Local Public Goods and Property Tax Compliance: Evidence from Residential Street Pavement

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Abstract

Does property tax compliance improve when the supply of local public goods expands? This paper uses administrative property tax records and information on the rollout of first-time asphalting of streets in inhabited residential neighborhoods in Mexico to show that providing local public goods can improve property tax compliance rates, by 9 pp (ITT) or 17 pp (LATE). In addition, it uses survey data to show that providing local public goods increases satisfaction with the local government, between 8% (ITT) and 13% (LATE). Why does property tax compliance improve when the supply of local public goods expands? Our explanation is that when citizens observe public goods being delivered, they update their beliefs about the government's quality in public goods provision and become more likely to comply. We build a model of tax compliance and satisfaction with the government, where citizens differ in their civic-mindedness and beliefs about the government. Citizens update their beliefs based on whether the government delivers (provides pavement) or not. The key testable prediction is that: the change in beliefs due to observing the delivery of the public good (street pavement) is less sensitive for citizens with extreme priors, and more sensitive for citizens with average priors. Testing this prediction allows us to disentangle learning from other potential mechanisms, such as reciprocity or wealth effects.

JEL Classification Codes: H26, H41.
Keywords: taxpayer behavior, property tax compliance, local public goods.

1 Introduction

> "*Why pay taxes? Why should I send them taxes when they aren't supplying services? It is sickening. ... Every time I see the tax bill come, I think about the times we called and nobody came.*" Fred Phillips, Incompliant Detroit Resident[1]

The problem of tax compliance is one of paramount importance for the proper functioning of a modern market economy, mainly because tax compliance is a necessary condition to guarantee the efficient provision of public goods.[2] In this paper, we ask two questions: Can the provision of public good increase tax compliance? Why?

Can the provision of public good increase tax compliance? We take advantage of a randomized trial involving the provision of a localized public good (first-time asphalting of streets in inhabited residential neighborhoods)[3] to investigate its impacts on property tax compliance and satisfaction with the local government, combining administrative tax records and survey data on satisfaction with the government, before and after the provision of street pavement.

The random pavement of streets, or the random provision of localized public goods, took place in Acaycuan (Mexico) between 2006 and 2012. We find that street pavement increases both property tax compliance and the satisfaction with the local government. The estimated increase in tax compliance is between 9 pp (ITT) and 17 pp (LATE); the estimated increase in satisfaction with the local government is relevant too, between 8% and 10% of the average satisfaction level.

Why does the provision of public good increase tax compliance? In economics, tax compliance has traditionally been studied through the lens of the Becker theory of crime (*i.e.*, Allingham and Sandmo (1972)) in which tax compliance is a function of the taxes due, the probability of detection, risk aversion, and penalties levied if the person is caught cheating. However, as emphasized in other disciplines (*i.e.*, Levi (1989)), taxes are an essential part of the social contract – they are paid in exchange for services provided by the state and if those services are not forthcoming or funds are diverted, then citizens may be less likely to comply with their tax duties. As highlighted in Besley and Persson (2014), with pervasive corruption, the average citizen may be less inclined to comply with the taxes already in place.

[1] Quote from MacDonald and Wilkinson, (Macdonald and Wilkinson, 2013).

[2] Samuelson (1954) shows that the *private* provision of public goods will be inefficiently low because each individual will have an incentive to "free ride" on the private purchases of others.

[3] Asphalting of streets is also known as road surfacing or pavement.

The explanation we put forth in this paper is that localized public good provision can have a signaling value for taxpayers regarding (the unknown) government's ability to deliver public goods. In short, when citizens observe public goods being delivered, they update their beliefs about the government's quality in public goods provision and, in turn, become more likely to comply. Inspired by the recent work of (Besley, 2020), we build a model of tax compliance and satisfaction with the government, where citizens differ in their civic-mindedness and beliefs about the government. Citizens updated their beliefs based on whether the government delivers (provides pavement) or not. The key insight of the model is its unique testable prediction: the change in beliefs due to observing the delivery of the public good (street pavement) is less sensitive for citizens with extreme priors, and more sensitive for citizens with average priors. Testing this prediction allows us to disentangle learning from other potential mechanisms, such as reciprocity or wealth effects.

In a recent review of literature, Slemrod (2019) states: "*In sum, a plethora of studies* ***have failed to find evidence*** *that appeals to tax morale, defined broadly, affect taxpayer behavior in the short run when delivered via a one-time mailing.*". Luttmer and Singhal (2014) argue that finding no effect is consistent with either tax morale not mattering, or these messages not effectively changing it. According to our findings, it is not enough to tell individuals about what the government does with their taxes, individuals need to actually observe what taxes are spent on, they need to see the delivery of the public goods.

The paper proceeds as follows. In section 2 we review the existing literature on the determinants of tax compliance. Section 3 presents a model of tax compliance and satisfaction with the government. Section 4 describes the data. Section 5 contains the the results, and section 6 concludes.

2 Related Literature

2.1 Beckerian Models of Tax Compliance

Standard expected utility model: In the standard model, tax compliance is a function of the taxes due, the probability of detection, risk aversion, and penalties levied if the person is caught cheating (Allingham and Sandmo, 1972; Srinivasan, 1973; Becker et al., 1987; Cowell and P.F. Gordon, 1988; Alm et al., 1992; Andreoni et al., 1998; Slemrod and Yitzhaki, 2002; Alm et al., 2012, 2014; Slemrod, 2019).

2.2 Beyond "Pure" Beckerian Models

Other explanations emphasize some aspect of **tax morale** – (non-pecuniary) motivations to paying taxes in addition to legal obligations, as well as deviations from expected utility maximization: reciprocal motivations, intrinsic motivations, and peer behavior.

Reciprocal motivations Taxes paid in exchange for services provided by the state. If those services are not forthcoming or funds are diverted, then citizens may be less likely to comply with their tax duties (Levi, 1989; Cowell and P.F. Gordon, 1988; Alm et al., 1992; Daude et al., 2012; Alm et al., 2014; Luttmer and Singhal, 2014). We find Beckerian **models** that incorporate the expenditure side of government activity (Cowell and P.F. Gordon, 1988; Alm et al., 1992; Besley, 2020; Krause, 2020) and **lab experimental** evidence suggesting that some individuals pay taxes because they recognize that payment is necessary to receive government goods (Becker et al., 1987; Alm et al., 1992). Much of recent experimental studies try to affect the perceived level of reciprocity of taxpayers, usually through information treatments via letters, finding mixed results. Castro and Scartascini (2015) run a field experiment in Junn, Argentina, where they randomly included messages in the municipal property tax bill of 23,000 individual taxpayers. In one of the treatments they gave taxpayers information about specific public goods in their community that had recently been provided by the local government. They find no effects. Chirico et al. (2016) sent reminder letters to tardy property taxpayers that their payments are due. The letters included messages about taxpayer's liabilities, accrued interest and penalties, plus additional treatments, one of which appealed to the positive community benefits in provided public services that the taxpayers dollars provide. The public service appeal had positive and significant effects. Hallsworth et al. (2017) find that late payment of taxes in the United Kingdom falls in response to reminder letters that emphasize the ways in which tax revenue finances public goods. The authors find that wording that emphasized that the individual was in the minority of people who have not yet paid was the most effective in getting individuals to remit their taxes. Meiselman (2018) use experimental mailings distributed in Detroit to 7,142 suspected resident nonfilers of income taxes. One of the treatments included a civic pride message reminding individuals of services provided by tax dollars. The civic pride treatment had no effect. They also investigate the impact of treatment mailings on the behavior of untreated neighbors (neighbors within 50 meters) and find no evidence of geographic network effects. Bott et al. (2020) find positive effects in three "moral suasion" treatments that highlight the public goods on which tax revenues are spent. The moral appeals mainly worked on the intensive margin by increasing the amount reported by those who report any foreign income. Neither moral appeal treatment had a statistically significant effect in the subsequent year. Bérgolo et al. (2017) carried out a large-scale field experiment

involving value-added-tax compliance of over 20,000 Uruguayan small-and medium-sized firms. Firms in a control group received a letter from the tax authority with generic information about taxes. Firms in the treatment arm received the same letter with an added paragraphs, conveying information about past audit rates, the penalty levels for tax evasion, and a description of all the public goods that could be provided if tax evasion was lower. The message about public goods did not have a statistically significant and robust effect on tax compliance.

There are also studies that exploit **actual changes in the provision of public goods**. For instance, Carrillo et al. (2017) study the impact of a randomized natural experiment in an Argentine municipality where four hundred taxpayers that complied with their property taxes were rewarded with a new sidewalk in front of their property and public recognition in local media. They found that being selected as a lottery winner had a positive and persistent direct effect on future compliance. They also find spillover effects. Because the reward can only be received by those in good standing, neighbors have direct and concrete evidence that people around them are paying the tax. They find that neighbors of those who receive the reward comply more, and these effects can be even larger than the direct effects. More recently, Krause (2020) cross-randomize both tax collection and public goods across a large city in Haiti. Hand-delivering property tax invoices reduces individual tax compliance by 48%, but increases independently observed measures of localized political violence. Providing a visible public good (namely municipal garbage removal) increases tax compliance by 27%, and reduces localized political violence. Using geographic variation to test for spillovers from properties not receiving public goods (limiting analysis to properties farther away from bloc boundaries) the study finds that main results may be an underestimate. There are no negative responses from properties farther removed from the public goods treatment.

Theoretical contributions include Besley (2020), who models 'tax morale' to be dependent upon the level of public goods provided, so that in low-capacity states with little-to-no public goods the incentive further depresses tax compliance. Tax compliance is affected by the civic-mindedness of citizens and by the composition of government spending, i.e. public goods versus transfers. The latter is affected by the value of public goods and the cohesiveness of political institutions. Civic culture evolves over time affecting the relative payoffs of civic-minded and materialistic citizens. The paper gives conditions under which this leads to an increase in social capacity. Krause (2020) extends Besley (2020) by modifying the 'civic-minded' incentive so that under some circumstances the net effects can be crowded-out by enforcement. Also incorporates a 'sense of obligation' to motivate compliance in a low-capacity state where punishment is less credible when caught evading. The taxpayer chooses a level of evasion to maximize the monetary value of the sum of public goods received plus net income. The perceived cost for the taxpayer,

is adjusted based on three non-pecuniary incentives: a sense of obligation, perceived fairness of the tax, the social incentive.

Intrinsic motivations Taxes are paid because they provide additional utility or individuals have *duty-to-comply* preferences. Dwenger et al. (2016) find evidence that, in contexts where tax enforcement is limited or nonexistent, and private rewards are minimal, people still comply. The study is based on a randomized field experiment that introduces either positive deterrence or the provision of recognition and other nonpecuniary incentives in the context of a local Church tax in Germany. They find that about 20 percent of individuals remitted their true tax liability in the baseline case with no deterrence in place. Recognition through social rewards for compliance caused some people to further increase their payments, but the provision of information on social norms or moral appeal had no impact. Besley et al. (2019) propose a tax-compliance model where individuals are motivated to pay by three factors: i. the threat of punishment, ii. intrinsic motivation, and iii. adherence to a social norm. Compliance depends on the lagged population fraction of evaders. To test the model they exploit a natural experiment in the UK where a poll tax was introduced in the early 1990s. The tax was deemed unfair, so it triggered mass evasion, which provoked restoration of a property-based tax system after three years. They use council level variation in compliance between 1980-2000. There is not a clear identification strategy; mostly a calibration exercise. In regards to intrinsic motivations, the authors interpret hikes in tax evasion as proxying for shocks to the intrinsic motives to pay.

Political institutions, cultural norms, and perceptions about governance can affect the strength of these intrinsic motivations (Besley and Persson, 2014; Luttmer and Singhal, 2014). Cummings et al. (2009), using a lab experiment, finds that if perceptions of fairness and efficacy are higher (good governance), compliance is higher. Kountouris and Remoundou (2013); DeBacker et al. (2015) show evidence that differences in cultural norms within a common enforcement environment explain differences in tax evasion. Both use variation in cultural background, either of first generation immigrants or of owners of corporation.Cullen et al. (2018) find evidence in a quasi-experimental setting that **political alignment** with the party of the presidential administration in the United States has a positive impact on compliance. They analyze data from 1999, 2001, 2007, and 2009 -years surrounding the turnover elections of 2000 and 2008to study how counties that consistently vote either Democrat or Republican change their evasion behavior following a change in the party of the president. The authors examine changes in reported income at the county level by source of income as a function of political alignment. Moving into alignment results in a 0.4 percent increase in reported adjusted gross income (i.e., evasion declines), coming mostly from a 3.5 percent increase in business income.

Peer behavior Individuals may be influenced by peer behavior and the possibility of social recognition or sanctions from peers. When compliance is a norm, taxpayers may also worry about the reputation cost among peers of being caught evading. Del Carpio (2014) implements a field experiment on property tax collection in Peru. She finds that an intervention combining information about peer compliance and a payment reminder leads to a small and statistically insignificant increase in compliance relative to a baseline intervention consisting of only a payment reminder. Hallsworth et al. (2017) finds that late payment of taxes in the United Kingdom falls in response to reminder letters that informed participants about the high levels of compliance in the Country. Perez-Truglia and Troiano (2018) sent letters to 34,334 tax delinquents in three U.S. states. They randomized some of the information contained in the letter to vary the salience of financial penalties, shaming penalties, and peer comparisons. Information about the delinquency of neighbors had no effect on payment rates. In Besley et al. (2019) model, norms matter because tax payers care about their reputation should evasion be seen by others. Average evasion returned only gradually towards pre-poll-tax levels, particularly in councils that had high evasion during the poll tax period, consistent with a social norm effect. More recently, Drago et al. (2020) study the spread of compliance behavior in neighborhood networks in Austria. They exploit a field experiment that varied the content of mailings sent to potential evaders of TV license fees. They find strong treatment spillover: untreated households are more likely to switch from evasion to compliance in response to mailings received by their network neighbors (measured in terms of distance to treated units). The effect is concentrated among close neighbors of the targets and increases with the treated households' diffusion centrality. Local concentration of equally treated households implies a lower spillover.

3 Model of Tax Compliance and Government Satisfaction

3.1 Provision of Public Goods and Beliefs About Government Efficiency

Efficiency. The local government uses tax revenue to provide public goods. We assume public goods take the form of new roads. Governments can differ on how efficient they are in transforming resources into roads. In particular, only a fraction $(1-\theta^g)$ of total per capita expenditure, G, goes to constructing the roads; the rest is either wasted or stolen. θ^g is not observed by citizens, but the distribution of θ^g across governments is known to be a standard uniform.

We normalize the cost per capita of building one road to one. The total number of roads built, N_R[4], is

[4]We allow for the possibility that the last road is only partially built, so that $N_R \in \mathbb{R}_+$.

$$N_R = (1 - \theta^g)G. \tag{1}$$

The amount G depends on total tax revenue, which in turn depends on tax compliance. We defer this discussion until the next subsection and, for the moment, take G as given.

Each new road is observed by a fraction μ of the population (i.e. those close to were it was constructed). To simplify, we assume there is a continuum of citizens of size 1 and that the probability of observing more than one new road is zero (i.e. the city is large enough). Following our empirical strategy, we assume government allocate roads randomly. The probability that a citizen will observe a road ($R = 1$), given a level of expenditure, is

$$\pi(\theta^g|G) \equiv \Pr(R = 1|\theta^g, G) = \mu(1 - \theta^g)G. \tag{2}$$

This probability is increasing in the level of per capita expenditure ($\frac{\partial \pi}{\partial G} > 0$) and decreasing in inefficiency of the local government ($\frac{\partial \pi}{\partial \theta^g} < 0$).

Beliefs. Before any expenditure is made, each citizen has a prior belief, θ_0, about the government's type θ^g. Individual beliefs are also driven from the same uniform distribution as the government's type. Given these assumptions, the pre-expenditure share of the population that believes the government is of type $\underline{\theta}$ or better is $S_0(\underline{\theta}) \equiv \Pr(\theta_0 \leq \underline{\theta}) = \underline{\theta}$. However, observing a new road provides new information about the governments' type, so citizens can update their priors once roads are built. We show in Appendix B.1 that, for citizens that observe a new road, the share that believes the government is of type $\underline{\theta}$ or better is

$$S_1^1(\underline{\theta}) \equiv \Pr(\theta^g \leq \underline{\theta}|R = 1, G) = \frac{\Pr(R = 1|\theta^g \leq \underline{\theta}, G)}{\int_0^1 \pi(\theta|G)d\theta} \times \underline{\theta} = (2 - \underline{\theta})\underline{\theta}. \tag{3}$$

Note $S_1^1(\underline{\theta}) \geq \underline{\theta} = S_0(\underline{\theta})$, so S_0 first-order stochastically dominates S_1^1: a higher share of the population that observes the new roads believes the government is of a better type (see Panel (a) of Figure 1).

Following a similar argument, for citizens that do not observe a new road ($R = 0$), the share that believes the government is of type $\underline{\theta}$ or better is

$$S_1^0(\underline{\theta}) \equiv \Pr(\theta^g \leq \underline{\theta} | R = 0, G) = \frac{\Pr(R = 0 | \theta^g \leq \underline{\theta}, G)}{\int_0^1 (1 - \pi(\theta|G)) d\theta} \times \underline{\theta} = \left(\frac{2 - \mu G(2 - \underline{\theta})}{2 - \mu G} \right) \underline{\theta}. \quad (4)$$

In this case the opposite happens: S_1^0 first-order stochastically dominates S_0, and a higher share of the population that do not observe the new roads believe the government is of a worst type.

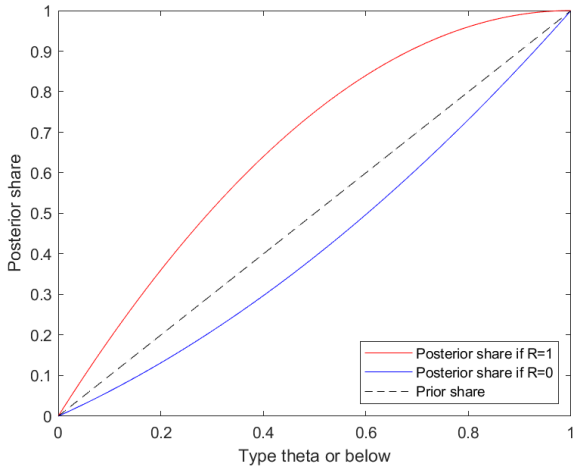
Finally, the overall (unconditional) share of the population that believes the government is of type $\underline{\theta}$ or better is a weighted average between those that observe the roads and those that do not. The weights are given by the probabilities defined in Equation 2, which depend on the realized value of θ^g. We show in Appendix B.1 this share is

$$\begin{aligned} S_1(\underline{\theta}) &\equiv S_1^0(\underline{\theta}) + \pi(\theta^g|G)\big(S_1^1(\underline{\theta}) - S_0^1(\underline{\theta})\big) \\ &= \frac{2 - \mu G\Big(2(1 - \underline{\theta})\theta^g + \underline{\theta}\Big)}{2 - \mu G} \times \underline{\theta}. \end{aligned} \quad (5)$$

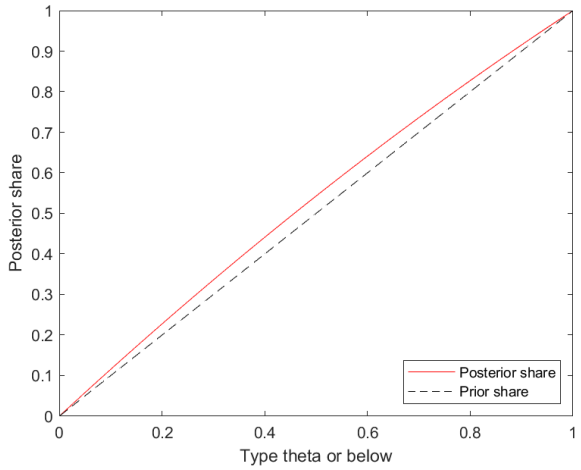
If $\theta^g < \frac{1}{2} = \mathbb{E}(\theta^g)$, that is, if the government's type is better than an average government, S_0 first-order stochastically dominate S_1, and the average perception about the government type improves after the roads are built. Otherwise, the average perception decreases (see Panels (b) and (c) of Figure 1).

Figure 1: Share of population the believes government is of a type below $\underline{\theta}$
Parameter values: $G = 6, \mu = 0.1$

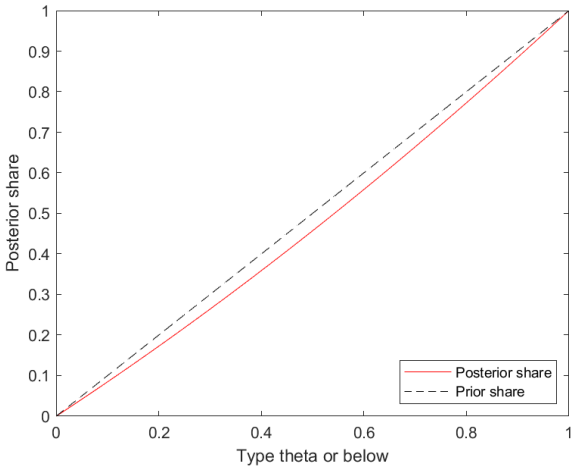
(a) Conditional on R



(b) Overall, $\theta^g = 0.3$



(c) Overall, $\theta^g = 0.7$



Support for the government. People support the local government if, among others, they believe it is of a good type (i.e. is efficient). Any monotonic decreasing function of θ^g could be used. In that case,

1. For those citizens that observe the new roads, government support will increase relative to a situation in which they make their decisions based on prior beliefs.

2. For those citizens that do not observe the new roads, government support will decrease relative to a situation in which they make their decisions based on prior beliefs.

3. The support can increase or decrease, depending on the realized type of the government. If the government is better than average ($\theta^g > \mathbb{E}(\theta^g = 0.5)$), support increases, otherwise, support decreases.

Let $\Delta S^j(\underline{\theta}) \equiv S_1^j(\underline{\theta}) - S_0(\underline{\theta})$ for $j \in \{0, 1\}$ be the change in the share of population that

believes the government is of type $\underline{\theta}$ or better, conditional on observing (not observing the road), relative to the prior distribution.

1. $\Delta S^1(\underline{\theta}) = \underline{\theta}(1-\underline{\theta})$. The function is positive and concave, with a maximum at $\underline{\theta} = 1/2$).
2. $\Delta S^0(\underline{\theta}) = \underline{\theta}(\underline{\theta}-1)\frac{\mu G}{2-\mu G}$. The function is negative[5] and convex function with a minimum at $\underline{\theta} = 1/2$).
3. $\Delta S(\underline{\theta}) = \underline{\theta}\big(2\underline{\theta}(\theta^g-1)+1-2\theta^g\big)\frac{\mu G}{2-\mu G}$. The function is positive and concave (negative and convex) if $\theta^g \leq 1/2$ ($\geq 1/2$). Takes a maximum (minimum) at $\underline{\theta} = 1/2$).

The implication is that change in beliefs are less sensitive for citizens with extreme priors, and more sensitive for citizens with average priors.

3.2 Tax Compliance and Tax Revenue

Citizens. Two parameters determine citizen's preferences: first, whether they are *civic-minded*, captured by $\lambda \in \{0, \bar{\lambda}\}$; second, their prior belief about the government's type θ_0. Citizens choose whether to comply or not, $n \in \{0, 1\}$, with property taxes, defined as a rate t over the property value w, assumed to be equal across agents.

Let θ_x^R be the posterior belief of a citizen about the government's type, θ^g, conditional on whether they observe a new road or not ($R \in \{0, 1\}$), and their prior belief ($\theta_0 = x$)[6]. Following Besley (2020), the problem of each citizen is

$$\max_{n\in\{0,1\}} y - w(1-n)\left[t - \lambda\left(1-\theta_x^R\right)G\right)\Big], \tag{6}$$

where y is gross income. Equation 6 captures the idea that the effective tax rate depends on how much people value public expenditure. If a citizen is not *civic-minded* ($\lambda = 0$), the effective tax rate is t; but if the citizen is *civic-minded* ($\lambda = \bar{\lambda} > 0$), the effective tax rate is $\left[t - \lambda\left(1-\theta_x^R\right)G\right)\Big]$. In this case public expenditure is discounted by $(1-\theta_x^R)$ because people only care about what they believe is actually spent in public goods (i.e. not wasted or stolen).

Tax Compliance. There are two possibilities depending on the value of λ:

[5] $2 - \mu G \geq 1$. See constraints in Section B.2

[6] Note this implies roads are built *before* tax intake. We are assuming governments build the roads at the beginning of the period, but collect taxes and pay for them at the end of the period. In equilibrium, what is spent at the beginning has to be equal to the tax intake at the end.

1. if $\lambda = 0$, then $n^* = 1$: a citizen that is not *civic-minded* will never comply.[7] Let $\Pr(\lambda = \bar{\lambda}|\theta_0) = \Pr(\lambda = \bar{\lambda}) = \alpha$ be the proportion of the population that is *civic-minded*, assumed to be exogenously determined and independent of θ_0.[8] There will be at least a fraction $(1 - \alpha)$ of the population that will not comply.

2. if $\lambda = \bar{\lambda}$, a citizen complies ($n^* = 0$) if

$$\theta_x^R \leq 1 - \frac{t}{\bar{\lambda}G}. \tag{7}$$

   This implies that a citizen must be *civic-minded* and believe the government is good enough to comply, where the latter is influenced by whether she observes the new roads or not.

For a given level of public expenditure, the share of the population that complies (henceforth the compliance rate) corresponds to the share of the population that are *civic-minded* and for which Equation 7 holds. This is fully determined by equation 5, evaluated at $\underline{\theta} = 1 - \frac{t}{\bar{\lambda}G}$, and by α. In particular,

$$\begin{aligned} C(G;\Theta) &\equiv \Pr\left(\theta_x^R \leq 1 - \frac{t}{\bar{\lambda}G} | \lambda = \bar{\lambda}\right) \Pr(\lambda = \bar{\lambda}) \\ &= \Pr\left(\theta_x^R \leq 1 - \frac{t}{\bar{\lambda}G}\right) \alpha \\ &= \left(1 - \frac{\mu t(2\theta^g - 1)}{\bar{\lambda}(2 - \mu G)}\right)\left(1 - \frac{t}{\bar{\lambda}G}\right)\alpha. \end{aligned} \tag{8}$$

Where $\Theta = (t, \mu, \bar{\lambda}, \alpha, \theta^g)$ is the set of exogeneous parameters. From the stochastic dominance analysis in the previous section, we can directly derive some implications of observing roads on tax compliance.

1. For those citizens that observe the new roads, tax compliance will increase relative to a situation in which they make their decisions based on prior beliefs. This is because, on average, a higher share of this group will believe the government is of a better type.

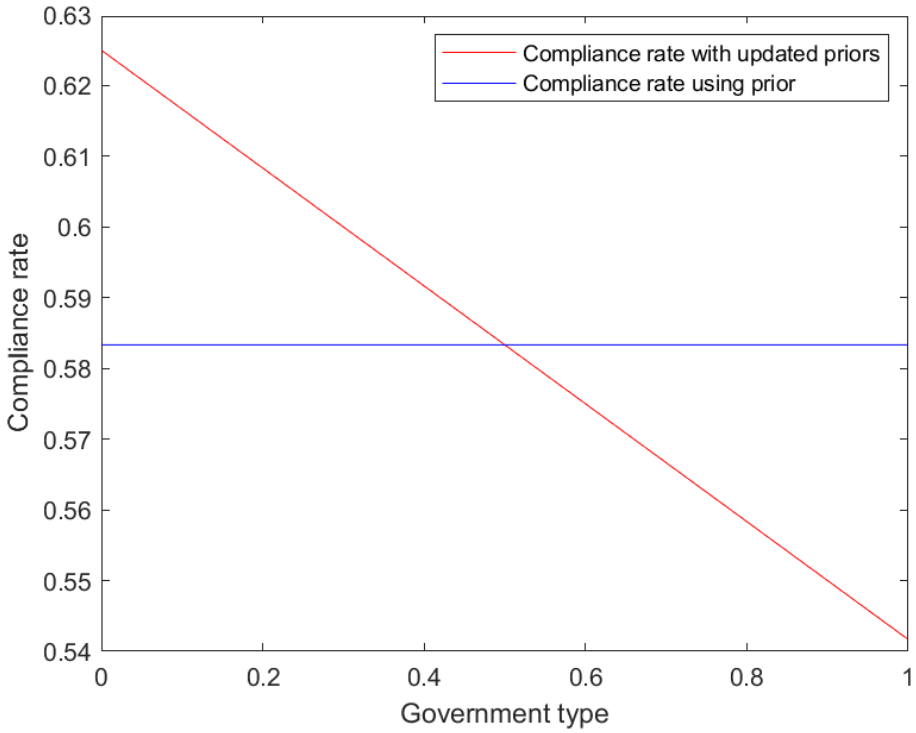
2. For those citizens that do not observe the new roads, tax compliance will decrease relative to a situation in which they make their decisions based on prior beliefs. This is because, on average, a lower share of this group will believe the government is of a better type.

[7] This is in part due to the fact that we assume that non-compliance is not punished, reflecting the environment in the city of Acayucan.

[8] We can cite Bowles (2020) argument that civic culture evolves slowly, but the latter assumption might be revised in an extension.

3. The overall compliance rate can increase or decrease, depending on the realized type of the government. In particular, if the government is better than average ($\theta^g > \mathbb{E}(\theta^g = 0.5)$), compliance increases, otherwise, compliance decreases.

Figure 2: Compliance Rate, $C(G)$
Parameter values: $G = 6, \mu = 0.1, t = 0.1, w = 100, \bar{\lambda} = 0.1, \alpha = 0.7$.



Tax Revenue and Government Expenditure. The maximum tax revenue per capita that can be raised with full compliance is tw, but only a fraction of citizens comply. The actual per capita tax revenue is:

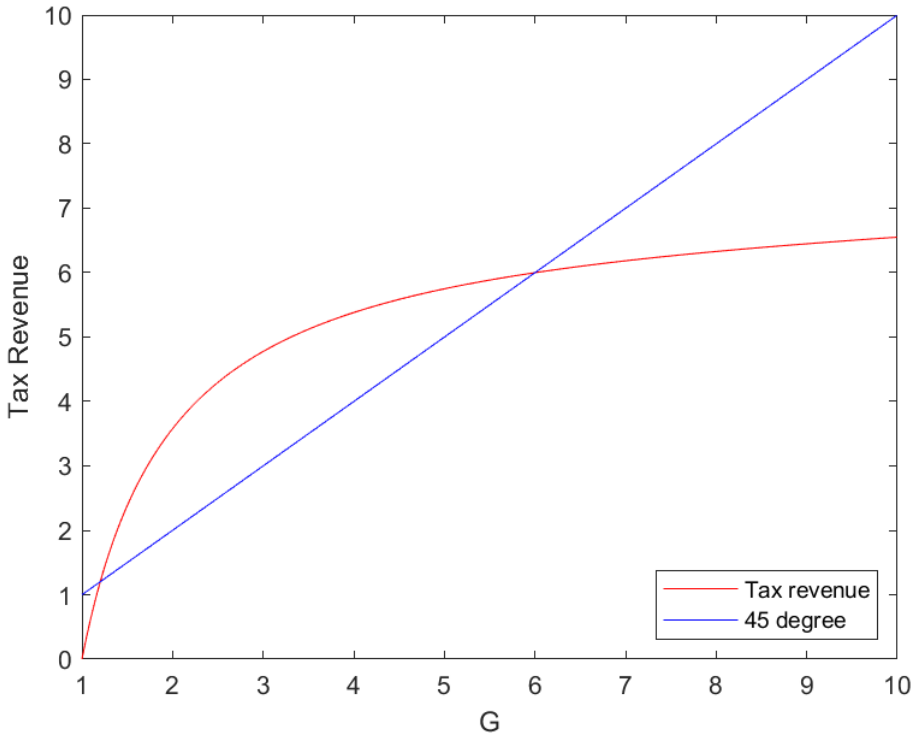
$$T(G) = twC(G). \tag{9}$$

To close the model, we assume that governments have to satisfy the budget constraint:

$$G = T(G). \tag{10}$$

$T(G)$ is non-linear, so it's not easy to find a closed-form solution. The solution implies finding a fixed point (under certain restriction on the values of G).

Figure 3: Equilibrium
Parameter values: $\mu = 0.1, t = 0.1, w = 100, \bar{\lambda} = 0.1, \alpha = 0.7$.



Two possible equilibria emerge: one with low tax revenue and low public good provision, and one with high tax revenue and high public good provision.

4 Data

4.1 Property tax data

Administrative property tax data were obtained for the city of Acayucan for the years 2005-2012. There are about 16,000 plots in the city. The government-appraised property value is on average 215,092 pesos (17,174 in 2012 USD$). Property values were not updated during the study years – including for properties that received pavement. Instead, tax rates were increased for all properties to keep up with the inflation rate. Annual property tax invoices amounted to an average 196 pesos (15 in 2012 USD$). For every plot in the city, we observe whether the property tax was paid in the corresponding calendar year. On average 74% of properties paid their property taxes in the calendar year they were due.

4.2 Street asphalting

The data we use come from the city of Acayucan - one of Mexico's 56 metropolitan areas encompassing three municipalities with a combined population of 105,000 (INEGI, 2007).

The city has a central core where most streets have been paved, and outer sections where street pavement is gradually rolled out. Residences are built and inhabited long before streets are paved, as shown in Figure **??**. This situation is common throughout Mexico and other Latin American countries (Fernandes, 2011), suggesting that the results from our analysis are potentially relevant for many other countries.

Municipal governments in Mexico are responsible for most of the elements of their urban infrastructure. Each three-year administration has ample leeway as to budgetary allocations. The municipal budget consists mainly of transfers from general funds obtained from the federal value-added tax, the federal income tax, and oil revenues. Less than 10% of the municipal budget derives from local taxes (consisting of the property tax and business-permit fees). Property-tax receipts, especially in small cities, play a less significant role in Mexico than they do in the U.S. Cadastral property valuations are very low and rarely updated.

As in other Mexican cities, the local government expands its pavement grid over time via "street asphalting projects", each defined as a contiguous set of unpaved street segments connecting to the existing pavement grid. The intervention consists of first-time asphalting of residential non-arterial streets, varying in width from 8 to 15 meters, and allowing for two lanes of vehicular traffic and one or two lanes for parking. The pavement material used is either hot-mix asphalt concrete or portland cement reinforced concrete. Like most infrastructure, the lion's share of costs are borne initially: the transportation literature estimates annual cost of maintenance to be only 1.5% of construction costs (BITRE, (**?**)), or 0.3%-0.7% using the cost estimates in Chen et al. (2003). After a street is paved, maintenance is a municipal responsibility and is funded from general revenues.

Street pavement in an urban context provides multiple services: it facilitates vehicle, pedestrian and cyclist movement and access, provides accessible space for vehicle parking, allows commercial vehicles to deliver goods, and has a significant impact on the visual appearance of the area. Moreover, fieldwork confirmed that congestion was not a concern − as expected given the residential nature of the streets. A valid question is then why the market does not provide street pavement to begin with. One reason is that residential street pavement is a pure public good (non-rivalrous and non-excludable), and hence, free rider incentives prevent private provision.

The city engaged in 26 street pavement projects between 2007 and 2012. Detailed data on street asphalting completion projects by the municipality allows us to identify plots that present a change in street pavement status using plot addresses from the property tax data database. The pavement projects were rolled out randomly from 2006-2009, and although the experimental rollout ceased in 2009, we can still use the random assignment for an instrumental variables analysis.

5 Results

5.1 Property tax compliance, property tax and property values in 2005 and 2012

Table 1 shows the average property tax and property values in 2005 and 2012, and a negative time trend in property tax compliance, which decreased from 0.89 to 0.68 between 2005 and 2012. To contextualize these magnitudes, a range of property tax collection rates across different Latin American cities are displayed in Table 2.

Table 1: Means [Standard Deviations]

	2005	2012
Property Tax Compliance	0.89	0.68
	[0.31]	[0.47]
Property Tax (Pesos)	151.97	200.21
	[46.00]	[42.70]
Property Value (Pesos)	140,707	178,454
	[168,453.4]	[188,177.8]
N	735	735

***p < 0.01, **p < 0.05, *p < 0.1.

Table 2: Property Tax Collection in Latin American cities

City	Country	Year	Property Tax Collection Rate
Acapulco	México	2001	0.81
Lima	Perú	2010	0.80
Brasilia (DF)	Brazil	2008	0.77
Bucamaranga	Colombia	2010	0.76
Chacao	Venezuela	2003	0.76
Guayaquil	Ecuador	2001	0.75
Rosario	Argentina	2011	0.75

Source: Selected cities from *Lincoln Institute of Land Policy* report.

5.2 Baseline Balance in Property Tax Compliance and Satisfaction with the Government

The assignment of streets to be paved was randomly assigned, as discussed by Gonzalez-Navarro and Quintana-Domeque (2016), and consistent with the randomization being successful in balancing the characteristics of assigned-to-be-treated and -control units, we find evidence of baseline balance (2005) in terms of property tax compliance, and the log of property tax and property values, in Table 3, and in terms of satisfaction with the government (local, state, federal), in Table 4.

Table 3: Baseline Balance in 2005: tax compliance

	Means		
	$z_s = 0$	$z_s = 1$	Difference in Means
Property Tax Compliance	0.89	0.88	−0.01
	[0.31]	[0.32]	(0.03)
Log Property Tax	5.01	4.99	−0.02
	[0.19]	[0.15]	(0.02)
Log Property Value	11.28	11.15	−0.13
	[1.25]	[1.21]	(0.18)
N	449	286	735

***p < 0.01, **p < 0.05, *p < 0.1.

Standard errors in parentheses clustered at project level (47 clusters).

Table 4: Baseline Balance in 2005: satisfaction

Variable	ITT=1	ITT=0	*Diff.*
Satisfaction with	2.30	2.33	−0.035
local government	(0.060)	(0.065)	(0.092)
	[439]	[366]	[805]
Satisfaction with	2.48	2.54	−0.082
state government	(0.041)	(0.038)	(0.052)
	[439]	[366]	[805]
Satisfaction with	2.54	2.54	0.000
federal government	(0.044)	(0.046)	(0.061)
	[439]	[366]	[805]
Knows who paves streets	0.858	0.883	−0.026
	(0.015)	(0.021)	(0.026)
	[439]	[366]	[805]

***p < 0.01, **p < 0.05, *p < 0.1.

Seemingly unrelated regression estimates for satisfaction. Bootstrapped standard errors clustered at the pavement-project level in parentheses. Number of observations in brackets.

5.3 Effects of Public Good Provision on Property Tax Compliance and Satisfaction with the Government

In Table 4 we estimate ITT and LATE effects on property tax compliance in 2012, controlling or not for tax compliance in 2005. First, households in streets assigned to be paved are 9 pp more likely to comply with their property tax in 2012; scaling up this effect up by the fraction of compliers, we find that the effect of being on a paved street on property tax compliance in 2012 among compliers is 17 pp. These effects are between 10 and 20% the compliance rate in 2005. According to Table 5, indirect ITT effects can be ruled out.

Table 5: Pavement and Tax Compliance

		ITT and LATE			
	Baseline Balance	*Without Lagged Compliance*		*With Lagged Compliance*	
Tax compliance in:	2005	2012	2012	2012	2012
	OLS	OLS	2SLS	OLS	2SLS
z_s (street assigned to be paved)	−0.008	0.093**	—	0.098***	—
	(0.031)	(0.036)		(0.031)	
p_s (paved in 2012 instrumented with z_s)	—	—	0.168**	—	0.177***
			(0.077)		(0.065)
Tax compliance in 2005	—	—	—	0.555***	0.572***
				(0.048)	(0.046)
Observations	735	735	735	735	735

***p < 0.01, **p < 0.05, *p < 0.1.

Standard errors in parentheses clustered at project level (47 clusters).

Table 6: Indirect ITT effects

Tax compliance in:	2005	2012	2012
$z_{b,s}$	−0.004	0.063	0.065
	[0.021]	[0.031]**	[0.029]**
	(0.029)	(0.037)*	(0.035)*
	p=0.9533	p=0.1667	p=0.16
$z_{b,s}^{neverpaved}$	0.021	−0.021	−0.031
	[0.027]	[0.042]	[0.041]
	(0.036)	(0.057)	(0.067)
	p=0.78	p=0.7933	p=0.8733
$z_{b,s}^{alwayspaved}$	−0.037	−0.051	−0.033
	[0.031]	[0.043]	[0.041]
	(0.034)	(0.043)	(0.035)
	p=.2867	p=0.36	p=0.4067
Tax Compliance in 2005	—	NO	YES
N	1,552	1,552	1,552

***p < 0.01, **p < 0.05, *p < 0.1.

CSE in brackets: blocks (104 clusters).

CSE in parentheses: projects (36 clusters).

p: p-value Clustered Wild Bootstrap (300 replications).

Finally, in Table 6 we find evidence that the provision of public good increases satisfaction with all levels of government, and in particular, with the responsible for pavement, that is, the local government.

Table 7: Pavement and Government Satisfaction in 2009 (Survey Data)

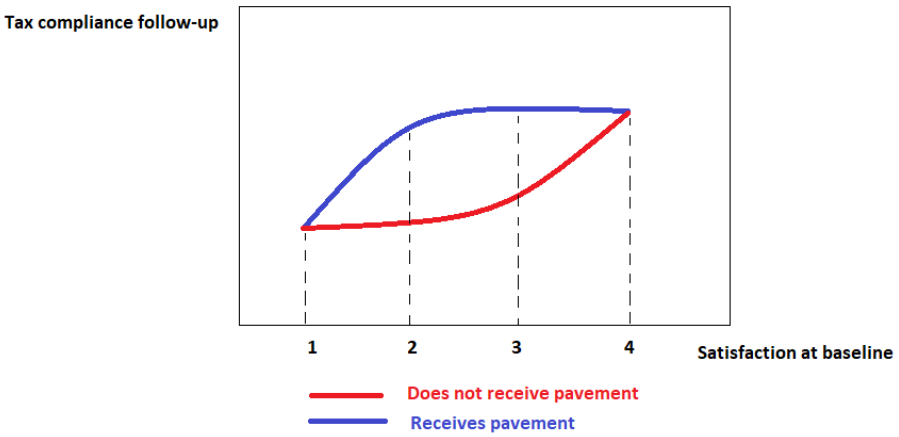
	ITT	2SLS	Mean Control (Follow-up)
Satisfaction with the *local* government	0.204***	0.304***	2.29
	(0.063)	(0.087)	(0.036)
	[805]	[805]	[366]
Satisfaction with the *state* government	0.114**	0.168**	2.56
	(0.053)	(0.084)	(0.041)
	[805]	[805]	[366]
Satisfaction with the *federal* government	0.085*	0.140*	2.48
	(0.051)	(0.080)	(0.045)
	[805]	[805]	[366]

***p < 0.01, **p < 0.05, *p < 0.1.

5.4 Reciprocity or Learning?

One of the key implications of our model which allows us to distinguish reciprocity from learning (and other alternative mechanisms) is that the change in beliefs due to observing the delivery of the public good (pavement) is less sensitive for citizens with extreme priors, and more sensitive for citizens with average priors. This is a testable implication which in the next iteration of the paper we will investigate by regressing tax compliance in 2012 against street pavement, satisfaction with the local government in 2006 (baseline survey), and the interaction of street pavement times the satisfaction with the local government in 2006. In such analysis, street pavement will be instrumented with assignment to be paved, and the interaction of street pavement with satisfaction with the local government will be instrumented with the interaction of assignment to be paved times satisfaction with the local government in 2006. Note that there will be more than one interaction, since the effects predicted by the model are non-monotonic as displayed in the figure below.

Figure 4: Tax compliance rates by public good status as a function of satisfaction at baseline



6 Conclusion

This paper shows that the provision of public goods increases property tax compliance and satisfaction with the local government in a context where the provision of the public good takes the form of first-time asphalting of streets in inhabited residential neighborhoods in Mexico. The impacts on property tax compliance are economically relevant, 9 pp (ITT) or 17 pp (LATE). The effects on satisfaction with the local government are relevant too, between 8% (ITT) and 13% (LATE).

The paper also provides a model of tax compliance and satisfaction with the government which allows us to investigate and test a simple explanation: when citizens observe public goods being delivered, they update their beliefs about the governments quality in public goods provision and become more likely to comply. In our model, citizens differ in their civic-mindedness and beliefs about the government, and they update their beliefs based on whether the government delivers (provides pavement) or not. The key testable prediction is that: the change in beliefs due to observing the delivery of the public good (street pavement) is less sensitive for citizens with extreme priors, and more sensitive for citizens with average priors. Testing this prediction allows us to disentangle learning from other potential mechanisms, such as reciprocity or wealth effects.

Several previous studies have found that informing individuals about what the government spends the taxes on does not seem to affect compliance. Our findings seem to indicate that while it is not enough to tell individuals about what the government does with their taxes, tax compliance can be enhanced when individuals actually observe the actual delivery of the public goods.

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Figures Compliance

Figure 5: Before and After Pavement

(a) Before Pavement

(b) After Pavement

Figure 6: Grid Plan of Acayucan

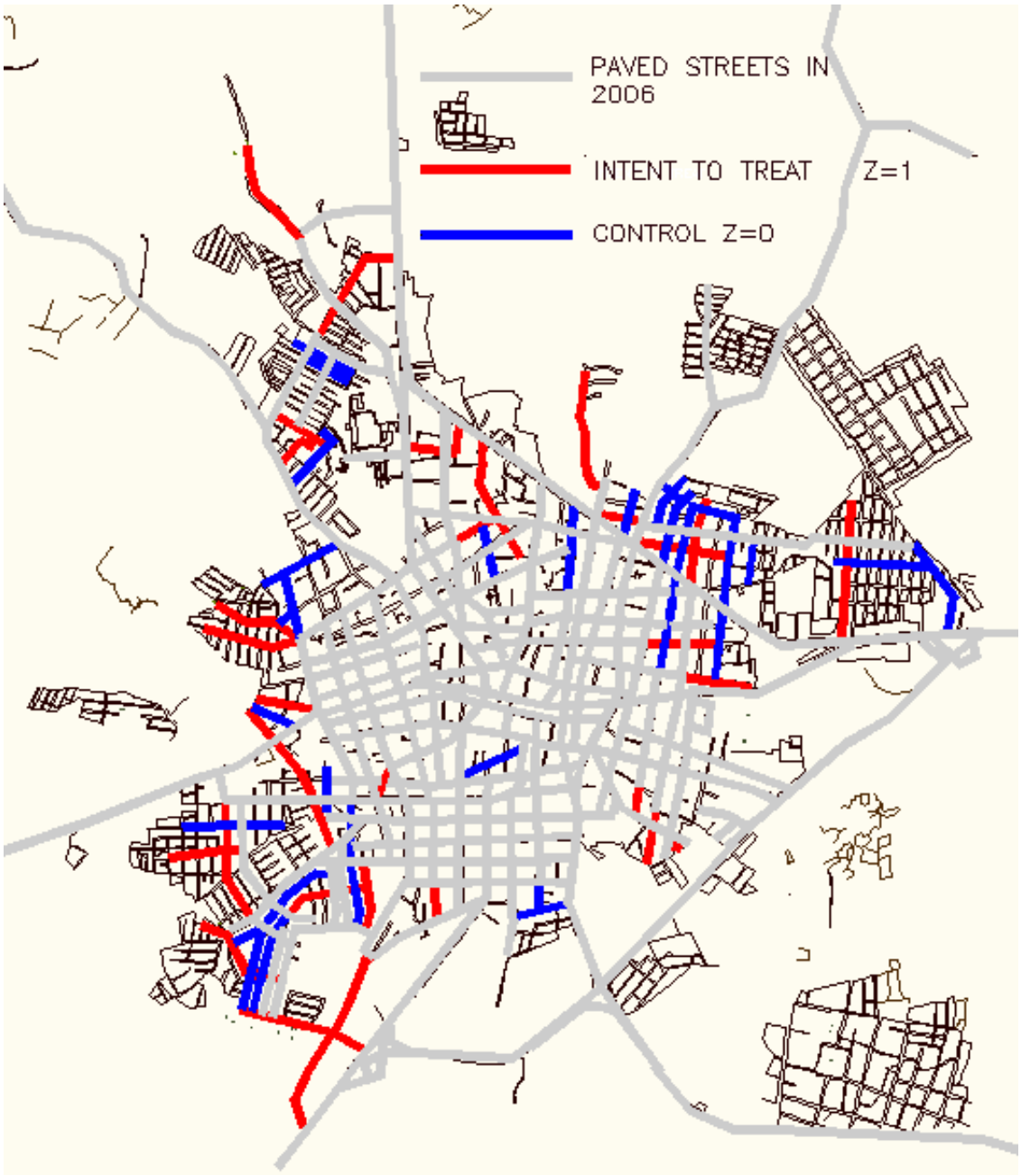


Figure 7: Acayucan Electoral Sections

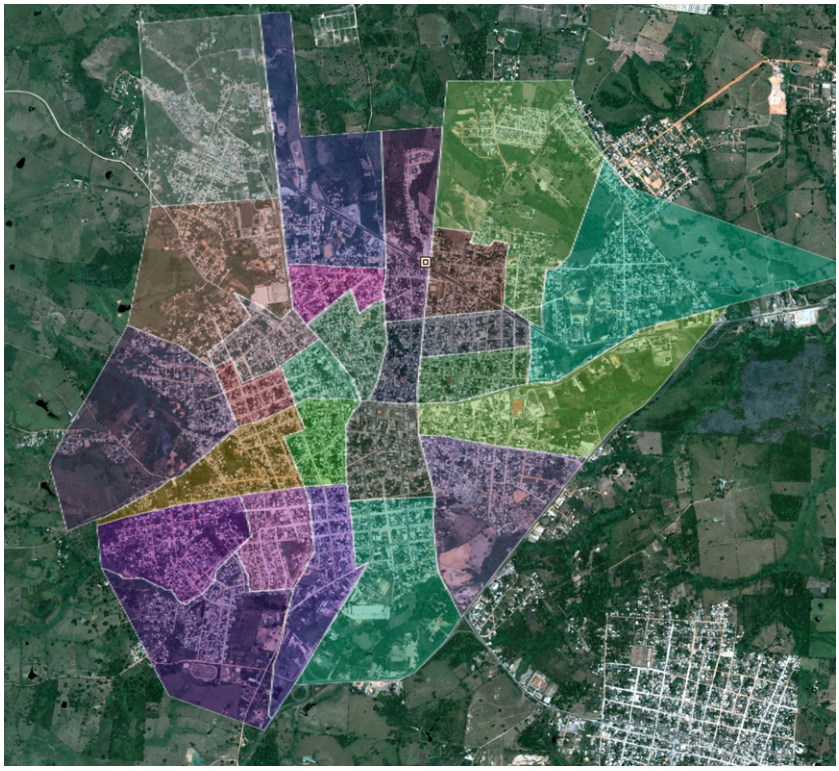
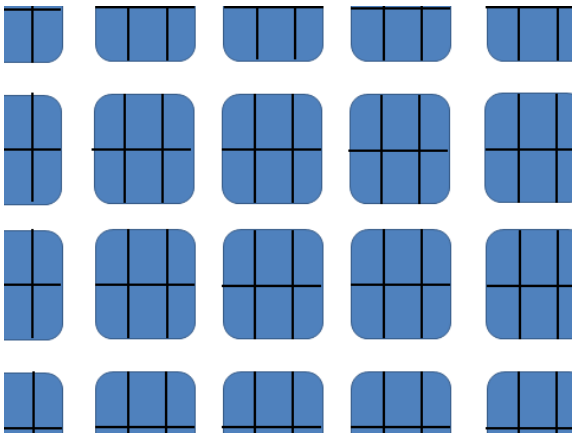


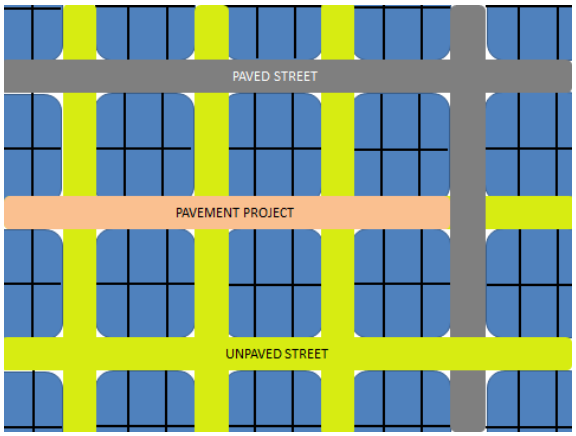
Figure 8

(a) Blocks and Plots



(b) Paved and Unpaved Streets: 2005

(c) Street Pavement Projects



(d) ITT Street Projects

(e) Control Street Projects

(f) Unpaved and Paved Streets: 2012

A Appendix to Data Section

Below is question wording and coding for the satisfaction variable:

"How satisfied are you with the local government?"

1. Very Dissatisfied
2. Somewhat Dissatisfied
3. Somewhat Satisfied
4. Very Satisfied

"How satisfied are you with the state government?"

1. Very Dissatisfied
2. Somewhat Dissatisfied
3. Somewhat Satisfied
4. Very Satisfied

"How satisfied are you with the federal government?"

1. Very Dissatisfied
2. Somewhat Dissatisfied
3. Somewhat Satisfied
4. Very Satisfied

B Appendix to the Theoretical Model Section

B.1 Posterior beliefs

For citizens that observe a new road, the share that believes the government is of type $\underline{\theta}$ or better is

$$S_1^1(\underline{\theta}) \equiv \Pr(\theta^g \leq \underline{\theta} | R = 1, G) = \frac{\Pr(R = 1 | \theta^g \leq \underline{\theta}, G)}{\int_0^1 \pi(\theta|G) d\theta} \times \Pr(\theta^g \leq \underline{\theta} | G). \tag{11}$$

The probability of observing a new road, given that the government is of type $\underline{\theta}$ or better, and expenditure is G, is

$$\begin{aligned} \Pr(R = 1 | \theta^g \leq \underline{\theta}, G^*) = \frac{1}{\underline{\theta}} \int_0^{\underline{\theta}} \mu(1-\theta) G d\theta &= \frac{\mu G}{\underline{\theta}} \int_0^{\underline{\theta}} (1-\theta) d\theta \\ &= \frac{\mu G}{\underline{\theta}} \left(\underline{\theta} - \frac{\underline{\theta}^2}{2} \right) \\ &= \frac{\mu G}{2} \left(2 - \underline{\theta} \right). \end{aligned} \tag{12}$$

The probability of observing the road given that expenditure is G:

$$\begin{aligned} \Pr(R = 1 | G) = \int_0^1 \pi(\theta|G) d\theta = \int_0^1 \mu(1-\theta) G d\theta &= \mu G \int_0^1 (1-\theta) d\theta \\ &= \mu G \left(1 - \frac{1}{2} \right) \\ &= \frac{\mu G}{2}. \end{aligned} \tag{13}$$

Combining the two we get the posterior:

$$\begin{aligned} S_1^1 &= \frac{\Pr(R = 1 | \theta^g \leq \underline{\theta}, G)}{\int_0^1 \pi(\theta, G) d\theta} \times \underline{\theta} \\ &= (2 - \underline{\theta})\, \underline{\theta}. \end{aligned} \tag{14}$$

For citizens that do not observe a new road, the share of the population that believes the government is of type $\underline{\theta}$ or better is

$$S_1^0(\underline{\theta}) \equiv \Pr(\theta^g \leq \underline{\theta} | R = 0, G) = \frac{\Pr(R = 0 | \theta^g \leq \underline{\theta}, G)}{\int_0^1 (1 - \pi(\theta | G)) d\theta} \times \Pr(\theta^g \leq \underline{\theta} | G). \tag{15}$$

The probability of not observing a road, given that the government is of type $\underline{\theta}$ or better, and expenditure is G, is

$$\Pr(R = 0 | \theta^g \leq \underline{\theta}) = 1 - \Pr(R = 1 | \theta^g \leq \underline{\theta}, G) = \frac{2 - \mu G \left(2 - \underline{\theta}\right)}{2}. \tag{16}$$

The probability of not observing the road given that expenditure is G is:

$$\Pr(R = 0 | G) = 1 - \Pr(R = 1 | G) = \frac{2 - \mu G}{2}, \tag{17}$$

Combining the two we get

$$S_1^0 = \frac{\Pr(R = 0 | \theta^g \leq \underline{\theta}, G)}{\int_0^1 (1 - \pi(\theta, G)) d\theta} \times \underline{\theta} = \left(\frac{2 - \mu G (2 - \underline{\theta})}{2 - \mu G} \right) \underline{\theta}. \tag{18}$$

Finally, the overall share of the population that believes the government is of type $\underline{\theta}$ or better, given a level of expenditure G, is

$$\begin{aligned} S_1 &= S_1^1 \Pr(R = 1 | \theta^g, G) + S_1^0 \Pr(R = 0 | \theta^g, G) \\ &= S_1^0 + (S_1^1 - S_1^0) \Pr(R = 1 | \theta^g, G) \\ &= \frac{2 - \mu G \Big(2(1 - \underline{\theta}) \theta^g + \underline{\theta} \Big)}{2 - \mu G} \times \underline{\theta}. \end{aligned} \tag{19}$$

B.2 Equilibrium expenditure

$$\begin{aligned} G &= T(G) \\ &= tw\alpha \left(1 - \frac{\mu t(2\theta^g - 1)}{\bar{\lambda}(2 - \mu G)}\right)\left(1 - \frac{t}{\bar{\lambda} G}\right). \end{aligned} \tag{20}$$

Constraints:

1. Maximum tax revenue is $tw\alpha \implies G \leq tw\alpha$.
2. Probability of observing a new road: $\pi(\theta^g|G) \in [0,1] \implies tw\alpha \leq \frac{1}{\mu}$. Also implies: $2 - \mu G \geq 1$.
3. $G \geq \frac{t}{\bar{\lambda}}$, otherwise nobody complies.

   From two constraints we have

$$\frac{t}{\bar{\lambda}} \leq G \leq tw\alpha \leq \frac{1}{\mu}. \tag{21}$$

   Argument

   (a) $T(\frac{t}{\bar{\lambda}}) = 0 < \frac{t}{\bar{\lambda}}$. The function starts below the 45 degree line.

   (b) $T(G)$ is bounded above by $tw\alpha$. $T(tw\alpha) < tw\alpha$. The function ends below the 45 degree line.

   (c) If

   - $T(G)$ is strictly concave in the interval defined by Equation 21, and
   - $\frac{\partial T(G)}{\partial G}|_{G=G^{**}} = 1$ and $T(G^{**}) > G^{**}$,

   there are two equilibrium points.