061***	0.060***	0.073***	0.068***	0.077***	0.058***	0.066***	0.063***	0.277**
	(0.004)	(0.004)	(0.021)	(0.008)	(0.023)	(0.005)	(0.007)	(0.009)	(0.119)
Sample	Admin	Admin	Admin	Admin & Midline	Admin & Midline	Admin	Admin	Admin & Midline	Admin & Midline
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Observations	39222	36407	2060	13146	2042	24186	14896	13635	9649
Strata	358	358	358	358	358	358	358	358	358
Mean	.064	.062	.073	.081	.116	.064	.065	.064	.064
Elasticity	-.49	-.49	-.49	-.47	-.34	-.47	-.5	-.46	-.81

Notes: This table reports the tax compliance coefficients estimated by regressing tax compliance on property level tax rate treatment indicators. Column 1 includes no controls. Column 2 controls for the tax rate of the four neighbors closest to an individual property. Column 3 restricts to a group of property owners whose closest two neighbors were randomly assigned to the same tax rate. Columns 4 and 5 estimate coefficients on samples of property owners who report not knowing or knowing their neighbor's rate, respectively. Columns 6 and 7 estimate coefficients on samples of property owners that were part of a previous tax campaign or not, respectively. Columns 8 and 9 estimate coefficients on samples of property owners who report being unaware or aware of tax discounts, respectively. The number of observations, number of randomization strata and mean of the outcome considered as well as the corresponding elasticity of tax compliance are reported in the bottom rows.

5.4 Timing of Tax Compliance

In this section we study the dynamics of tax compliance over time which Figure 4, Tables 5 and Table 6 ignore. In Table 7, we estimate Equation 1 using tax compliance as the outcome at different periods of time of tax collection: on the first day of tax collection (Column 1) and within 5, 10, 15, 20, 25 and 30 days of tax collection (columns 2 to 7). We see that the resulting elasticity of tax compliance decreases monotonically with the amount of time tax collectors spend collecting taxes in each neighborhood. The elasticity is -0.56 on the first day of tax collection and decreases to -0.49 by the end of the tax collection period. This decreasing pattern over time could be explained by cash constraints which are more likely to be an impediment to tax compliance if tax collection has been going on for a few days and are less likely to matter if tax collection has been going on for several weeks. Taken at face value our estimates suggest that cash constraints could explain as much as 14% of the elasticity of tax compliance. We will return to cash constraints as a potential mechanism for the elasticity of tax compliance when studying heterogeneous treatment effects in Section 8.

Table 7: Dynamics of Tax Compliance

	First day of census (1)	Within 5 days of census (2)	Within 10 days of census (3)	Within 15 days of census (4)	Within 20 days of census (5)	Within 25 days of census (6)	Within 30 days of census (7)
Rate 83 pct	-0.001	-0.000	0.003	0.003	0.001	0.001	0.001
	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Rate 66 pct	0.002**	0.006***	0.017***	0.025***	0.031***	0.034***	0.034***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
Rate 50 pct	0.005***	0.013***	0.029***	0.040***	0.049***	0.056***	0.058***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
Sample	Admin	Admin	Admin	Admin	Admin	Admin	Admin
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Observations	39045	39045	39045	39045	39045	39045	39045
Strata	358	358	358	358	358	358	358
Mean	.004	.011	.025	.039	.049	.057	.059
Elasticity	-.56	-.54	-.54	-.50	-.49	-.49	-.49

Notes: This table reports the tax compliance coefficients estimated by regressing tax compliance on property level treatment indicators. The outcome is defined in increasing periods from the start of the tax campaign in a particular polygon, ranging from the first day to 30 days after the start. The number of observations, number of randomization strata and mean of the outcome considered as well as the corresponding elasticity of tax compliance are reported in the bottom rows.

6 Effects on Secondary Outcomes

6.1 Effects on Bribe Payments

In a context of low state capacity changes in tax rates might result in additional behavioral responses that should be considered when evaluating the fiscal impacts of changes in tax rates. In this section, we considers to what extent assignment to lower tax rates affects bribe payments. The relationship between tax rates and bribes is a priori ambiguous. On the one hand, a reduction in tax liability could lead to lower bargaining power of the tax collectors which would result in lower levels of bribes (**?**). On the other hand, it may also be possible that tax collectors ask for bribes more often and succeed more often when the tax rate is low – e.g. if tax collectors threaten property owners who are assigned a high property tax rate with a higher property tax rates or agree to collect the low property tax rate only if given an additional bribe.

In Table 8 we investigate the relationship between tax rates and bribe payments using midline survey questions about whether the property owner paid a bribe to the tax collectors (column 1). Assignment to the full liability treatment group **T1** is associated with 2.04% of property owners paying a bribe to the tax collectors, assignment to 83% of the liability (treatment groups **T2**) with 2.14% of owners paying a bribe, assignment to 66% of the liability (treatment groups **T3**) with 1.87% of owners paying a bribe and assignment to 50% of the liability (treatment groups **T4**) with 1.17% of owners paying a bribe. The difference between bribe payments in treatment groups **T1** and **T4** is statistically significant at the 1 percent level while smaller reductions in the tax liability (assignment to treatment group **T2** and **T3**)

do not seem to significantly decrease bribe payments. The resulting elasticity of bribe payments with respect to the tax rate is 0.64.

The effects of tax liability on bribe payments are also visible on the intensive margin. In column 2 of Table 8 we use midline survey questions to investigate the relationship between tax rates and amount of bribe paid. For individuals who reported paying a bribe, assignment to the full liability treatment group **T1** is associated with an average bribe paid to the tax collectors of 2000 CF (USD $1.25), assignment to 83% of the liability (treatment groups **T2**) with an average bribe of 1600 CF (USD $1), assignment to 66% of the liability (treatment groups **T3**) with an average bribe of 1400 CF (USD $0.88) and assignment to 50% of the liability (treatment groups **T4**) with an average bribe of 900 CF (USD $0.56). The difference between bribe payments in treatment groups **T1** and **T2**, **T3**, **T4** is statistically significant at the 5, 20 and 1 percent level respectively. The resulting elasticity of bribe amounts with respect to the tax rate is 1.21. In column 3, the measure of bribe payment combines the extensive and intensive margin and find that the elasticity of bribe payments with respect to the tax rate is even higher, at 2.88.

In column 4-6 of table 8 we construct an alternative measure of bribe payment as a robustness check. We use our midline survey questions on self reported property tax compliance and amount of property tax paid combined with the administrative property tax payment data and define the payment of a bribe as reporting paying the property tax when no property tax payment is recorded in the administrative data. Using this definition we find that assignment to the full liability treatment group **T1** is associated with 9% of property owners paying a bribe and assignment to 50% of the liability (treatment group **T4**) being assigned with 7.56% of owners paying a bribe (Column 4). Similarly, assignment to the full liability is associated with an average bribe paid of 2,800 CF while assignment to the 50% liability is associated with an average bribe of 1900 CF (Column 5). The resulting elasticity of bribe payments with respect to the tax rate is 0.2 on the extensive margin, 0.46 on the intensive margin and 0.69 when combining the extensive and intensive margin (Column 6).

Table 8: Effects on Bribes

	Direct Measure Ext. Margin	Direct Measure Int. Margin	Direct Measure Combined	Compliance Gap Ext. Margin	Compliance Gap Int. Margin	Compliance Gap Combined
	(1)	(2)	(3)	(4)	(5)	(6)
Rate 83 pct	0.002	-667.336**	-5.037	-0.004	-282.525**	-34.949**
	(0.002)	(245.554)	(6.003)	(0.005)	(102.009)	(14.465)
Rate 66 pct	-0.001	-469.578*	-12.161**	-0.015**	-601.271***	-55.557***
	(0.002)	(245.906)	(5.440)	(0.005)	(110.572)	(13.972)
Rate 50 pct	-0.007**	-1175.014***	-24.869***	-0.016**	-883.450***	-69.402***
	(0.002)	(295.332)	(4.765)	(0.005)	(104.326)	(13.412)
Sample	Midline	Midline	Midline	Midline	Midline	Midline
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Observations	26340	440	26306	23268	1213	22577
Strata	358	358	358	358	358	358
Mean	.02	1967.81	35.1	.09	2833.49	163.17
Elasticity	.64	1.21	2.88	.2	.46	.69

Notes: This table reports coefficients estimated by regressing bribe measures on property level treatment indicators. There are two measures of bribes. Columns 1, 2, and 3 use a citizen-reported measure of bribes; columns 4, 5, and 6 compare actual tax payments to self-reported tax payments for individual citizens as a measure of bribes. Columns 1 and 4 report the extensive margin of paying a non-zero bribe according to each measure, respectively. Columns 2 and 5 report the intensive margin among bribe-payers, and columns 3 and 6 combine the two measures (coding bribe payments as zero for individuals who are classified as non-bribe-payers) and estimate the intensive margin effect on the combined measure. The number of observations, number of randomization strata and mean of the outcome considered as well as the corresponding elasticity of tax compliance are reported in the bottom rows.

6.2 Effects on Other Tax Payments

We now investigate to what extent assignment to lower tax rates affects participation in informal taxation (*Salongo*) and other formal provincial taxes (market tax, firm tax and vehicle tax).

In our context the main tax paid by citizens is the *Salongo*, an informal tax that consists in weekly contributions to public goods[13]. Despite the importance of informal taxes for government revenues in developing countries (**??**), we still know relatively little about how informal contributions to public goods respond to changes in formal taxation. In particular, the relationship between the property tax rate and informal taxation is a priori ambiguous. For taxpayers, it depends on whether formal and informal taxes are substitutes or complements. On the one hand, taxpayers may feel relieved of the duty to participate in informal taxation if they contributed formally (i.e. formal and informal taxes are substitutes). On the other hand, taxpayers may feel that they have to take a more active role in directing the focus of the *Salongo* and participate more (i.e. formal and informal taxes are complements). For tax evaders, a lower property tax rate could decrease (resp. increase) participation in *Salongo* if it leads citizens to believe that compliance and tax revenues will be higher (resp. lower) and will be sufficient (resp. insufficient) to provide public goods. In Table 9, we investigate this issue empirically and estimate Equation 1 using weekly participation in *Salongo* (column 1), number of hours per week

[13] According to our baseline survey *Salongo* mostly consist in road building or improvement (79%), filling ravines due to erosion (27.43%), water source building or improvement (10%) and bridge building or improvement (2%).

contributed to *Salongo* (column 2) from the midline survey and combining both (column 3). We see that assignment to a lower tax rate is not significantly associated with a change in informal contributions.

In the context of our study, some citizens are also liable to pay other provincial taxes such as the market tax (*Ticket* in French - for market vendors), the firm tax (*Patente* or *Registre de commerce* in French - for small firms and big firms respectively) and the vehicle tax (*Vignette* in French - for motorbike and/or automobile owners). For the same reasons as outlined above, the relationship between property tax rates and compliance with these other taxes is a priori ambiguous. In Table 9, we study this issue and estimate Equation 1 using survey questions about payments of the market tax (column 5), the firm tax (column 6) and the vehicle tax (column 7) in the same fiscal year as when the randomization of property tax rates took place. We consider these results as preliminary since they use data from our endline survey which is currently being collected. We find that lower property tax rates result in a substantial decline in compliance with other provincial taxes. Assignment to the full liability treatment group **T1** is associated with self reported compliance levels of 20.22% for the market tax, 9.37% for the market tax and 4.26% for the vehicle tax . In contrast, assignment to 50% of the liability (treatment groups **T4**) is associated with self reported compliance levels of 13.98% for the market tax, 6.06% for the business tax and 3.43% for the vehicle tax. The corresponding elasticity of compliance with other taxes with respect to the property tax rate are 0.45 for the market tax, 0.54 for the firm tax and 0.24 for the vehicle tax. These preliminary results therefore suggest that compliance with the property tax and with other provincial taxes are substitutes. Because we worry that these results are driven by citizens misreporting tax compliance, we also asked respondents if they paid a non-existing poll tax which we use as a placebo test (column 8). Reassuringly, we do not find any effect of tax rate assignment on self reported compliance with the non-existing pool tax, suggesting that our results are not driven by citizens misreporting tax compliance.

Table 9: Effects on Other Tax Payments

	Informal Taxes Ext. Margin	Informal Taxes Int. Margin	Informal Taxes Combined	Market Tax	Firm Tax	Vehicle Tax	Fake Tax
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rate 83 pct	0.005	61.973	22.737	-0.028	-0.009	-0.012	0.017**
	(0.009)	(61.381)	(22.617)	(0.027)	(0.015)	(0.013)	(0.009)
Rate 66 pct	0.006	8.795	1.156	-0.059**	-0.025*	-0.018	0.006
	(0.009)	(12.694)	(2.586)	(0.026)	(0.015)	(0.012)	(0.007)
Rate 50 pct	0.007	8.918	1.204	-0.068**	-0.021	-0.012	0.005
	(0.009)	(12.640)	(2.589)	(0.026)	(0.015)	(0.013)	(0.007)
Sample	Midline	Midline	Midline	Endline	Endline	Endline	Endline
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Observations	19100	6677	18589	1853	1851	1849	1830
Strata	358	358	358	316	316	316	316
Mean	.38	4.26	1.52	.22	.06	.04	.01
Elasticity	0	-.05	-.07	.46	.51	.42	-.36

Notes: This table reports coefficients estimated by regressing other tax compliance measures on property level treatment indicators. Columns 1–3 examine the impact on measures of participation in *salongo*: column 1 along the extensive margin, column 2 participation in number of hours, and column 3 combining the two measures (coding non-contributors as contributing zero) and estimating the intensive margin effect on the combined measure. Columns 4–7 show estimated effects on citizen-reported payments of market, firm, vehicle, and fake (non-existent) taxes, respectively. The number of observations, number of randomization strata and mean of the outcome considered as well as the corresponding elasticity of tax compliance are reported in the bottom rows.

6.3 Beliefs about the Government

This section investigates whether assignment to lower tax rates affect citizens' beliefs about and views of the government, thus contributing to the nascent literature that studies the relationship between taxation and governance (**??**).

Using our ongoing endline data, we evaluate citizens' ratings of performance of two government institutions – the provincial government and the tax ministry – and citizens' perceptions about each body's diversion of revenues towards corruption. We also evaluate the perceived fairness of aspects of the tax campaign. We find preliminary evidence that lowering the property tax rate has mixed effects on trust in the provincial government. Table 10 shows that assignment to a lower tax rates results in beliefs that more of the money will be spent on public goods (Column 1), corresponding to a marginally significant 1.1 percentage point increase in the 50% liability treatment group **T4** relative to a low comparison group mean of 2% in the full liability treatment group **T1**. On the other hand, decreases in the tax rate are also associated with respondents reporting that a higher fraction of the tax revenues will be stolen by the provincial government (Column 3), with marginally significant positive differences for the 83% and 66% liability treatment groups **T2** and **T3**, compared to the full liability group **T1**. Respondents also report that a higher amount of revenues will be stolen by the tax ministry at lower tax rates (Column 5), but the coefficients are not significantly different from zero. While these two simultaneous results are puzzling, both could possibly be generated by the increase in compliance that results from lower tax

rates. We do not find any effects of assignment to lower tax rates when using trust in the provincial tax ministry as the outcome (Columns 4 and 5). Finally, reducing tax rates has a positive and large effect on the perceived fairness of the tax rate (Column 6) but no effect of perceived fairness of tax collection (Column 7) or tax collectors (Column 8).

Table 10: Beliefs about the Government

	Prov. Gov Pub. Goods	Prov. Gov Trust	Prov. Gov Performance	Prov. Gov Steal	Prov. Tax Ministry Trust	Prov. Tax Min. Performance	Prov. Tax Min. Steal	Fairness Tax Rates	Fairness Tax Collection	Fairness Tax Collectors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		
Rate 83 pct	0.003	0.060	0.027	38.003*	0.094	-0.140*	22.391	0.079	0.011	-0.001
	(0.008)	(0.060)	(0.083)	(22.577)	(0.068)	(0.083)	(21.518)	(0.058)	(0.040)	(0.048)
Rate 66 pct	-0.006	-0.009	0.102	42.398*	0.032	-0.028	15.346	0.147**	0.015	-0.056
	(0.009)	(0.062)	(0.082)	(22.890)	(0.069)	(0.083)	(21.536)	(0.060)	(0.039)	(0.050)
Rate 50 pct	0.010	-0.027	0.061	13.462	0.002	-0.097	30.622	0.130**	-0.026	0.042
	(0.008)	(0.060)	(0.079)	(22.833)	(0.068)	(0.080)	(21.220)	(0.058)	(0.041)	(0.047)
Sample	Midline	Endline	Endline	Endline	Endline	Endline	Endline	Endline	Endline	Endline
House	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
Observations	20783	1840	1801	1855	1844	1807	1844	1701	1848	1666
Strata	358	358	358	316	358	316	316	316	316	316
Mean	.58	1.67	3.86	531.93	1.89	4.23	394.69	1.28	2	1.7
Elasticity	-.01	-.01	-.01	-.04	-.04	.02	-.07	-.1	0	-.03

Notes: This table reports coefficients estimated by regressing measures of beliefs about government on property level treatment indicators. Column 1 reports impacts on a measure of how likely the provincial government is to provide public goods with tax revenues from the campaign, column 2 on a measure of provincial government performance, and column 3 the amount the provincial government will divert towards corruption (of the amount collected as part of the campaign). Columns 4 and 5 report apposite measures for the provincial tax ministry. Columns 6–8 report impacts on perceived fairness or tax rates, tax collection, and collectors, respectively. The number of observations, number of randomization strata and mean of the outcome considered as well as the corresponding elasticity of tax compliance are reported in the bottom rows.

7 Effects on Government Revenue

We now turn to effect of changing tax rates on government revenues. In Figure 5 we show the total revenues from taxation and the total amount of bribes paid to the tax collectors for each treatment group **T1**-**T4**. The total revenues from taxation by tax rate treatment group are displayed in Figure 5a. Properties assigned to treatment group **T1** (full liability) generated 2.49 millions CF of tax revenues, while properties assigned to 83% of the liability (treatment groups **T2**) generated 2.16 millions CF of tax revenue, properties assigned to 66% of the liability (treatment groups **T3**) generated 2.65 millions CF of tax revenue and properties assigned to 50% of the liability (treatment groups **T4**) generated 2.55 millions CF. Overall, we see that decreasing the tax rate to 83% (resp. 50%) of the full liability generates a 7% (resp. 3%) increase in government revenue. Our results therefore suggest that the property tax rate in our setting are above the revenue-maximizing Laffer rate. Note that as we've seen in Table 7 the elasiticity of tax compliance decreases with time suggesting that this result is starker for shorter periods of tax collection.

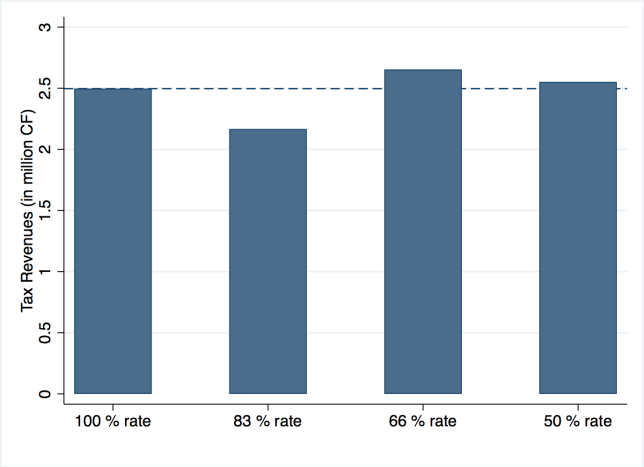
In Figure 5b we turn to the total amount of bribe paid by tax rate treatment groups. Properties assigned to treatment group **T1** (full liability) paid 0.24 millions CF in bribes, while properties assigned to 83% of the liability (treatment groups **T2**) paid 0.2 millions CFin bribes, properties assigned to 66%

of the liability (treatment groups **T3**) paid 0.16 millions CF in bribes and properties assigned to 50% of the liability (treatment groups **T4**) paid 0.06 millions CF in bribes. Therefore decreasing the tax rate to 50% of the full liability results in a 74% decrease in the total amount of bribes paid to tax collectors. Our results also suggest that the property tax rate in our setting are above the bribe-minimizing rate. To put the bribe amounts in perspective, 5c displays both total revenues from taxation and total amount of bribes paid to the tax collectors for each treatment group **T1**-**T4**.

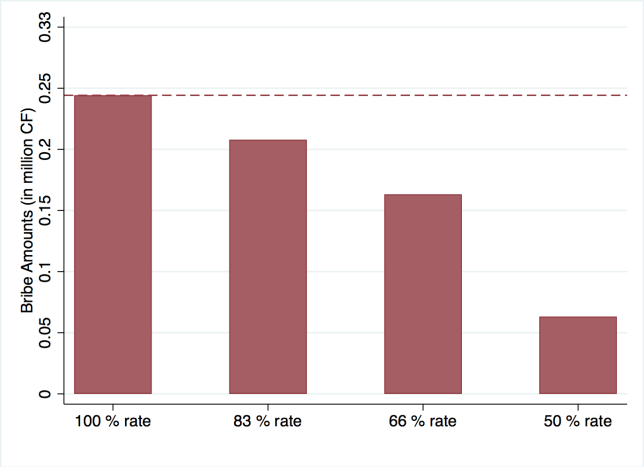
Finally, it is worth mentioning that the effect of assignment to property tax rates on compliance with other provincial taxes (vehicle tax, market tax and firm tax) analyzed in Table 9 should also enter our calculations of total revenues from taxation by treatment groups **T1**-**T4**. However, these results are based on our ongoing endline data and we see them as preliminary. As a consequence, we do not yet compute the effect on government revenues of the decrease in compliance with other provincial taxes generated by the decrease in property tax rates. Similarly, assignment to property tax rate treatment groups **T1**-**T4** has an effect on trust in the provincial government as documented in Table 10 which might have additional effects on government revenues. Because these results use our endline data, we consider them as preliminary and do not attempt to estimate these additional effects.

Figure 5: Revenue Maximizing Tax Rate

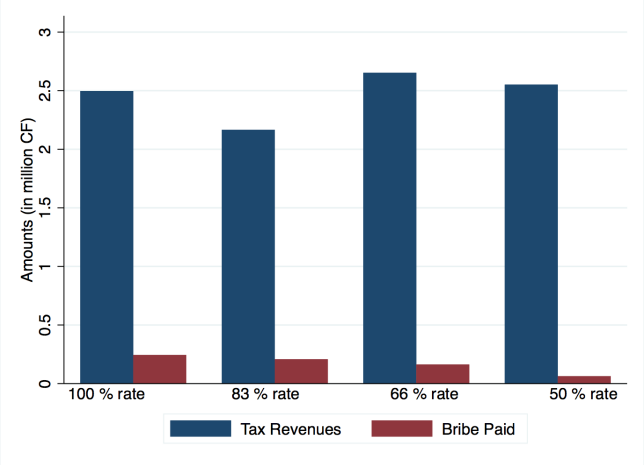
(a) Tax Revenue Maximizing Tax Rate



(b) Bribe Minimizing Tax Rate



(c) Tax Revenue and Bribe Payments



8 Heterogeneous Treatment Effects using Machine Learning

In this section, we aim at studying the characteristics of property owners that result in higher treatment effects. To do this we follow **?** and use machine learning to make inference on key features of heterogeneous treatment effects. We estimate the best linear predictors of the effects using machine learning proxies, the average effects sorted by impact groups, and the average characteristics of the most and least impacted units.

The identification strategy developed in **?** provides several advantages in studying heterogeneity in the treatment effects of tax rates reduction. First, it allows us to be agnostic about the source of heterogeneity rather than relying on ad hoc subgroup analysis across a few baseline characteristics. This is especially valuable because ex ante we had little idea about what would predict heterogeneity in the treatment effects of tax rates reduction[14]. Second, it is valid in high dimensional settings, allowing us to include a rich set of characteristics in an unspecified functional form. Finally, we are able to identify the characteristics of the most and least affected subpopulation, which could be an important input in understanding how governments should set their tax rates in developing countries.

We focus on heterogeneity in treatment effects on the main outcome variables: a dummy for tax compliance (Figure 4 and Table 5 and 6), a dummy for paying a bribe to the tax collectors (Table 8, column 1) and the amount of bribe paid to tax collectors (Table 8, column 3). To simplify the analysis we consider a single treatment variable, which is an indicator for assignment to the lowest tax liability (treatment group **T4**) relative to being assigned to the highest liability (treatment group **T1**). We analyze heterogeneous treatment effects in terms of property and property owner level covariates from our midline survey. In terms of property characteristics we use an index of erosion threatening the property, an index of of quality / materials of the walls and an index of quality / materials of the roof. Regarding property owner characteristics we use age, gender, employment status, an indicator for being salaried, an indicator for being a government employee, an indicator for having a relative who is a government employee and an indicator for being from the same tribe as the majority of the citizens in Kananga. In future versions of the paper, we will also use baseline and endline survey data to compute heterogeneous treatment effects for a broader range of characteristics[15].

Table 11 compares three Machine Learning methods – Elastic Net, Boosting and Random Forest – for producing the best Best Linear Predictors (BLP) using Λ and the best Sorted Group Average Treatment Effects (GATES) of the effects in the auxiliary sample using $\bar{\Lambda}$ (**?**) [16]. We find that the

[14] We submitted our Pre-Analysis Plan to the American Economic Association's registry for randomized controlled trials (AEA RCT Registry) on January 28th 2019. The Pre-Analysis Plan discusses heterogeneous treatment effects including using **?** to characterize heterogeneous treatment effects.

[15] Endline data collection started in April 2019 and will be completed in September 2019.

[16] For BLP, the best Machine Learning method can be chosen in the main sample by maximizing $\Lambda = Corr^2(S_0(Z), S(Z))Var(S_0(Z))$ where $S_0(Z)$ is the average treatment effect (ATE) and $S(Z)$ is the Machine Learning proxy predictor of $S_0(Z)$. For GATES, the best ML method can be chosen in the main sample by maximizing $\bar{\Lambda} = \mathbb{E}\big(\sum \gamma_k 1_{\{S \in I_k\}}\big)^2$ where $\gamma_k = \mathbb{E}[S_0(Z)|G_k]$ are the GATES parameter and I_k are non-overlapping intervals that divide the support of S.

Random Forest and Boosting outperform Elastic Net. Accordingly, we focus on these two methods for the rest of our analysis.

Table 11: Comparison of ML Methods

	Elastic Net	Boosting	Random Forest
Paid Taxes Indicator			
Best BLP Λ	0.003	0.003	0.003
Best GATES $\bar{\Lambda}$	0.006	0.017	0.007
Paid Bribe Indicator			
Best BLP Λ	0.000	0.000	0.000
Best GATES $\bar{\Lambda}$	0.002	0.002	0.003
Bribe Amount			
Best BLP Λ	0.000	0.000	0.000
Best GATES $\bar{\Lambda}$	0.002	0.002	0.003

Notes: Medians over 100 splits in half.

Table 12 presents results of the BLP using the ML proxies $S(Z)$ for our outcome variables. We report estimates of the average treatment effect (ATE) and the heterogeneity loading (HET) parameters in the BLP. In parentheses, we report confidence intervals adjusted for variability across the sample splits using the median method, and in brackets we report adjusted p-values (**?**). The estimated ATEs on the effect of being assigned to the lowest tax liability (treatment group **T4**) relative to being assigned to the highest liability (treatment group **T1**) are consistent with the estimates reported in Table 5, i.e. are similar to the unconditional ATE, as expected by virtue of the randomization.

Turning to the heterogeneity results, we reject the hypothesis that HET is zero at the 10% level for the tax payment indicator with the random forest and boosting methods, suggesting the presence of heterogeneity in the effect of assignment to lower tax rates on tax compliance. Finally, the BLP analysis does not reveal any significant heterogeneity in the effect on bribe payment indicator and amounts of bribe paid. Overall, these results suggest that assignment to lower tax rates has heterogeneous impacts on tax compliance but not on bribe payments.

Table 12: Best Linear Predictor

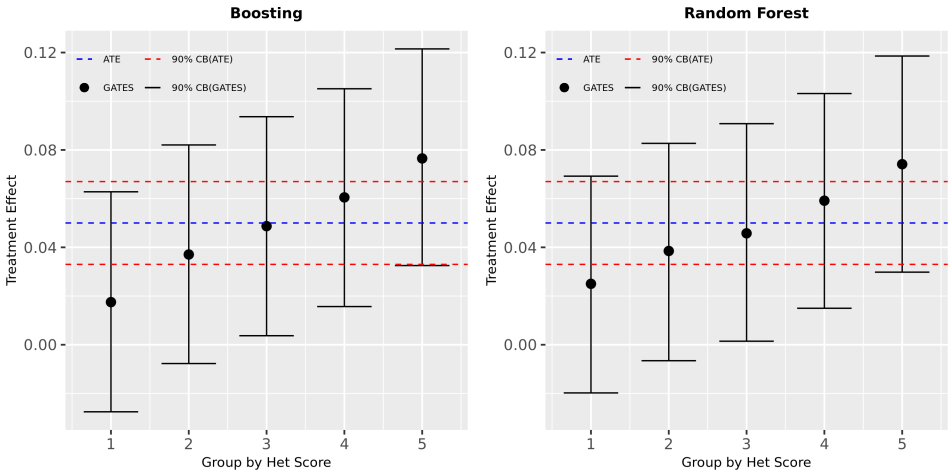
	Random Forest		Boosting	
	ATE	HET	ATE	HET
Paid Taxes Indicator	0.050	0.167	0.050	0.089
	(0.033,0.067)	(0.005,0.334)	(0.033,0.067)	(0.005,0.173)
	[0.000]	[0.098]	[0.000]	[0.096]
Paid Bribe Indicator	-0.008	-0.001	-0.008	0.003
	(-0.017,0.000)	(-0.230,0.237)	(-0.017,0.000)	(-0.277,0.300)
	[0.120]	[1.000]	[0.123]	[1.000]
Amount Bribe Paid	-19.28	-0.017	-19.30	-0.025
	(-36.53,-2.587)	(-0.229,0.194)	(-36.39,-2.252)	(-0.329,0.251)
	[0.047]	[1.000]	[0.049]	[1.000]

Notes: Medians over 100 splits. 90% confidence interval in parenthesis. P-values for the hypothesis that the parameter is equal to zero in brackets.

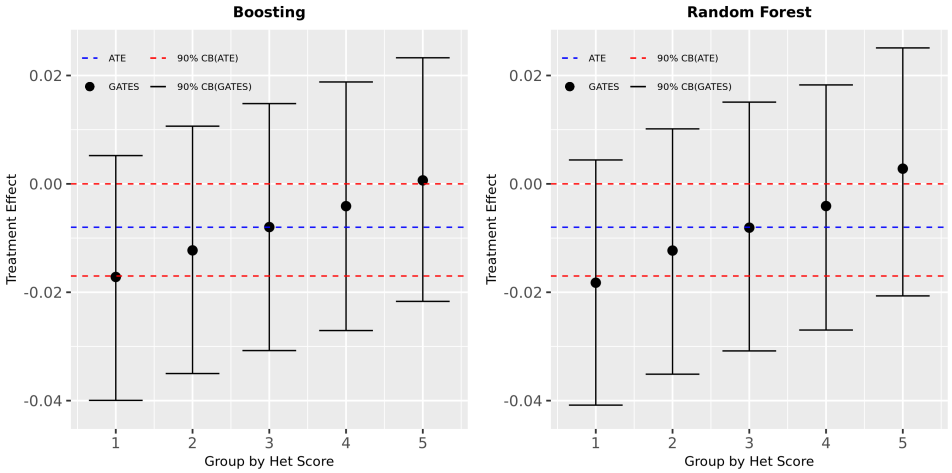
We next estimate the GATES. We divide the property owners into $K = 5$ groups based on the quintiles of the ML proxy predictor $S(Z)$ and estimate the average effect for each group. Figure 6 is the estimated GATES coefficients $\gamma_1 - \gamma_2$ along with joint confidence bands. $\gamma_k = \mathbb{E}[S_0(Z)|G_k]$ are the GATES parameters. We also report the ATE and its confidence interval that were obtained in the BLP analysis for comparison. The GATES provide a richer understanding of the heterogeneity. In particular, Figure 6a reveal that there are groups for which the GATES on the indicator for paying the property tax are significantly different from zero. These groups are likely to drive the heterogeneity in the treatment effect that we find in the BLP analysis. Figure 6b and 6c also reveal that there are no groups for which the GATES on bribe payments are significantly different from zero. All the results for the GATES are fairly robust to the ML method.

Figure 6: GATES

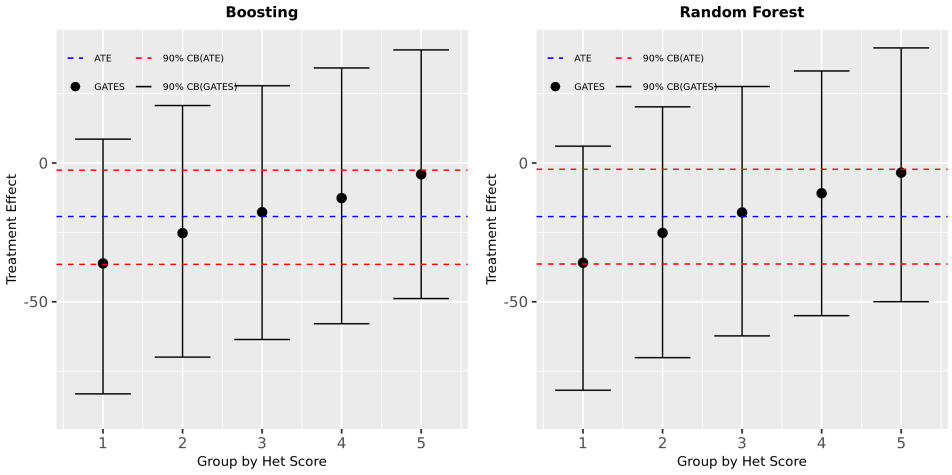
(a) GATES - Paid Taxes Indicator



(b) GATES - Paid Bribe Indicator



(c) GATES - Amount Bribe Paid



We conclude by looking at the average characteristics of the most and least affected groups to understand what generates heterogeneity in the treatment effects. We omit the results for bribe payments as we do not detect heterogeneity for the bribe payment indicator or the amount of bribe paid. We focus on ten characteristics in this analysis. Three characteristics of the property (an index of quality / materials of the walls, an index of quality / materials of the roof and an index of erosion threatening the property) and seven characteristics of the property owner (age, gender, employment status, an indicator for being salaried, an indicator for being a government employee, an indicator for having a relative who is a government employee and an indicator for being from the same tribe as the majority of the citizens in Kananga). Table 13 reports the CLAN for the 20% least and most affected groups defined by the deciles of the CAT proxy $S(Z)$ as well as the difference between the two. We find that assignment to the lowest property tax rate has the strongest effect on the poorest and most cash constrained citizens (measured by house quality but also the employment and salaried indicators). These preliminary results confirm that cash constraints might explain part of the effects of changes in tax rates on tax compliance, a result that is consistent with the elasticity of tax compliance decreasing with time spent collection taxes as previously mentioned in Table 7. We also find that assignment to the lowest property tax rate has the strongest effect on property owners who are less socially and politically connected (measured by working for the government, having a relative who works for the government or being from the majority tribe).

Table 13: Taxes Paid Indicator - Classification Analysis

	Random Forest			Boosting		
	20 % Most Affected	20 % Least Affected	Difference	20 % Most Affected	20 % Least Affected	Difference
Roof Quality	6.918	6.955	-0.029	6.762	6.995	-0.237
	(6.885,6.951)	(6.922,6.985)	(-0.079,0.016)	(6.715,6.807)	(6.949,7.042)	(-0.301,-0.173)
			[0.421]			[0.000]
Walls Quality	2.042	2.450	-0.413	1.984	2.382	-0.400
	(1.982,2.101)	(2.391,2.508)	(-0.499,-0.328)	(1.925,2.043)	(2.323,2.441)	(-0.483,-0.318)
			[0.000]			[0.000]
Erosion Threat	0.530	0.416	0.144	0.448	0.382	0.058
	(0.491,0.569)	(0.378,0.454)	(0.091,0.197)	(0.410,0.486)	(0.345,0.420)	(0.005,0.110)
			[0.000]			[0.063]
Owner's Gender	0.864	0.792	0.077	0.865	0.819	0.043
	(0.843,0.884)	(0.772,0.812)	(0.047,0.107)	(0.844,0.885)	(0.799,0.840)	(0.015,0.071)
			[0.000]			[0.006]
Owner's Age	52.27	51.58	1.397	51.88	52.21	-0.219
	(51.49,53.07)	(50.80,52.37)	(0.241,2.526)	(51.10,52.65)	(51.44,52.99)	(-1.292,0.850)
			[0.036]			[1.000]
Ethnic Majority	0.724	0.829	-0.111	0.787	0.830	-0.047
	(0.701,0.746)	(0.806,0.852)	(-0.142,-0.079)	(0.765,0.808)	(0.809,0.852)	(-0.078,-0.017)
			[0.000]			[0.005]
Employed	0.786	0.816	-0.038	0.814	0.828	-0.013
	(0.764,0.809)	(0.794,0.839)	(-0.070,-0.007)	(0.793,0.836)	(0.807,0.849)	(-0.043,0.017)
			[0.035]			[0.786]
Salaried	0.256	0.345	-0.089	0.232	0.340	-0.120
	(0.231,0.281)	(0.320,0.370)	(-0.124,-0.053)	(0.207,0.257)	(0.315,0.365)	(-0.155,-0.085)
			[0.000]			[0.000]
Work for Gov. Self	0.119	0.251	-0.132	0.122	0.250	-0.132
	(0.098,0.140)	(0.231,0.271)	(-0.161,-0.103)	(0.100,0.143)	(0.229,0.272)	(-0.162,-0.102)
			[0.000]			[0.000]
Work for Gov. Self or Relatives	0.229	0.334	-0.104	0.196	0.346	-0.149
	(0.204,0.254)	(0.309,0.359)	(-0.139,-0.068)	(0.171,0.220)	(0.322,0.370)	(-0.183,-0.115)
			[0.000]			[0.000]

Notes: This table reports the average characteristics of the 20% most and least affected units defined by deciles of the conditional average treatment proxy, for applications of random forest and boosting approaches. Columns 3 and 6 report the difference between the most and least affected units and the corresponding confidence interval and p-values. Medians over 100 split. 90% confidence interval in parenthesis. P-values for the hypothesis that the parameter is equal to zero in brackets.

9 Conclusion

This paper provides experimental evidence that lowering tax rates can drastically improve extensive margin compliance in a low-capacity, low-compliance setting. We also find that lower tax rates also reduce corruption and show no evidence of crowd-out of informal taxes. Preliminary machine learning analysis reveals that poorer, more cash constrained and less socially and politically connected households are more responsive to tax rate reductions in terms of tax compliance.

Local governments in the developing world struggle to raise sufficient revenues to fund public goods

and services that are key inputs to the development process. Improving revenues requires identifying the tax instruments that can maximize collections, one of which is the choice of tax rates. Future work in low tax capacity settings can explore how tax rates interact with the nature of collection — e.g., manual visits or e-filing — and strength of enforcement.