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Kleptocracy and tax evasion under resource abundance

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Abstract

Evidence has shown that petroleum wealth is associated with less transparency and at the same time less tax collection. In this paper, we find that the two issues are linked through the citizens' tax evasion behavior. We develop a model to explain this link and conduct extensive empirical tests of its validity. The explanation is that officials tradeoff greater transparency to improve tax compliance against less transparency to increase gains from corruption. Oil windfalls diminish tax revenue needs, causing officials to optimize on less transparency. Seeing this, citizens optimize on a lower level of tax compliance. At equilibrium, both decline with a positive oil shock. We also study the alternative channel in which tax compliance responds to enforcement. Transparency is found to be the more robust channel. Ignoring citizens' strategic behavior would lead to predicting suboptimal investment in state capacity for tax enforcement. Using giant oil discoveries data combined with oil price data, we develop a dynamic composite instrument and estimate the model with a dynamic panel system generalized method of moments. We find robust support for our explanation and the model's *deep* structure for 130+ countries and the 1980–2010 period.

JEL CLASSIFICATION

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corruption, oil, public policy, resource curse, tax evasion, taxation, transparency

1 | INTRODUCTION

Does a kleptocratic state produce less compliant citizenry? This paper provides a framework to answer this question with reference to a kleptocratic state's tax policy and its citizen tax evasion behavior, both in general and under natural resource abundance. Natural resource wealth is linked to a range of adverse economic and political outcomes.[1] Focusing on the state's capacity to collect taxes, and adopting the fiscal capacity framework of Besley and Persson (2009) and Cárdenas, Ramírez, and Tuzemen (2011) show that natural resource dependence reduces the state's capacity to collect taxes. When Besley and Persson (2010, 2011) introduced natural resources in their framework, they too predict that natural resource dependence leads to weaker state capacity. Crivelli and Gupta (2014) found evidence of resource revenues having a negative effect on income taxes, while Jensen (2011) suggested that "resource intensification weakens state-building by impeding the state's fiscal capacity."[2]

The approach taken in these papers implicitly assumes that citizens automatically increase compliance in response to greater tax enforcement as a part of the state's investments in capacity. This implies a more or less passive citizenry and overlooks their active participation in a tax evasion game. Ignoring citizens' strategic behavior may predict suboptimal investment in state capacity for tax enforcement when agents' (citizens') behavior is not anticipated. Critically, tax compliance may respond to other factors in addition to enforcement, such as the transparency of state policy. Overlooking this issue will lead to a second suboptimality of investments in state capacity for tax enforcement.

We show that optimal level of enforcement (when it exists) depends on how much transparency is provided and find that (under some mild conditions) more transparency means less enforcement is needed. Specifically, we analyze a game in which tax payers comply/evade optimally, given the state's enforcement and transparency policies. In turn, the state chooses its policies, anticipating the tax payers' optimal compliance/avoidance response. Although this aspect of the model, i.e., the interaction between transparency and tax enforcement, is general and independent of natural resource wealth, the focus on resource rich economies brings in an additional dimension to consider. Specifically, resource windfalls diminish tax revenue needs and this causes corrupt officials to optimize on less transparency and less enforcement, and citizens to "optimally" comply less. Empirically, we find that (a) oil wealth does reduce both transparency and tax enforcement (or its proxy) and consequently the level of citizen tax compliance; and (b) that transparency is a more robust substitute for tax enforcement even in the presence of oil wealth. In short, the model and its deep structure is supported by extensive empirical evidence. For oil wealth, we use exogenous oil discoveries and for method, we use a dynamic generalized method of moments (GMM) technique that addresses endogeneities. In effect, we show that natural resource abundance alters, not only the nature of institutions but the *behavior* of the citizens.

Interestingly, tax evasion/tax compliance is discussed primarily in the taxation literature and mostly for developed economies (Andreoni, Erard, & Feinstein, 1998; Cuccia, 1994; Jackson & Milliron,

[1]For summaries of this voluminous literature, see Frankel (2010), Ross (1999, 2015), Stevens and Dietsche (2008) and Wick and Bulte (2009).

[2]Juan Pardinas, the General Director of the Mexican Institute for Competitiveness stated in 2013 that, "We collect few taxes because we have oil… That allows us to pay less in taxes…" (New York Times, September 9, 2013).

1986; Kinsey, 1986; Long & Swingen, 1991; Richardson & Sawyer, 2001) and, at any rate, almost never in the context of a natural resource windfall.

Transparency matters. It allows the tax payers to observe how public funds are spent. Without such observation, tax payers lose trust which increases their incentive to evade taxes. In addition, because rentier states prefer less transparency to hide extraction of resource rents for personal use, more resource rent implies even more rentier behavior, providing the tax payers with added incentive to evade. Petroleum wealth is indeed associated with reduced transparency, meaning fewer public disclosures about government policies, institutions, and activities,[3,4] as shown in Figure 1. We explore *why* resource wealth reduces transparency. Figure 2 also confirms the negative association of oil wealth with tax revenues.

We employ several rich datasets. First, we exploit plausibly exogenous cross-country variations on new giant oil field discoveries (e.g., Arezki, Ramey, & Sheng, 2017) complied by Horn (2014), combining it with exogenous temporal variations from oil prices to construct a composite dynamic instrument for oil. We also use high quality data on taxation, meticulously complied by the International Center for Tax and Development (ICTD, 2014), and oil values complied by Ross (2013) both of which remedy shortcomings of other alternatives as detailed in the data section, along with datasets on transparency and accountability by Williams (2011, 2015). With the aid of this and other data, the deep structure of the model and its implications are tested for the period 1980–2010 and for 130–150 countries using a dynamic panel system GMM approach. Results strongly support the model and its implications.

This paper is related to several strands of the literature. First, its key channel besides enforcement, i.e., the link between tax compliance and government transparency, is inspired by the

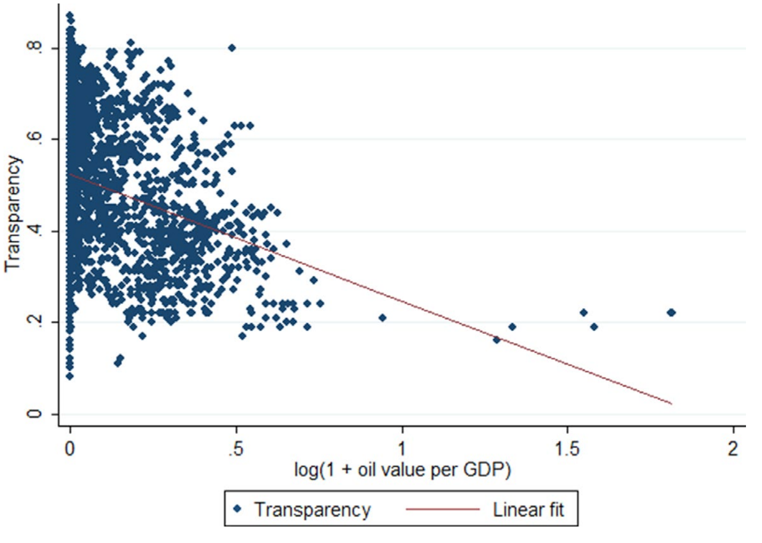

FIGURE 1 Oil and transparency*Source:* authors

[3]A prevailing definition of transparency used by the International Monetary Fund (2012) is: "the clarity, reliability, frequency, timeliness, and relevance of public reporting and the openness to the public of the government's fiscal policy-making process."

[4]Several international initiatives are based on the belief that this outcome is not inevitable. They include the Extractive Industries Transparency Initiative, the IMF's Fiscal Transparency Code, the UNDP's Strategy for Supporting Sustainable and Equitable Management of the Extractive Industries, and the mandatory disclosure laws adopted by the US and EU for extractive industry firms operating abroad.

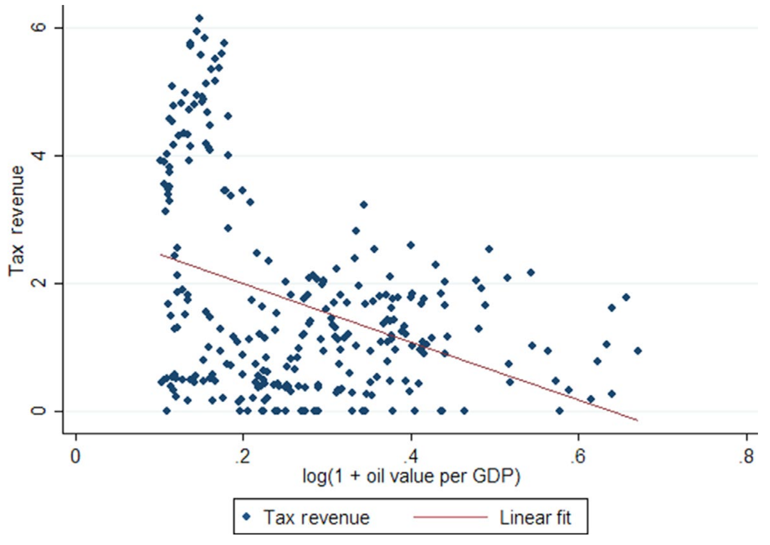

FIGURE 2 Oil and taxation

taxation-representation arguments in which the government's need for direct taxation induced greater political accountability both in the nineteenth century Europe (Hoffman & Norberg, 1994; North, 1990; North & Weingast, 1989) and in contemporary societies (Brautigam, Fjeldstad, & Moore, 2008; McGuirk, 2010; Ross, 2004). Viewed in this perspective, the paper examines whether the presence of large oil revenues may compromise this historical social contract and, if so, the way in which this happens.

Second, this paper is also related to the literature on the effect of natural resources on institutions. Several papers find that the "economic resource curse", i.e., the adverse effect of natural resources on growth, operates only *conditionally*, i.e., only if institutions are weak to begin with.[5] More recent work suggests that institutions are themselves affected by resource dependence. This paper is related to latter breed. Specifically, it is related to the existing evidence on the negative association between oil or natural resource wealth and transparency (Mohtadi, Ross, & Ruediger, 2014; Ross, 2011; Williams, 2011).[6]

Since the lack of transparency is likely to promote corruption, this paper is also related to the literature on government corruption and tax evasion. For example, Tanzi and Zee (2000) linked citizens' tax evasion to their perception of government corruption. Mohtadi and Polasky (2016) developed a model in which corrupt governments operate under information asymmetry, leading citizens to evade taxes when uncertain about efficacy of government spending.

[5]Studies indicating that the impact of natural resources on income depends on the quality of institutions are found in Boschini, Pettersson, and Roine (2007), Lane and Tornell (1996), Mehlum, Moene, and Torvik (2006), Robinson, Torvik, and Verdier (2006), and Tornell and Lane (1999).

[6]Williams (2011) found a correlation between resource wealth and reduced transparency in a smaller panel of countries over a briefer span of time. Ross (2011) reported a cross-national correlation between oil wealth and lower scores on the Open Budget Index, but only among authoritarian states. Mohtadi et al. (2014) estimate the relationship between petroleum wealth and transparency, finding that oil is associated with less transparency when it constitutes a significant share of national income (representing a country's dependence on oil), but not when it merely contributes to a higher average wealth of the country (an indicator of oil abundance). Consistent with this finding, the present paper also uses oil as a fraction of national income both in its model and in its empirical formulation.

Finally, if we view the government's incorporation of citizen tax evasion in its policy decision as a tacit acknowledgment of such a behavior and thus a form of implied subsidy, this paper is related to the rentier state literature where regimes use resource revenues to subsidize pressure groups that might otherwise demand accountability (e.g., Ross, 2001). In this case, paying less tax is akin to receiving funds.

Intuitively, corruption requires some degree of opacity to conceal corrupt acts, so that it makes sense for corruption and transparency to move in opposite directions. But tax enforcement is more complex. On one hand, a corrupt state might prefer less enforcement since enforcement is costly, requiring elaborate collection structure and may reveal other forms of corruption; on the other hand, corrupt states might have an interest in enforcing taxes *more* vigorously in order to extract more revenues. We allow for both possibilities in the model. But empirically we do not find this latter outcome. By identifying each channel separately, we find (a) that oil wealth reduces *both* transparency and tax enforcement; (b) that tax payers' compliance responds positively to both transparency and tax enforcement, and therefore falls, given the drop in both that is associated with a positive oil shock; and (c) that *transparency* is a more robust channel, both as the government's preferred policy, and in terms of its impact on tax compliance/avoidance behavior. A broader implication of our findings is that resource abundance not only affects the structure of the state and its institutions but also the *behavior* of the citizens.

In the remainder of this paper, Section 2 presents the model; Section 3 presents the linkages between the model and the empirical methodology by mapping theoretical propositions to empirically testable hypotheses; Section 4 discusses the data and choice of the instruments; Section 5 discusses the estimation strategies, the econometric model and additional data. Section 6 presents the results and Section 7 offers concluding remarks.

2 | THE MODEL

To capture the key ideas, a simple stylized model of the economy is developed. In this framework, the private economy is made of firms and households. Firms are perfectly competitive and produce a single final good with labor (l), capital (k) and a non-excludable public input provided by the government which is external to the agents (e.g., infrastructure) G_n. This represents net spending on public goods (hence subscript), i.e., net of costs of building capacity on tax enforcement (L) and transparency (T). Specifically, transparency and tax enforcement are both costly to provide. An example of the first is investments in statistical capacity and measurements, and of the second is investments in legal institutions. We make the reasonable assumption that this cost is a fraction $c(T, L)$ of *gross* spending G so that $G_n = (1 - c(T, L))G$ where $c(T, L)$ is additive in T and L so that $c(T, L) = \theta(T) + \phi(L)$. It is also reasonable to assume that these costs rise with the amount of T and L that are provided so that $\theta_T(T) > 0$, $\phi_L(L) > 0$.

Although having public goods in the production function is commonly done, going back at least to Barro (1990), its use in the context of a kleptocratic state requires some explanation. For example, why not steal all of G_n? Why provide any public goods at all? There are at least two reasons for this. First, the extraction of rents takes place through the budgetary process—which means through the relation between revenues and expenditures which we will model shortly below. Second, this extraction, cannot be for the entire revenues earmarked for G_n, as this would pose another problem: Without the provision of any G_n, output would collapse and there would be no income base from which to tax and extract rents. This is in line with Mancur Olson's (1993) well-known argument that a kleptocratic ruler (referred to as a "stationary bandit") provides a minimal supply of public goods to facilitate a steady stream of rents. In this view as in our model self-interest, rather than the threat of revolution, is what compels the government to provide some public goods. Without loss of generality, we assume a representative firm. This means:

$$Y = A(k^{\alpha} l^{1-\alpha}) G_n^{\beta} = A(k^{\alpha} l^{1-\alpha})[(1-c)G]^{\beta} \quad \alpha, \beta \in (0,1) \tag{1}$$

where A is the usual scale factor representing the level of technology. Demand for labor and capital by the firms are given by their marginal products, derived from maximization of profits, $\pi_Y = A(k^{\alpha} l^{1-\alpha}) G^{\beta} - wl - rk$, where Y is the numéraire good with price of 1. Labor is fully employed with measure 1, so that $l^* = 1$ where l^* is demand for labor. We assume that capital markets are open so that return to capital, r, is exogenous, given by the international capital markets: $r = \bar{r}$. Profit maximization then yields aggregate output Y and labor demand, given G. G (and of course capacity cost c) is exogenous to the agents but subject to balanced budget equation (below). Thus total output, labor, and capital income are,

$$Y = \Omega[(1-c)G]^{\frac{\beta}{1-\alpha}} \tag{2}$$

$$Y_l = w^* l = w^* = (1-\alpha)\Omega[(1-c)G]^{\frac{\beta}{1-\alpha}} \tag{3}$$

$$Y_k = \bar{r} k^* = \alpha \Omega[(1-c)G]^{\frac{\beta}{1-\alpha}} \tag{4}$$

where $\Omega \equiv A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{\bar{r}}\right)^{\frac{\alpha}{1-\alpha}}$ which is a function of the constants of the economy. Households own factors of production so that Y_l and Y_k constitute their pretax gross income.

2.1 | Public goods and government budget

Public goods G are financed by natural resource revenue R and income tax revenue X. (We reserve the notation T for transparency introduced later.) Gross income is taxed at the rate t. But taxes are subject to citizen underreporting, the extent of which is determined later by the outcome of a game between the government and citizens. Note that this game will occur *only* in the tax compliance space once income is earned. This means that through the game, the citizens can affect only their *disposable* income, while their pretax income is determined outside of the game by supply and demand for labor and capital.

For simplicity, but no loss of generality, we assume that capital and labor incomes are taxed at the same rate and are subject to the same level of underreporting. This is represented by a fraction, $1 - \mu$, where μ is the *reported* fraction of total income. This simplification allows us to aggregate both types of income so that total reported income, Y_r, is proportional to aggregate income:

$$Y_r = \mu Y \tag{5}$$

Resource revenue is also expressed as a fraction ρ of total income, Y as:

$$R = \rho Y \tag{6}$$

It is important to note that although the model is set in the context of natural resource rich economy, R can represent any form of nontax revenue that is proportional to income and in fact can be zero.

In this sense, the model has greater generality than with respect only to natural resources.[7] We allow for "leakage" of some revenue to the outside of the transparent system. This is represented by a fraction b for total government revenue and represents the degree of extractive (corrupt) behavior by government officials. With this background, gross government spending on public goods is given by, $G = (1 - b)(R + X)$. Since X is the government's aggregate income tax revenue, we have $X = t\mu Y$. So, the balanced budget equation can also be expressed in term of tax compliance:

$$G = (1-b)(\rho + t\mu)Y \tag{7}$$

Substituting for Y from Equation (2) into seven yields, $G = (1-b)(\rho + t\mu)\Omega G^{\frac{\beta}{1-\alpha}}$. Solving for G, we find:

$$G = [1 - c(T,L)]^{\frac{\beta}{1-\alpha-\beta}}[(1-b)(\rho + t\mu)\Omega]^{\frac{1-\alpha}{1-\alpha-\beta}} \tag{8}$$

Note that even though G in 8 is the gross, not the net, level of public goods with respect to the cost of capacity building c, the term $1 - c$ still shows up in 8. This is of course due to the negative impact of c on output Y (Equation 2) which is then carried over from the tax base Y into the expression for G.

Next, we focus on the tax evasion behavior of the citizens following an outline of the game.

2.2 | Game outline

Citizen follow the government's lead. Observing government transparency and enforcement policies, they choose their level of tax compliance in response. In turn, the government chooses its transparency and enforcement policies taking into account citizen response. Everything is common knowledge.

2.3 | Tax evasion/compliance technology

Citizens decide what fraction of their earned income to hide. We use the terms underreporting, evasion, and noncompliance interchangeably. First, we show how rational tax payers evade taxation in response to both transparency and tax enforcement policies of the government. Let C_u denote the cost/penalty of evasion, measured by underreporting a fraction $1 - \mu$ of income. We assume that tax payers who are caught for underreporting with some probability (see below), face a convex cost for tax evasion, i.e., they receive progressively higher penalty for higher rates of tax evasion. This assumption is needed to produce an interior solution. For analytical tractability, we assume that a quadratic form reflects this convexity.

$$C_u(1-\mu) = \frac{\delta}{2}(1-\mu)^2 \text{ with} \tag{9}$$

where δ is some constant. Let π_b^e denote the perceived probability of being caught and penalized for underreporting. Without loss of generality we assume that, if caught, the individual is always penalized, thus ignoring the possibility of bribing the functionary to avoid penalty. While it is easy to incorporate this aspect, for example, by considering μ to be *net* of the bribe rate, the paper's focus is on sovereign or grand corruption, rather than bribery and functionary corruption as in Polinsky and Shavell (2001). The distinguishing feature is that high officials who divert resources for personal use are also the ones who make policy decisions and this is what we are interested in.

[7]Later, in the model when we focus on exogenous changes in ρ we will interpret this as a positive natural resource shock. Also, our empirics are geared to the testing of the model in the context of natural resources.

In light of the above, a risk averse taxpayer facing convex costs considers $E[C_u(1-\mu)]$, i.e., the expected penalty for tax evasion per unit of income, in her calculations.[8] This is given by:

$$E[C_u(1-\mu)] = \frac{1}{2}\pi_b^e(1-\mu)^2 \tag{10}$$

Citizens choose their compliance ratio by balancing the benefits and the costs of noncompliance. They do so by maximizing their expected *disposable* incomes from labor and capital, given their gross labor and capital income discussed earlier (which is made outside of the game). Since we have assumed, for simplicity, similar tax evasion behavior from both sources, this amounts to maximizing expected *total* income as follows:

$$\underset{\{\mu\}}{\text{Max}}\,[E(Y)|_{\bar{G}}] = \underset{\{\mu\}}{\text{Max}}\,E[(1-\mu t) - C_u(1-\mu)]Y|_{\bar{G}} = \underset{\{\mu\}}{\text{Max}}\,[E(1-\mu t)Y|_{\bar{G}} - E(C_u(1-\mu)Y|_{\bar{G}}] \tag{11}$$

We now relate $E(1-\mu t)Y|_{\bar{G}}$ to transparency, relying on the *uncertainty reducing* property of transparency. Before we do so, we must discuss why greater transparency might be expected to improve tax compliance. The argument is that if tax payers better understood where their taxes went they might comply more since greater transparency will be associated with greater accountability among other things. It must therefore be the case that there is some understanding of the connection between taxes and public services, albeit with some uncertainty (the extent of which will decline with transparency as we will see), and from there to their income Y (see Equation 2). Let $\varepsilon \sim N(0, \sigma^2)$. Then, our argument can be formulated as follows:

$$E(1-\mu t)Y|_{\bar{G}} = (1-\mu t)(1+\varepsilon)^a Y|_{\bar{G}} \tag{12}$$

where ε captures the noise and σ^2 the associated uncertainty that tax payers perceive in how their tax evasion might impact their own income (via less public goods) and a expresses the sensitivity (elasticity) of tax evasion to this uncertainty. Taylor series expansion around ε yields $(1+\varepsilon)^a \simeq \varepsilon^a + a\varepsilon^{a-1} + [a(a-1)/2]\varepsilon^{a-2} + \ldots]$. We shall assume for analytical simplicity and tractability that $a = 2$ in which case the approximation becomes exact equality: $(1+\varepsilon)^2 = 1 + 2\varepsilon + \varepsilon^2$. This amounts to having a relatively sensitive (elastic) response. Since $E(\varepsilon) = 0$ and $E(\varepsilon^2) = \sigma^2$, we find:

$$E(1-\mu t)Y|_{\bar{G}} = (1-\mu t)(1+\sigma^2)Y|_{\bar{G}} \tag{13}$$

Substituting from 10 and 13 into 11, citizens' best response to government transparency is given by,[9]

$$\mu^*(t,T,L) = 1 - \frac{t(1+\sigma^2)}{\pi_b^e} \tag{14}$$

Since it is reasonable, as we have argued above, to assume that greater transparency reduces the degree of uncertainty (captured by σ^2 here), denoting transparency by T, we define some monotonically increasing function of transparency $\gamma(T)$ with $\gamma' > 0$, and let $\gamma(T) = 1/(1+\sigma^2)$ so that $\sigma^2 = [1/\gamma(T)] - 1$ and $d(\sigma^2)/dT = < -\gamma'/\gamma^2 < 0$, i.e., uncertainty falls with transparency.

[8]This is because, $E[C_u(1-\mu)] = \frac{\gamma}{2}\pi_b^e(1-\mu)^2 > C_u[E(1-\mu)] = \frac{\gamma}{2}[\pi_b^e(1-\mu)]^2$

[9]First-order condition is, $-t + \gamma(T)\pi_b^e(1-\mu) = 0$. Second-order condition is, $-\gamma(T)\pi_b^e < 0$.

Next, we focus on the probability of being caught. Citizens estimate π_b^e from experience and casual observation. In the aggregate, (a) expectations are realized so that $\pi_b^e = \pi_b$; and (b) the probability of being caught increases with greater enforcement of the tax laws, denoted by L, so that $\pi_b^e = \pi_b = f(L)$ with $f' > 0$ and $f < 1$. Putting these together, optimum compliance becomes[10] :

$$\mu^*(t,T,L) = 1 - \frac{t}{\gamma(T)f(L)} \text{ with } \gamma', f' > 0 \tag{15}$$

It follows that tax compliance increases with better transparency and tax enforcement:

$$\frac{\partial \mu^*}{\partial T} > 0, \frac{\partial \mu^*}{\partial L} > 0, \frac{\partial \mu^*}{\partial t} < 0 \tag{16}$$

Proposition 1a *Citizen tax compliance increases in transparency* T.

Proposition 1b *Citizen tax compliance increases in tax enforcement* L.

In addition, if $\gamma'' < 0$ and $f'' < 0$ tax compliance becomes concave in T and L.[11] This concavity condition turns out to be sufficient for the government (as the first mover) to optimize in T and possibly L. This is discussed in the next section. Both the increasing and the concavity of compliance μ will be empirically tested later.[12] The empirical section will also have to wrestle with what we mean by transparency. Is transparency just access to information as in Williams' (2011), or should transparency be associated with a channel through which the government can be held accountable as in Williams (2015)? We will later visit this issue and the empirical challenges that either measure introduces.

2.4 | Government

2.4.1 | Budgetary versus political considerations

First we focus on fiscal budgetary issues. Incorporating citizens' best response, i.e., Equation (15), in Equation (8), government spending is found to be:

$$G = [1 - c(T,L)]^{\frac{\beta}{1-\alpha-\beta}} [(1-b)(\rho + t\mu^*(t,T,L))\Omega]^{\frac{1-\alpha}{1-\alpha-\beta}} \tag{17}$$

Define $g$as the ratio of spending to GDP, $g \equiv G/Y$. It will be useful to express G in terms of g and continue the discussion in terms of g which is free of scale, rather than G which is scale dependent. In addition, in the estimation section, data will be in terms of g not G. To do this, divide both sides of 2 by G to find $1/g = \Omega G^{-\frac{1-(\alpha+\beta)}{1-\alpha}}$ or $G = (1-c)^{\frac{\beta}{1-\alpha-\beta}} (\Omega g)^{\frac{1-\alpha}{1-\alpha-\beta}}$. Substituting into 17 and solving for $t\mu^*$ we get,

$$t\mu^*(t,T,L) = g \cdot (1-b)^{-\frac{1-\alpha-\beta}{1-\alpha}} - \rho \tag{18}$$

[10]In Equation (15), since $\mu^* \leq 1$, f and γ have lower bounds, i.e., $\gamma(T=0) = \gamma^L > 0$ and $f(L=0) = f^L > 0$. In the case of γ, a lower bound means σ^2 is finite. Since ε is normally distributed, its variance is always finite and the condition is satisfied.

[11]We show this in the case of T: $\mu^*_{TT} = (t/f) \cdot (\gamma''\gamma^{-2} - 2\gamma^2\gamma^{-3}) < 0$, if $\gamma'' < 0$.

[12]We do not have systematic data on t to test the sign of $\frac{\partial \mu^*}{\partial t}$. But the literature suggests that compliance does decline with the tax rate (e.g., Friedman, Johnson, Kauffman, & Zoido-Lobaton, 2000). As we will see, at equilibrium, t itself will depend on T, L, and G.

Note that $t\mu^*$ which is just tax revenue as a share of national income (i.e., X/Y) does not depend on cost of capacity building c. This is because c comes out of the amount that is spent on public goods not the amount that is raised. We assume that government spending decision on g is exogenous vis-a-vis its transparency (T) and tax enforcement (L) strategies.[13] Although we *will* empirically test the validity of this assumption in a later section, there are several a priori reasons why this may be a realistic assumption. First, the decision of how strongly to enforce the laws in general or tax laws in particular, or how much transparency to allow, are strategic and political decisions that influence citizens' behavior, as seen in the model. On the other hand, decisions on g are mainly driven by fiscal considerations. It could be argued, however, that if g can be used as a tool by an extractive state to elicit greater loyalty from its constituency, as argued for example, in the rentier literature, would this tool not allow the government to trade more g with less T or L (in which case g, T, and L would be interdependent)? As far as transparency is concerned, we observe that T is a *pure* public good, available equally to all constituencies, whereas g would have to be an *excludable* quasi-public good, available to some but not others in order to enable an extractive state to buy-off one constituency as against another. This argument can also be extended to the enforcement of taxes, L as well. While tax enforcement *can be* differentially administrated to different groups, such a scheme would be very costly to the government and hence probably impractical. Finally we point out that in our model, g, is also modeled as a pure public good (e.g., roads, bridges, etc.) since it directly enters the production function. So it cannot be denied of one constituency or the other. All of this suggest that a higher (lower) g may be a rather poor substitute for a lower (higher) T and L and vice versa. In the empirical section, we find support for the argument that g is *not* a substitute for either T or L.[14]

Other factors could of course influence g. For example, the distinct political economic structures in democracies versus non-democracies imply that there may be systematic effects on government spending. In the empirical section, we will control for this effect by including a polity variable. We will show that the main findings of this paper remain robust despite all these considerations. Finally, more oil revenue might influence the amount of spending. We will take up this issue shortly below.

The assumption of exogenous g means that variations in spending g drive variations in the tax rate, t, to satisfy the budget constraint. Since direct data on tax compliance is not available, this assumption allows us to identify compliance in the empirical section of the paper: Because tax revenue as a share of national income, $t\mu$, is made up of tax rate t and compliance rate μ, tax revenue $t\mu$ can serve as a proxy for tax compliance μ if we can control for variations in t. The latter is possible if variations in g are a proxy for variations in t, thus allowing us to isolate the compliance component μ from $t\mu$. While nominally published tax rates for each country do not vary greatly from year to year, effective average tax rates probably do, for example, due to changes in the threshold taxable income, in the income bracket at which marginal rates change, or in the "enforcement coverage" zones. Moreover, effective tax rates encompass subsidies, i.e., negative taxes, so that we have an additional source of variation in t.

The assumption of exogenous g will be empirically tested by allowing it to be endogenous in a GMM setting with its lagged values as instruments versus entering it without lags. The results are nearly identical.[15]

[13]Even so, changes in g may still influence T and L indirectly through the balanced budget Equation (18), coming from the accompanying changes in the tax rate (t) to keep the budget balanced. This will be discussed later.

[14]There is also the possibility that g is subject to political economy forces. For example, interest groups lobbying the government for more spending (e.g., Mohtadi & Roe, 1998, 2003) or voters choose the types of government associated with different levels of spending (e.g., Persson, Roland, & Tabellini, 2007). As long as citizens' voting or lobbying behavior is independent of their tax evasion behavior, our results will hold.

[15]This also rules out reverse causality if, for example, anticipating more tax revenues, via higher the tax rate, were to drive spending decisions. It also rules out other potential endogeneity factors such as if tax revenues and spending are driven by the same unobserved factor(s).

Given this discussion, we express the tax rate t as the implicit solution to Equation (18):

$$t = h(g|T,L,b,\rho) \tag{19}$$

It is easy to show that $t_{g|T,L,b,\rho} > 0$ as long as the tax rate is bounded from above.[16] We also observe from 18 that tax revenue as a share of national income $t\mu$ falls with more oil revenue, ρ. This result does *not* depend on how an increase in g or in ρ affects the compliance behavior μ indirectly via T, L, or t channels. It simply says that any change on the right side of 18 has to match an equal change on the left hand side. What if oil producers do spend more on all their citizens? In that case g depends on ρ: $g = g(\rho)$ with $g_\rho > 0$. Then, $d(t\mu^*)/d\rho < 0$ still holds, so long as g_ρ has an upper bound.[17] Notice, however, if $g_\rho > 0$, then:

$$d(t\mu^*)/d\rho|_{g=\bar{g}} < d(t\mu)/d\rho|_{g=g(\rho)} < 0 \tag{20}$$

Inequality 20 allows us to test whether or not oil producing governments spend more on their citizens. We will test this in the empirical section by including and excluding g from our controls and compare the coefficients of oil and find support for this finding. We can put this in the form of the following proposition:

Proposition 2 *An increase in oil revenue reduces tax revenue either if government spending* g *is independent of oil revenues* ρ *or its increase (*Δg*) in response to a positive oil shock (*Δρ*) has an upper bound (given above). In the latter case, more oil revenue will mean less of a reduction in tax revenues than would otherwise be the case.*

2.4.2 | Strategic considerations

Government moves first by anticipating citizens' level of tax compliance in response to setting the level of transparency, T, and possibly enforcement of tax laws, L. We now study T and L policies. In choosing its level of T and L, the government takes into account, not only the effect of its action on compliance directly via μ^* but also indirectly via the implicit dependence of the tax rate t on T and L as seen in 18. Therefore, before the government's decision is discussed, this relationship must be analyzed and understood. Focusing on T first, we make the reasonable assumption that extra-budgetary diversions b are easier to hide when there is some opacity, i.e., $\partial b/\partial T \leq 0$. This leads to the following lemma.

Lemma 1 *Under reasonable upper bound on the tax rate,* t, ∂b/∂T ≤ *0 implies that* $\partial t/\partial T < 0$

Proof See Appendix A.

The fact that more democratic societies which are also more transparent may also experience higher tax rates is because such societies may also spend a higher fraction of their GDP on public spending

[16]To see this, totally differentiate 18 in g: $t_g(\mu^* + t\mu_t^*) = (1-b)^{\frac{1-(\alpha+\beta)}{1-\alpha}}$. Now, $\mu + t\mu_t > 0$ if there is an upper bound on the tax rate: i.e., if $t < \gamma(T)f(L)/2$. (This is the same condition as for Lemmas 1 and 2 below.) If this holds, then, $t_g > 0$.

[17]$g_\rho < (1-b)^{\frac{1-(\alpha+\beta)}{1-\alpha}}$. Note also that $\alpha + \beta < 1$ or $\beta < 1 - \alpha$. Evidence supports this assumption, with $1 - \alpha$ as the labor share typically known to be about 60% and β as the share of public goods, typically known to be about 20%.

(g) which would raise the tax rate we hold exogenous here. To avoid possible confounding between democracy and g, in the empirical section we control for variations in both democracy and in g.

The application of Lemma 1 to tax enforcement is somewhat more complex. On one hand, corrupt officials may be interested in extracting more taxes from the citizen to generate more revenues in order to divert more rents in which case $\partial b/\partial L > 0$; on the other, better tax collection is a part of better rule of law institutions in which case there would be less corruption so that $\partial b/\partial L < 0$. This leads to the second lemma:

Lemma 2 *Under reasonable upper bound on the tax rate,* t*,* $\partial b/\partial L \leq 0$ *implies that* $\partial t/\partial L < 0$ *while* $\partial b/\partial L > 0$ *implies that* $\partial t/\partial L \gtreqless 0$.

Proof See Appendix B.

We will take advantage of both lemmas in determining the government's transparency and tax enforcement policy. Let the government payoff depend on how much it diverts for personal use, b. This yields the following utility function:

$$U_G(T,L) = \bar{V}_{oG} + b(T,L) \cdot [\rho + t\mu^*(t,T,L)]Y = \bar{V}_{oG} + b(T,L) \cdot [1 - c(T,L)]^{\frac{\beta}{1-\alpha-\beta}} \cdot [\rho + t\mu^*(t,T,L)]\Lambda g^{\frac{\beta}{1-\alpha-\beta}} \text{ with } b_T \leq 0 \text{ and } b_L \lesseqgtr 0 \tag{21}$$

where $\Lambda = \Omega^{\frac{1-\alpha}{1-\alpha-\beta}}$.The second equality in 21 comes from substituting for Y in terms of G from Equation (2) and G in terms of g from the earlier discussion on Equation (17). As stated earlier, we assume that the government's choice of transparency and rule of law are independent of its spending decision, g. Hence for our purposes, g is exogenous to L and T. In the above equation, $\bar{V}_{oG}$ is some base level government utility independent of L and T. In a democracy, $\bar{V}_{oG}$ is determined by the median voters and b is small, in which case variations in $U_G(T)$ would come from $\bar{V}_{oG}$. But more generally this will not be the case. Our control for variations in democracy in the empirical sections also controls for variations in $\bar{V}_{oG}$.

The government, in its own self-interest, optimizes over the choice of T and L. The idea that the government optimizes over the choice of transparency is found in monetary and public policy discussions based on the costs and benefits of transparency (e.g., Cornand & Heinemann, 2008), but to our knowledge this is its first application to the case where a corrupt government optimizes over the choice of transparency based on tax payer behavior. In this context, the transparency decision involves clear tradeoffs; on one hand, $\partial b/\partial T < 0$ as already discussed; on the other hand, the fact that citizens tax compliance increases with transparency, i.e., $\partial \mu^*/\partial T > 0$ (see Equation 16), gives the government a larger income base from which to extract rent. In this case we expect an interior solution for optimum transparency:

$$T^* = \arg\max_{\{T\}} U_G(T,.)|_g \tag{22}$$

The first-order condition for T^* demonstrates the balance of costs and benefits to the government, from a transparency policy:

$$T^*|_g : b(t\mu_T^* + t\mu_t^* t_T) = -b_T(\rho + t\mu^*) - bt_T\mu^* + \frac{\beta}{1-\alpha-\beta}(1-c)^{\frac{\beta}{1-\alpha-\beta}-1} b(\rho + t\mu^*)\theta_T \tag{23}$$

The left side of 23 shows the marginal payoff of greater transparency to the government, via larger tax base due to better compliance (Proposition 3a $t\mu_T^* > 0$) *and* the compliance response to lower tax rate (Lemma 1 $t\mu_t^* t_T > 0$); the right-hand side is the marginal cost of transparency via lower rent seeking ($-b_T > 0$), the marginal loss due to the reduction in the tax rate ($t_T \mu^* < 0$) and the marginal cost of building transparency capacity (θ_T weighted by the term in front of it). Note that even though g is exogenous, its variation still influences the government's decision on T through the balanced budget Equation (18) coming from the relation between transparency (T) and tax rate (t). In other words, Equation (18) acts as a constraint: for a given g and ρ on the right hand side of 18, a change in T or L is accompanied by a change in t.[18]

Using the condition $b_T < 0$ and Lemma 1, Appendix C shows that the second-order condition for optimal T^* holds *if* $\partial^2\mu/\partial T^2 < 0$. In short, governments limit transparency to their citizens. Their choice of this limit depends on how tax payers behave and, soon we will learn, also on the available natural resource revenue. The empirical section examines the validity of this result which we summarize as follows:

Proposition 3a *If* $\partial\mu/\partial T > 0$ *per Proposition 1a but at a decreasing rate* ($\partial^2\mu/\partial T^2 < 0$)*, an interior* T^* *exists (assuming* $b_T < 0$ *per Lemma 1).*

Note that μ is never maximized with respect to T. Proposition 3a only requires that $\partial^2\mu/\partial T^2 < 0$ for a T^* policy to exist. The requirement that $\partial^2\mu/\partial T^2 < 0$ is what is needed to tie the behavior of the citizens and the government in the Stackelberg game.

We now turn to the enforcement of tax laws, $L^* = \arg\max U_G(L,.)|_g$ as an alternative mechanism by which a government may improve tax compliance. The first-order conditions for optimum enforcement, L^*, is identical to Equation (23) with L replacing T. But now the sign of b_L plays a crucial role. If $b_L < 0$, the result is identical to the above and an optimum level of enforcement of taxes will exist. But if $b_L > 0$ it is possible that $t_L > 0$ by Lemma 2. In such a case, no interior solution and thus no optimum enforcement will exist (see Appendix D). This outcome arises because there can be no tradeoff if stronger tax enforcement leads to more rent extraction by the officials while increasing the government's coffers. In this case, a corner solution will exist where tax extraction is at its maximum. We can summarize this result as follows:

Proposition 3b *If* $\partial\mu/\partial L > 0$ *per Proposition 1b but at a decreasing rate* ($\partial^2\mu/\partial L^2 < 0$)*, an interior* L^* *may or may not exist. It exists if* $b_L < 0$*. It may not exist If* $b_L > 0$*, i.e., if enforcing taxes exacerbates government's rentier behavior.*

2.5 | Equilibrium

Citizens react to the strategic variables, T and L, chosen by the government. But the tax rate, t, is also a variable entering into the government decision (see for example, the use of Lemmas 1 and 2 in Propositions 4a and 4b). This then means that *at equilibrium t* must enter the tax payer's post optimization value of μ^*. This point has a number of important implications that we will now explore.

2.5.1 | Compliance

Focusing on transparency and compliance first, at equilibrium transparency affects compliance in two ways:

[18] g is not the only driver of t. In Equation (18) $t_g > 0$ is conditional on other variables. Changes in these also affects t.

$$\frac{d\mu^*}{dT}|_{T=T^*(\text{eq})} = \mu^*_{T|T=T^*(\text{re})} + \mu^*_t t_T|_{\text{gov.budget}} > 0 \tag{24}$$

where $\mu^*_{T|T=T^*(\text{re})}$ is the slope of citizens' optimal response at T^*, denoted by subscript "re". This first effect is the direct effect and is positive. However, since an increase in transparency also reduces the tax rate (second term on right), it follows that an increase in tax payer compliance at equilibrium (denoted by subscript "eq" on the left) may be either due to citizen's greater participation in a more transparent economy or a reduction in the tax rate. The second differential, via the transparency and the taxation paths, is:

$$\frac{d^2\mu^*}{dT^2} = \mu^*_{TT} + 2\mu^*_{Tt} < 0 \text{ if } \mu^*_{TT} < 0 \tag{25}$$

Empirically, systematic observations on the tax rate t are not available. Thus, we can only estimate the total effects of $d\mu/dT$ and $d^2\mu/dT^2$ but will not know how much is due to the first term and how much is due to the second term in 24. However, a positive total differential and a negative total second differential are consistent with rational tax payers optimizing over compliance. Similar argument holds for tax enforcement.

2.5.2 | Tax revenue and tax compliance

Appendix E shows that so long as compliance responds positively to transparency, tax collections per capita $t\mu^*$ will also increase with transparency, at equilibrium. This is significant in two ways. First theoretically, we have found that tax rates fall with transparency ($t_T < 0$) but compliance increases with it ($\mu^*_T > 0$). So it is not obvious that tax collections $t\mu^*$ should increase with T. Second, as we have discussed before, while controlling for g empirically is supposed to pin down the tax rate t in the $t\mu^*$ expression so as to "force" variations in the tax revenue to reflect variations in compliance, the fact that tax collections ($t\mu^*$) increase in transparency *in the absence of controlling for g*, provides further evidence that the underlying compliance must be responding positively to transparency. Of course, we will not be satisfied with this indirect evidence and will actually use compliance data to test the compliance hypothesis directly, albeit for a much more limited period, as a robustness check. Similar results hold for tax enforcement. To summarize,

Proposition 4 *If tax compliance increases with transparency or tax enforcement, so do overall tax collections. That is, if $d\mu^*/dT > 0$ (or $d\mu^*/dL > 0$), it will be the case that $d(t\mu^*)/dT > 0$ (or $d(t\mu^*)/dL > 0$).*

2.6 | Tax enforcement and transparency

In the Introduction, we argued that transparency can influence the state's capacity to collect taxes. In this subsection, we show how higher levels of transparency will allow the state to put less effort in tax enforcement at the optimum. We will show how this effect arises before we actually test this empirically later. Since in the Introduction we suggested that this result is independent of natural resource wealth, we can set $\rho = 0$ for simplicity only for this part of our analysis. In addition, our findings will be independent of the cost of capacity building and would hold even if transparency institutions were as costly as tax enforcement institutions. For this reason and for further analytic simplicity we will set $\theta(T) = \phi(L) = 0$ so that $c(T, L) = 0$. Our results should be stronger, if analytically more complex, when tax enforcement institutions were costlier to set up than transparency institutions. With these considerations, the first-order condition for optimum enforcement, *if it exists* (see Proposition 3b), is given by,

$$L^*|_g = \arg\max U_G(L,.)|_g \rightarrow \frac{d}{dL}(bt\mu^*) = 0 \rightarrow b_L t\mu^* + b\frac{d}{dL}(t\mu^*) = 0 \tag{26}$$

Since L^* is the solution to 26, we make use of the implicit function rule to implicitly differentiate L^* with respect to T. This yields (after collecting terms):

$$\left[b_{LT}t\mu^* + b\frac{d^2}{dLdT}(t\mu^*)\right]\frac{dL^*}{dT} + b_L\frac{d}{dT}(t\mu^*) + b_T\frac{d}{dL}(t\mu^*) = 0 \tag{27}$$

We now make use of the first-order conditions for enforcement and transparency, Equations (23) and (26), to substitute respectively for the 3rd and 4th terms in 27. After simplification this yields,

$$\left[b_{LT}t\mu^* + b\frac{d^2}{dLdT}(t\mu^*)\right]\frac{dL^*}{dT}|_{T*} = \frac{2b_L b_T}{b}t\mu^* \tag{28}$$

We shall assume that corruption is separable in the effect of tax enforcement versus transparency, for example $b(T, L) = b^T(T) + b^L(L)$. This implies that $b_{LT} = 0$. Under this assumption Appendix F shows that $\frac{d^2}{dLdT}(t\mu^*) < 0$ unambiguously. In that case $\frac{dL^*}{dT} < 0$

Proposition 5 *If corruption falls with better tax enforcement (i.e., $b_L < 0$) so that an optimal enforcement level exists (Proposition 3b) and if transparency and tax enforcement separately affect corruption, then less enforcement of taxes is needed at the optimum. Thus, transparency acts as a substitute for tax enforcement.*

This result is particularly interesting. The result would be probably reinforced if capacity costs entered the analysis since tax enforcement is likely to be costlier than transparence at the margin ($\phi_L > \theta_T$). Thus, it is likely that the results from Equation (28) and Proposition 5 are understated and would be strengthened under these conditions, allowing for a more efficient outcome in the sense of lower tax enforcement costs. We have ignored this situation for analytic simplicity. We now consider capacity building costs.

2.7 | Capacity building costs

Recall that $c(T,L) = \theta(T) + \phi(L)$. We first focus on cost of transparency capacity $\theta(T)$. Reexpress the first order condition 23 in its general form (from the original objective function 21) as,

$$\frac{d}{dT}[1 - c(T,L)]^{\frac{\beta}{1-\alpha-\beta}} b(T,L) \cdot [\rho + t\mu^*(t,T,L)] = 0 \tag{29}$$

This simplifies to,

$$\frac{d}{dT}b(T,L) \cdot [\rho + t\mu^*(t,T,L)] = \frac{\beta}{1-\alpha-\beta}(1-c)^{-1}[\rho + t\mu^*(t,T,L)]\frac{d\theta}{dT} \tag{30}$$

Let $H(T) \equiv b(T, L)\cdot[\rho + t\mu^*(t, T, L)]$. Then if the left hand of 30 is set to zero, i.e., if $dH(T)/dT = 0$ we simply have the first-order condition for optimal transparency when capacity costs are zero, yielding $T^*|_{\theta=0}$. However, the full equation in 30 yields $T^*|_{\theta>0}$. From this it is clear that the slope of the curve $H(T)$ which peaks at $T^*|_{\theta=0}$ is positive at $T^*|_{\theta>0}$, i.e., $H(T)$ is still on its ascendance at $T^*|_{\theta>0}$. It follows that $T^*|_{\theta>0} < T^*|_{\theta=0}$. Same argument holds for L^* subject to its existence. Thus,

Proposition 6 *Higher costs of capacity building lead to lower optimal levels of transparency or tax enforcement (when the latter exists).*

An interesting implication of this proposition, in light of Proposition 5, is that if tax enforcement is costlier than transparency capacity, relying on transparency would be cost saving.

We now return to the case where natural resource wealth is nonzero.

2.8. | Resource rents, transparency, and enforcement

Our key results are how rents from natural resources impact the government's transparency policy (though in the process we address tax enforcement as well). To see this, rewrite the first-order condition in Equation (23) as $\Psi(T^*,\rho) = 0$ (suppressing the dependence on L). Collecting all the terms in 23 to the right, we see that $\Psi_\rho(T,\rho) < 0$. Similarly, the second-order condition established in Appendix C can be written as $\Psi_T(T,\rho)|_{T^*} < 0$. Totally differentiating the first-order condition $\Psi(T^*,\rho) = 0$ in ρ we have,

$$\Psi_T(T,\rho)|_{T^*} \cdot \frac{dT}{d\rho} + \Psi_\rho(T,\rho)|_{T^*} = 0 \tag{31}$$

from which we obtain,

$$\frac{dT^*}{d\rho} = -\frac{\Psi_\rho(T,\rho)|_{T^*}}{\Psi_T(T,\rho)|_{T^*}} = -\frac{(-)}{(-)} < 0 \tag{32}$$

We summarize this result:

Proposition 7a *Given a positive resource/oil shock, and conditional on a T* existing, a kleptocratic state always opts for less transparency.*

Similar result holds for tax enforcement:

Proposition 7b *Given a positive resource/oil shock and conditional on an L* existing, a kleptocratic state always opts for less tax enforcement.*

Note that in the case of Proposition 7a, observing $\mu_T^* > 0$, $\mu_{TT}^* < 0$ is sufficient to guarantee an optimum T^* will exist from which $dT^*/d\rho < 0$ would result. But in the case of Proposition 7b, observing $\mu_L^* > 0$, $\mu_{LL}^* < 0$ is not sufficient. In addition, we must also have $b_L < 0$ as a sufficient (but not necessary) condition for $dL^*/d\rho < 0$. In the empirical section we are able to test for $\mu_T^* > 0$, $\mu_{TT}^* < 0$ and $dT^*/d\rho < 0$. Confirming these signs is consistent with the inference that a self-interested state rationally chooses/limits transparency to suite its self-interest. In the case of tax enforcement, again we can test for $\mu_L^* > 0$ $\mu_{LL}^* < 0$ as well as for $dL^*/d\rho < 0$. Should we confirm that $\mu_L^* > 0$, $\mu_{LL}^* < 0$ *and* $dL^*/d\rho < 0$, we are then able to make the same inference for L^* as we did for T^*. In this instance, the role of b_L is mute since establishing $dL^*/d\rho < 0$ is an indication of the underlying rational self-interest.

3. | FROM MODEL TO HYPOTHESIS TESTING

Before we empirically test the theory, we must be able to map the propositions of the model into empirically testable hypotheses. We begin with Proposition 1 rather than 2.

> H1: For a given level of public spending, more resource revenue means less income tax revenue.

Testing H1 is a "reduced form" test since it says nothing about the structure of the model. Other propositions connect different aspects of the model so testing them can be viewed as "structural." For example, Propositions 3a and 3b link the tax payers' compliance behavior to the rentier government's transparency and tax enforcement policy. They also relate the curvature of this compliance behavior as a way of testing whether a rational self-interested rentier government "optimizes" in the policy space to benefit itself. Combining Propositions 1a and 3a and Propositions 1b and 3b in pairs we have the following pair of hypotheses:

> H2a: Tax compliance increases in transparency at a diminishing rate.

> H2b: Tax compliance increases in enforcement at a diminishing rate.

Testing these hypotheses sheds light on both the tax payer behavior and the rentier government behavior. Given the possibility that, in principle, corrupt governments *may* have the incentive to enforce taxes more vigorously to extract more rents, i.e., that b_L may be >0 (besides the more intuitive possibility of $b_L < 0$), hypothesis H2b requires some elaboration. Specifically, if the "diminishing rate" part of H2b is rejected, then no self-serving optimal enforcement of taxes exists by a rentier government. Intuitively, this implies corrupt governments might prefer to enforce tax rules maximally to get more taxes because $b_L > 0$. In this case, tax enforcement behaves differently from transparency: instead of a tradeoff, we have positive feedback from corruption to tax enforcement. The empirical section will examine these hypotheses.

In addition, Proposition 4 provides a check on the relation between transparency, or tax enforcement, to tax revenue collections, as a reflection of the underlying relation between these two drivers and tax compliance. In hypothesis format we can write,

> H3: Tax collections should increase with transparency or tax enforcement.

Finally, mapping Propositions 7a and 7b, with the caveat discussed at the end of Section 1, we have:

> H4a: Transparency falls with resource revenue as a share of GDP.

> H4b: Tax enforcement falls with resource revenue as a share of GDP.

Figure 3 presents a conceptualization of these hypotheses and the relationship among them. For example, one can view hypothesis H1 as signifying the "demand side" for tax revenues (by the government) while hypotheses H3 and H4 as signifying the "supply side" (by the citizens).

4. | DATA

We employ several datasets, beginning with the transparency data. First we discuss our approach to measuring transparency. We follow Williams (2015) and consider transparency, at large, to consist of both *informational transparency* and *accountability*. Our theoretical model on compliance indicates that both the degree of knowledge (information) about the government's budget and the degree of confidence by the citizens that it is spent on public goods are important. The former is better captured by an information transparency index, first developed by Williams (2009) called release of information (RI), then later used in Williams (2011), and further refined in Williams (2015), while the latter is better captured by an accountability index per Williams (2015). Accountability and transparency capture somewhat different things. Discussing accountability Williams (2015, p. 811) states, "this is a different form of transparency, in that access to this information by the public has less meaningful economic value unto itself, but is designed to provide a check on the behavior of the government, and to therefore promote accountability." Williams (2009) Information transparency index, which was updated on Williams' website to 2010, counts the frequency and extent of annual data released by governments and published in World Bank's World Development Indicators (WDI) and the IMF's International Financial Statistics. Its main advantage is coverage: covering every country listed in WDI from 1970 to 2010, though the common time period between this dataset and a second dataset on taxation and government revenue (below), limits us to the 1980–2010 period.[19] Although we will use both the transparency and the accountability indices, the accountability index turns out to be highly correlated with the proxy that we must use for tax enforcement, i.e., rule of law[20] (correlation of about 0.73[21]). This makes sense since a large part of accountability of any government is abiding by rule of law. While we will still opt to use both measures and present both sets of results, because

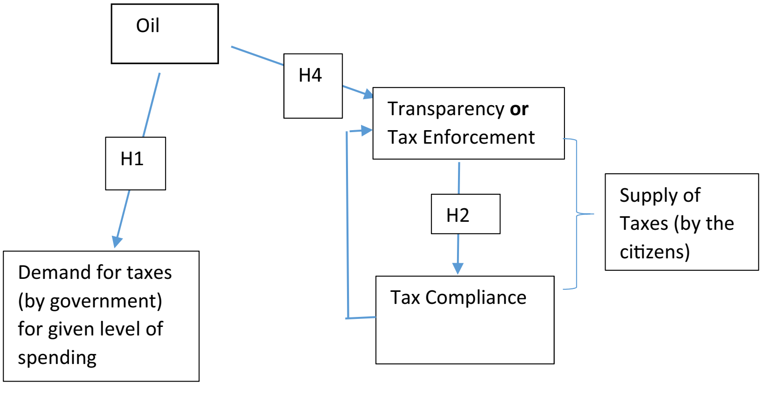

FIGURE 3 Hypotheses and model structure

[19]In Williams (2015), the information transparency and accountability indices are broken down into their subcomponents but for our purposes using the overall measure for each is more appropriate.

[20]The WDI index of rule of law is composite index which includes the enforcement of taxes as one of its components. However, WDI does not provide information on the specific components of this index. For this reason we use the full index as our best proxy for tax enforcement.

[21]Naturally, this correlation is for non-missing observations in both variables.

of the collinearity with the rule of law we present the accountability results as a robustness test for the main regressions, rather than as part of the main regressions.

Besides Williams' data, Hollyer, Rosendorff, and Vreeland (2014) have developed a transparency dataset similar to Williams (2009) but based on a Bayesian methodology. However, their transparency measure contains 1,500 fewer observations. Moreover, the correlation between the two datasets is very high (82%). Thus, we opted for the dataset by Williams which has the added advantage of compatibility with his accountability index. While simply counting the amount of information is not an accurate measure of the quality of information released by governments, Williams (2011) shows that the RI index is highly correlated with World Bank's Statistical Capacity index and thus also casts light on the quality of information released. This dataset allows us to use panel estimation techniques and hence examine within-country effects over time. The index ranges from −10 to +10 which we normalize to (0,1).

For taxation data, we use a dataset from the International Center for Tax and Development (ICTD, 2014) for 1980–2010. The ICTD dataset significantly improves on existing data in quality, standardization, and coverage.[22] Of the many tax revenue variables available from ICTD, we choose revenue from *personal income taxes* because this variable matches the theory more closely. Since no direct and reliable international data exists on tax compliance,[23] tax revenue is used as a proxy for tax compliance based on the earlier theoretical discussion (see discussion preceding Equation 19) in which by using government spending g to control for the variations in the tax rate, t, component of tax revenue $t\mu$ one should be able to isolate and identify the compliance component, μ. We carefully examine this assumption in detail in our results section (Section 6.3). Our findings there are consistent with this assumption. We also carry out a robustness test of our results, using a limited dataset available on tax compliance from the Fraser Chain Linked index (Gwartney, Lawson, & Hall, 2013) for 2004–2010.

The third main dataset is on oil wealth. There are several problems with using the data from the WDI. First, while the measure of rents nets out the production costs of a resource and therefore in theory seems a suitable measure, in practice costs are measured as a rough estimate taken at a single point in time and are heavily dependent on accounting assumptions; they are hence both uncertain and do not capture actual variations in extraction costs over time, which can be very large. Second, using the WDI "rents" measures create a serious endogeneity problem: The measure relies on countries' self-reporting of their resource data to the World Bank and since our measure of transparency is based on the frequency and extent of reporting of data by countries (see next section), any missing observations may be an indication of low transparency rather than being randomly distributed. Third, there are many missing observations, which may bias our estimate of oil's impact. Fourth, due to missing observations the scope of the coverage of WDI's data is more limited, especially when it is combined with other variables.

To circumvent these problems, we will use an alternative measure, namely "oil and gas value" available from Ross (2013) which is simply the quantity of oil and gas extracted in a given year

[22]Wilson, Cobham, and Goodall (2014) described the new ICTD data as follows: "The dataset meticulously combines data from several major international databases, as well as drawing on data compiled from all available International Monetary Fund (IMF) Article IV reports. It achieves marked improvements in data coverage and accuracy, including a standardized approach to revenue from natural resources."

[23]Efforts to measure tax evasion in developing countries have always involved some measure of the shadow or underground economy. To construct such measures a common variable that has been used is overall tax revenues themselves. Thus, rather than considering how compliance impacts total tax revenues, which is our focus, such studies assume instead that taxation leads to departures from the formal economy. Our concept of compliance here is closer to the measures calculated by the Internal Revenue Service (IRS) and widely discussed in academic circles. Unfortunately, such measures are not available internationally.

multiplied by the per-unit world price. Ross cleaned and compiled data from the U.S. Geological Survey, the U.S. Energy Information Administration's International Energy Statistics, the World Bank, and the BP Statistical Review. This dataset covers 172 countries, of which 95 have produced oil, from 1932 to 2011. Due to its approximate independence from the self-reporting aspect of the pure WDI measure, this measure largely circumvents the above endogeneity issue and yet is highly correlated with the WDI measure. Furthermore, by avoiding the thorny challenge of estimating extraction costs, this measure covers nearly all countries.

Most of the other variables are from WDI, but democracy data is from Polity IV (2013). The data coverage is 1980–2010 for approximately 150 countries. The latter varies slightly depending on the variables used. Appendix G provides information on variables, data sources, and descriptive statistics.

Finally, we need data to instrument for oil. Despite its many merits above, oil value still represents revenue and much has been written about its potential endogeneity to institutions. We will cover this issue later. Here we just mention the remedy and the data: We will combine two instruments for oil value; *oil prices* (in 2,000 constant prices) and *oil reserves* from the giant oil field discoveries data by Horn (2014) to create a single dynamic instrument. This approach has a number of advantages that we will discuss later. The appropriateness of using oil reserves is extensively discussed in Cassidy (2016). This type of data is also used in a recent paper by Arezki et al. (2017).

5. | ESTIMATION STRATEGY

We use GMM to estimate the structure of the model. Endogeneity concerns are of particular importance and an entire subsection is devoted to them. Three types of equations are estimated with their different variants: The first type are equations that test the direct effect of oil revenues on taxes. We may call these reduced form equations since they precede testing any structural mechanism that underlie this relation. They estimate the effect of oil revenues on taxation and are basically a test of hypothesis H1:

$$(t\mu)_{it} = a_1 + b_1\rho_{it} + c_1 g_{it} + \tilde{\mathbf{d}}'_1 \cdot \tilde{\mathbf{X}}_{it} + u_{1i} + v_{1t} + \varepsilon_{1it} \tag{33}$$

The residuals, u_{1i} and v_{1t} are country and time fixed effects and ε_{1it} is the regression error that includes unobserved heterogeneities; $\vec{\mathbf{X}}_{it}$ is the column vector of controls (see below). Based on hypothesis H1 we would expect that $b_1 < 0$. In addition if spending drives taxes then $c_1 > 0$. Here, if either g or ρ are endogenous, the estimates of both b_1 and c_1 will be biased. This will be taken up shortly in a separate section dedicated to the discussion of endogeneity, the remedies for it, and the instruments used.

The second and third types of equations test the structural mechanism underlying the reduced form relation. They join hypotheses H2 and H4, linking the behavior of the tax payers and the government in a Stackelberg game. Thus, for transparency and tax enforcement policies (hypotheses H4a and H4b) we have,

$$T_{it} = a_2 + b_2\rho_{it} + \tilde{\mathbf{c}}'_{12} \cdot \tilde{\mathbf{X}}_{it} + u_{2i} + v_{2t} + \varepsilon_{2it} \tag{34}$$

$$L_{it} = a_3 + b_3\rho_{it} + \tilde{\mathbf{c}}'_{13} \cdot \tilde{\mathbf{X}}_{it} + u_{3i} + v_{3t} + \varepsilon_{3it} \tag{35}$$

in which we expect b_2, $b_3 < 0$; for tax payer response to policies (hypotheses H2a and H2b), we have,

$$\ln(t\mu)_{it} = a_4 + [b_4 \ln \hat{T}_{it}] + [c_4 \ln \hat{L}_{it}] + d_4 g_{it} + \tilde{\mathbf{f}}_4' \cdot \tilde{\mathbf{X}}_{it} + u_{4i} + v_{4t} + \varepsilon_{4it} \tag{36}$$

Equations (34) and (35) are each tied to Equation (36) by the fact that the predicted values of L and T on the right hand side of 36 come from 34 and 35, following the theoretical model in which tax payers in Equation (36) "react" to the government's choice of T and L in Equations (34) and (35). The logarithmic specification for $t\mu$, $\hat{T}$ and $\hat{L}$ in 36 which is equivalent to estimating the generic form $Y = Z^m$ has two distinct advantages over the more common practice of using a quadratic specification. First the estimates of $\hat{b}_4$ and $\hat{c}_4$ in 36 are free of units of measurement. This is particularly important for the measure of T and L where the choice of units would otherwise affect the size of the coefficients. Second, per hypothesis, tax payer compliance always increases in T and L (albeit at a diminishing rate) but never decreases. A quadratic specification would pose additional burden to support (or reject) this hypothesis.[24] In accordance with this, we expect $0 < b_4, c_4 < 1$. The brackets in 36 is meant to indicate variations in the regression model with only one, or both, of the two variables, T or L, to be included in the regression.

The presence of g_{it} in 36 is meant to pin down the tax rate t in $t\mu$ (recall that g drives t) so that $t\mu$ really signifies compliance not revenue. To check this we estimate 36 both with and without g_{it}. In the empirical section, we will show that even if controlling for government expenditures does not control for the variations in tax rate, t, it would still be the case that the condition $0 < \hat{b}_4, \hat{c}_4 < 1$ in Equation (36) would constitute the necessary and sufficient condition in support of the tax compliance hypothesis.

5.1 | Controls

GDP per capita is our first control. In their questioning of the validity of the resource curse hypothesis, Alexeev and Conrad (2009) have argued that a positive resource shock leads to a boost in GDP per capita, artificially biasing subsequent growth rates downward. Similarly, they argue, such a boost places oil producers in the class of richer countries with better institutions so that by comparison resource rich countries appear as though they have worse institutions, a result less due to oil curse than a boost in national income. This argument would implicate our transparency, rule of law and taxation equations, the latter because tax revenue is also measured relative to GDP and suffers the same fate as growth rate. Alexeev and Conrad's proposed instruments are static (e.g., geographic factors such latitude) that would drop out in any fixed effects panel model. In the absence of a strong dynamic instrument for GDP per capita, the GMM method comes to our aid where lagged GDP per capita can be used to instrument for current GDP per capita.

*Polity*2, which measures democratic freedoms, is our second control. More democratic regimes tend to be more transparent. But as the components of the measure of Polity2 suggest, Polity2 is about more than transparency and covers many other aspects of society and polity. Controlling for Polity2 allows for the residual variations in transparency that are unrelated to polity but may be potentially related to a positive oil shock to be examined. The inclusion of *Polity*2 also controls for "the Norway factor", i.e., for non-idiosyncratic variations due to countries' high quality institutions. (The further

[24]In a quadratic specification, with the coefficients of the linear term and quadratic terms positive and negative respectively, to establish that tax payer compliance never falls with T and L one would have to establish that the peak of the resulting parabola occurs outside of the range of support of T and L, requiring one to compare the size of the linear term and quadratic terms. These additional calculations are not needed in our case.

possibility that Polity2 may be subject to reverse causality from transparency is addressed later in the GMM estimation). Finally, should we suspect that democratically elected governments may be more responsive to their citizens by spending differently (or more) on public goods than otherwise, Polity2 can control for variations in the variable g that are unrelated to the role of public spending in our model.

A variable called *Trade taxes* is our next control. This variable addresses the potential influence that the presence of a weak income tax environment might have on a government's decision to, say, increase its extraction of oil reserves to earn more revenue. Since trade taxes are easier to impose and collect in many developing economies with weak income tax environments, trade taxes would be expected to also be higher in such an environment. Our selection of a strong instrument for oil means that variations in oil revenues will be unrelated to any other source of variation in the model including trade taxes. Nonetheless, this issue will be examined. By including and excluding trade taxes in our regressions, we will be able to see whether or not trade taxes actually influence the size of the coefficients of the oil revenues.

5.2 | Endogeneity issues

In what follows, we first discuss some of the potential endogeneity issues that may arise in different parts of the model and offer remedies. In all cases, except one, the remedies are based on using GMM methodology. The appropriateness of using GMM in these cases is extensively discussed later. In the case of one variable, oil revenue, we construct a unique dynamic composite instrument that takes advantage of exogenous variations in oil reserves (Horn, 2014) *and* oil prices in an IV estimation embedded in the GMM methodology.

5.2.1 | Oil revenues

Possible endogeneity of oil revenues is the most critical issue, both in our paper and in the literature. In our paper, the specific points where this issue can possibly arise are as follows: In the relationship between oil and taxation, it is possible to imagine that the need for more tax revenues drives the decision to extract more oil so that taxation could also drive oil revenues. In the equation that relates oil revenues to transparency a potential endogeneity of oil revenue arises since countries that are more transparent may provide a better environment for foreign investments in oil (and other natural resources), creating a reverse causality from transparency to oil revenues. Bohn and Deacon (2000) found that democratic institutions and political stability positively affect investments in oil exploration. Cust and Harding (2015) showed that when oil is potentially located on a national border, 95% more exploration occurs in the country with relatively better institutions. As stated, we address the endogeneity of oil in both equations by the above mentioned composite instrument. We will discuss this instrument in greater detail shortly below.

5.2.2 | Public spending

In the oil-taxation equation, public spending g appeared as a variable. The model assumed that g was exogenous to, and a driver of, taxation $t\mu$ (Equation 18). This assumption may be questioned. For example, one can imagine that the *expectation* of higher tax revenues may drive officials to spend more. To maintain consistency with the theory, we will first estimate our model with an exogenous g. We then follow this with a robustness test by letting g to be endogenous. Our main results turn out to remain robust in either case.

In the transparency or tax enforcement versus compliance equation, there may be another source of endogeneity of g. Recall that in deriving the relation between the government's choice of T^* and L^* and the citizens' tax compliance, government level of spending g was assumed to be exogenous to its decision on T^* and L^*. But in the fiscal capacity model of Besley and Persson (2009, 2010, 2011) when institutions are relatively more "cohesive," a "common-interest" state is more likely to emerge. Such a state probably spends more on public goods, g. If greater cohesion also implies greater transparency because such a state is less threatened by disclosures due to greater public trust, then the unobserved variable "cohesion" is correlated with both g and T, leading to the endogeneity of g. Once again, we address this issue by allowing g to be endogenous in a robustness test of the oil-transparency equation, similar to the oil-taxation equation above.

Further to this point, if g were to influence the government's decision of T^* and L^* such that more g would buy the government less transparency (or rule of law), controlling for g in the tax compliance equation should lead to a smaller effect of T^* and L^*. To test this, we can simply include and exclude g and compare the results. We will find evidence against g being a "strategic" variable in the above sense.

Finally, the theory also allowed for g to either depend on oil revenues ρ or not (Equation 20). On this point the literature is conflicted. For example, Cassidy (2016) argued that resource windfall reduces the marginal utility of public goods to policy-makers, causing them to invest less in fiscal capacity, though he does not provide evidence while Ross (2012) finds than more oil revenue may lead to increased public spending. Empirically, in our test, this issue is not an endogeneity problem but merely a colinearity issue. This is addressed by *including* and *excluding* variable g in the empirical test of the relation between oil and taxation. While colinearity does lead to estimation bias, the direction of this bias is to underestimate the negative effect of oil on taxation, if more oil drives more spending as Ross (2012) suggests, as can be also seen from Equation (20) in the model. We find this to be the case.

5.2.3 | Polity2

The taxation-representation argument discussed in the introduction implies that the need for taxation by the government may actually drive more open political systems so that taxation may also influence the Polity2 variable. There is also a possibility of reverse causality in the relation between polity and transparency: one might ask whether it is democratic institutions that influence transparency, or that greater transparency induces more democratic institutions. To address both of these concerns, throughout the estimation, the variable Polity2 is allowed to be endogenous.

5.2.4 | Per capita income

The use of per capita income as a control must be carefully examined. Several studies suggest that oil revenues boost income (Alexeev & Conrad, 2009; Arezki et al., 2017; Smith, 2015). While static geography instruments such as absolute latitude and regions of the world have been used for example by Alexeev and Conrad (2009) such instruments amount to fixed effects and drop out in any dynamic or fixed effects estimation technique. As we discuss below, The GMM procedure offers an alternative.

5.3 | Remedies

5.3.1 | Instrument for oil

We begin with the most critical endogeneity issue that of oil revenues. One approach to this concern has been to use oil price fluctuations as an identification strategy (Andersen, Johannesen, Lassen, &

Paltseva, 2014; Brückner, Ciccone, & Tesei, 2012; Carreri & Dube, 2015; Caselli & Tesei, 2016; Dube & Vargas, 2013). While Price does offer the possibility of exogeneity (except perhaps Saudi Arabia), it lacks cross-country variations since the use of price shock ignores revenue variability which depends on quantity of oil extracted and does not reflect the countries' differences in endowments. Cassidy (2016) uses geologically determined oil basins to generate cross-country variation in oil wealth. We also use this variable. But this instrument lacks a time dimension. To address both problems, we combine both instruments to create a single instrument which we then use in an instrumental variable estimate (IV) embedded in the GMM procedure (see below).

5.3.2 | The GMM method

One major problem that plagues the use of 2SLS Instrumental Variable (IV) method is *the validity of exogenous instruments*. Given the nature of what we investigate, it is very difficult to identify instruments that satisfy the valid instrument criteria such that they can be used in the two-step procedure of the IV method. The only valid dynamic exogenous instrument we can make a case for is the instrument for oil reserve value, as discussed above.

To remedy this issue, we adopt a static and a dynamic panel System GMM approach that is suitable to address the above challenge. The methodology is a culmination of advances by Arellano and Bond (1991), Arellano and Bover (1995), Blundell and Bond (1998), and Holtz-Eakin, Newey, and Rosen (1988). The system GMM approach is ideal given the potential endogeneity of oil value and other variables as discussed. It assumes that the only available instruments are "internal", i.e., based on lags of the instrumented variables while also simultaneously allowing for the introduction of external instruments in an embedded IV procedure (i.e., our composite oil reserve instrument), so we have the best of both worlds. The flexible nature of GMM allows us to simultaneously correct for a number of econometric shortcomings embedded in an analysis such as this, including heteroskedasticity, autocorrelation, finite samples, and the presence of country fixed effects. This approach also readily provides tests for serial correlation, overidentification, and under-identification of the instrument sets used. Suppose,

$$y_{i,t} = \alpha y_{i,t-1} + X'_{i,t}\beta + \varepsilon_{i,t}$$

with

$$\varepsilon_{i,t} = \mu_i + \theta_{i,t}$$

Eliminating the fixed effects by the usual differencing methods exacerbates the problem of missing variables, drastically reducing a dataset with missing data. Arellano and Bover (1995) suggested an alternative method of transformation that minimizes the loss in data called forward orthogonal deviations. In place of taking the first difference, the forward orthogonal deviations transformation subtracts the average of all future available observations of a variable so no matter how many gaps exist in the dataset, observations will exist for all entries except the last observation for each individual using this transformation, while still eliminating the fixed effects. This way, data loss is minimized and because lagged variables are not part of the transformation process, they are still valid instruments (Roodman, 2009). If ω is a variable, then its transformation is,

$$\omega^{\text{trans}}_{it+1} = c_{i,t}\left(\omega_{i,t} - \frac{1}{T_{i,t}}\sum_{s>t} w_{i,s}\right)$$

where $c_{i,t} = \sqrt{T_{i,t}/T_{i,t+1}}$ and where $T_{i,t}$ is the number of available future observations. The choice of $c_{i,t}$ here preserves the properties of $\omega_{i,t}$ after transformation (Roodman, 2009). Denoting the orthogonally transformed variables by "*", the following equation is estimated:

$$y^*_{i,t} = \alpha y^*_{i,t-1} + X^{*\prime}_{i,t}\beta + \theta^*_{i,t}$$

To estimate the equation above, we use the xtabond2 command with the robust option and one step estimation in STATA which corrects for heteroskedasticity and auto correlation; the "small" option which corrects for finite sample regressions and generates t-stat and F-stats instead of z and chi square statistics; the "orthogonal" option which uses forward orthogonal deviations transforms instead of first differencing while simultaneously taking care of fixed effects across countries and finally, the IV option to use our only exogenous instrument: reserve value (estimated reserves × oil price). The GMM option is also used to instrument for other variables using lags as is the standard case in GMM regressions. The AR(1) and AR(2) tests for serial correlation with p stats greater than 0.05 suggest no serial correlation at lags 1 and 2. Note that when we introduce the lag of the dependent variables in the regressions, the specification indicates serial correlation of order (1) so the test should show p values for AR(1) less than 0.05 (Roodman, 2009). Finally, tests of overidentification are carried out for each regression using the Hansen Statistic as this is known to be the more appropriate test for our system GMM estimation. The null hypothesis associated with this statistic is that the instruments are valid so that large p values (e.g., greater than 0.05), suggest that we cannot reject the null, i.e., instruments *are* valid.

6. | RESULTS

6.1. | The direct effect of oil on taxation

Table 1 shows the direct effect of oil on tax revenue per Equation (33) with the first four columns representing static estimation and columns 5 through 8 representing dynamic panel estimation, i.e., with lagged dependent variable added, as shown here:

$$(t\mu)_{it} = a'_1 + l_1(t\mu)_{it-1} + b'_1\rho_{it} + c'_1 g_{it} + \acute{\mathbf{d}}''_1 \cdot \tilde{\mathbf{X}}_{it} + u'_{1i} + v'_{1t} + \varepsilon'_{1it} \tag{37}$$

Without exception, Table 1 corroborates the first hypothesis (H1): i.e., $\hat{b}_1 < 0$ and $\hat{b}'_1 < 0$ and significant through different permutations in all the columns of Table 1. This is in line with the literature cited earlier that oil revenues negatively impact tax revenue collection. In addition, in three out of four specifications, higher public spending drives greater tax collection as expected: i.e., $\hat{c}_1 > 0$, $\hat{c}'_1 > 0$.

As for the role of government spending itself, we have mentioned that Ross (2012) found that oil producers spend more (not less) perhaps to elicit greater constituent loyalty, while Cassidy (2016) argued the reverse. Table 1 finds support for the Ross view. This also verifies the derivative in Equation (20) and Proposition 2. Specifically, Equation (20) showed that if $g_\rho > 0$, i.e., if oil producers spend more to elicit greater constituent loyalty then $d(t\mu^*)/d\rho|_{g=\bar{g}} < d(t\mu^*)/d\rho|_{g=g(\rho)} < 0$, that is, controlling for g should mean a more negative effect of oil revenue on taxation. Indeed this is the case: when the difference in the estimates comes from controlling versus not controlling for g, the static model in Table 1 (column 3) shows significantly more negative oil coefficient than the respective coefficient in column 2; in the dynamic model of the same table, the difference is even more stark: the oil coefficient in column 7 is twice as large as its counterpart in column 6. This indicates that $g_\rho > 0$.

TABLE 1 Oil and tax revenue

	Tax revenue							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Static estimation (no lag)				Dynamic estimation (with first lag)			
Lag of tax revenue					0.978***	0.975***	0.970***	0.973***
					(0.008)	(0.008)	(0.01)	(0.010)
GDP PC	1.609***	1.336***	1.351***	1.507***	0.023*	0.028**	0.035**	0.039*
	(0.323)	(0.276)	(0.248)	(0.227)	(0.013)	(0.013)	(0.014)	(0.021)
Oil value	−6.018**	−4.580**	−6.109***	−6.543***	−0.235***	−0.261***	−0.445***	−0.396***
	(2.406)	(2.085)	(1.681)	(1.635)	(0.069)	(0.083)	(0.110)	(0.124)
Polity2		0.108**	0.066	0.031		−0.002	−0.004	−0.005*
		(0.049)	(0.046)	(0.045)		(0.003)	(0.003)	(0.003)
Gov. cons			0.109***	0.125***			0.005**	0.001
			(0.032)	(0.033)			(0.003)	(0.003)
International trade taxes				−0.028				0.005
				(0.065)				(0.006)
Constant	−8.537***	−6.986***	−8.438***	−9.868***	0	−0.116	0	−0.010
	(2.382)	(1.960)	(1.810)	(1.685)	(.)	(0.142)	(.)	(0.145)
Hansen specification test (p values)	1	1	1	1	1	1	1	1
Serial correlation (p values)								
1st order	0.459	0.237	0.290	0.256	0	0	0	0
2nd order	0.328	0.135	0.323	0.065	0.471	0.389	0.353	0.398
No of instr.	929	1,335	1,705	1,963	1,338	1,678	1,981	2,126
Countries	145	138	138	134	145	138	138	134
Observations	2,656	2,531	2,488	2,394	2,482	2,365	2,328	2,244

Notes. For variable measures see Appendix G. *,**,***Significant at 10%, 5%, and 1%. Standard errors in parentheses. All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification p values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. The first four columns capture the direct effect of oil value on tax revenue, the last four columns do the same but introduce dynamics by having the lag of the dependent variable as part of the regressors. For all variations, we see that oil has a consistently strong and significantly negative effect on tax revenue generation, confirming other works in the literature.

TABLE 2 Indirect effect stage 1: From oil to transparency and rule of law

	Transparency		Rule of law		Transparency (matching sample)	
	(1)	(2)	(3)	(4)	(5)	(6)
GDP PC	0.0520***	0.0473***	0.0858***	0.0883***	0.0501***	0.0424***
	(0.00605)	(0.00633)	(0.00834)	(0.00757)	(0.00870)	(0.00936)
Oil value	−0.170***	−0.184***	−0.273***	−0.309***	−0.143**	−0.166***
	(0.0563)	(0.0655)	(0.0963)	(0.0940)	(0.0657)	(0.0553)
Polity2	0.00774***	0.00649***	0.00755***	0.00564**	0.00922***	0.00743***
	(0.00131)	(0.00110)	(0.00247)	(0.00251)	(0.00222)	(0.00222)
Gov. cons	−0.00239***	−0.00206***	0.00198*	0.00261***	−0.00237**	−0.00222***
	(0.000621)	(0.000771)	(0.00102)	(0.000981)	(0.000975)	(0.000804)
International trade taxes		−0.00433**		−0.000146		−0.00409
		(0.00213)		(0.00182)		(0.00284)
Hansen specification test (*p* values)	1	1	1	1	1	1
Serial correlation (*p* values)						
1st order	0	0	0.630	0.342	0.191	0.0146
2nd order	0.139	0.285	0.153	0.134	0.786	0.945
No of Instr.	1,888	2,170	1,093	1,187	1,096	1,184
Countries	154	149	156	150	154	148
Observations	4,075	3,111	1,776	1,424	1,752	1,406

Notes. For variable measures see Appendix G. *,**,***Significant at 10%, 5%, and 1%. Standard errors in parentheses. For columns 1, 2, 5, and 6, the addition of lags of the dependent variable does not eliminate serial autocorrelation. We thus cluster the errors by the panel to generate more efficient estimates despite the presence of autocorrelation (see Wooldridge 2002). All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification *p* values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. All columns highlight the first stage of the indirect effect of oil on tax revenue by capturing the effect of oil revenue on transparency and rule of law. Columns 5 and 6 repeat the regressions of columns 1 and 2 on transparency but *match* the observations in the rule of law sample as closely as possible to rule out sample effects. We see the negative effect of oil on each variable of interest as hypothesized in the paper.

6.2 | Oil-transparency and oil-enforcement effects

In light of the above evidence on the negative effect of oil revenues on taxation, we now test the explanation that this effect arises because oil abundance represses the government's desire for transparency and/or rule of law (path 1) which in turn represses the citizens' tax compliance (path 2). We thus allow for equal treatment for the alternative mechanism of oil acting to reduce tax enforcement. First we test the validity of path 1. Results are given in Table 2. Because there is no direct systematic data on tax enforcement, we use the Rule of Law variable from WDI as a proxy. This may not be a major limitation because tax enforcement is in fact used as a components of the Rule of Law variable in WDI, and in any case the two are likely to be highly correlated. Thus, results on tax enforcement must be understood with this caveat in mind. Results for the oil coefficient in first four columns of Table 2 are negative and significant at 1%, supporting the view that oil subverts both transparency and tax enforcement (as proxied by rule of law), i.e., $\hat{b}_2, \hat{b}_3 < 0$. This is consistent with the expectation in Equations (34) and (35) and the hypotheses H4a and H4b. Due to sample size differences between the sample that includes rule of law and the one that includes transparency, care is exercised to assure coefficient differences are not due to sample differences. For this reason, columns 5 and 6 repeat the transparency regressions of columns 1 and 2 for the sample that matches the observations of the rule of law. Results from the matched sample remain consistent with the original sample but lose some size and some significance, possibly due to loss of many observations in the matched sample. Also,

TABLE 3 Indirect effect stage 2: From transparency and rule of law to tax compliance (test of strategic policy on both variables)

	Log of tax revenue					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Lag of tax revenue	0.943***	0.946***	0.959***	0.959***	0.947***	0.943***
	(0.0123)	(0.0119)	(0.0226)	(0.0224)	(0.0256)	(0.0256)
GDP PC	−0.0225	−0.0182	−0.0491***	−0.0354***	−0.0469**	−0.0317*
	(0.0140)	(0.0132)	(0.0137)	(0.0117)	(0.0204)	(0.0163)
Log of transparency	0.418***	0.458***			0.625***	0.574***
	(0.0961)	(0.114)			(0.239)	(0.204)
Log of rule of law			0.349***	0.265***		
			(0.0583)	(0.0411)		
Polity2	−0.00702***	−0.00715***	−0.00662**	−0.00436	−0.0105**	−0.00788**
	(0.00230)	(0.00241)	(0.00281)	(0.00276)	(0.00462)	(0.00356)
Gov. cons.	0.00499***	0.00449**	0.00112	0.000971	0.00664**	0.00597**
	(0.00189)	(0.00184)	(0.00103)	(0.000973)	(0.00302)	(0.00257)
International trade taxes	0.00109	0.00779***	−0.000367	0.000309	0.000148	0.00551**
	(0.00261)	(0.00281)	(0.00228)	(0.00224)	(0.00251)	(0.00274)
Hansen specification test (p values)	1	1	1	1	1	1
Serial correlation (p values)						
1st order	0	0	0	0	0	0
2nd order	0.105	0.0807	0.126	0.125	0.188	0.0849
No of Instr.	2,103	2,103	984	984	984	984
Countries	133	133	128	128	128	128
Observations	2,215	2,215	1,030	1,030	1,030	1,030

Notes. For variable measures see Appendix G. *,**,***Significant at 10%, 5%, and 1%. Standard errors in parentheses. All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification p values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. We use the lag of tax revenue here because the initial specification without lags fails the serial correlation test at the second lag. This resolves the second-order serial correlation for all columns reported. All columns capture the second path, i.e., the effects of transparency and rule of law on tax revenue as a proxy for tax compliance (see the text) with each column using estimates generated from corresponding columns of Table 2 (e.g., column 1 uses estimates of transparency from column 1 of Table 2, etc.). This is done to test for the tax payers' optimal response to the government's chosen level of transparency or tax enforcement (in turn impacted by oil revenue). We see that the coefficients of the logs of both transparency and rule of law are between 0 and 1 confirming concave (thus optimal) response of tax payers as per theory.

TABLE 4 Indirect effect stage 2: From transparency and rule of law to compliance (robustness test): Testing strategic choice of transparency (rule of law) with rule of law (transparency) as control)

	Log of tax revenue					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Lag of tax revenue	0.939***	0.940***	0.960***	0.960***	0.946***	0.940***
	(0.0202)	(0.0207)	(0.0211)	(0.0209)	(0.0235)	(0.0230)
Log of transparency	0.466***	0.515***			0.565***	0.726***
	(0.107)	(0.127)			(0.0762)	(0.0951)
Log of rule of law			0.354***	0.261***	−0.0911	−0.120***
			(0.0578)	(0.0393)	(0.0550)	(0.0441)
Rule of law	0.159	0.134				
	(0.104)	(0.103)				
Transparency			−0.0728	−0.0167		
			(0.137)	(0.161)		
GDP PC	−0.0572***	−0.0547***	−0.0493***	−0.0347***	−0.0314**	−0.0301**
	(0.0171)	(0.0176)	(0.0124)	(0.0107)	(0.0130)	(0.0123)
Polity2	−0.00700**	−0.00668**	−0.00655**	−0.00396	−0.00654**	−0.00727***
	(0.00287)	(0.00279)	(0.00298)	(0.00294)	(0.00258)	(0.00244)
Gov. cons.	0.00614***	0.00563***	0.000985	0.000706	0.00716***	0.00788***
	(0.00216)	(0.00207)	(0.00103)	(0.000941)	(0.00156)	(0.00164)
International trade taxes	0.000329	0.00498*	−0.000671	0.0000660	−0.0000661	0.00696***
	(0.00274)	(0.00267)	(0.00240)	(0.00230)	(0.00245)	(0.00257)
Hansen specification test (*p* values)	1	1	1	1	1	1
Serial correlation (*p* values)						
1st order	0.003	0.003	0.00	0.00	0.00	0.00

(*Continues*)

TABLE 4 (Continued)

	Log of tax revenue					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
2nd order	0.893	0.914	0.138	0.130	0.114	0.1
No of instr.	985	985	990	990	1,001	1,001
Countries	128	128	126	126	128	128
Observations	1,030	1,030	1,017	1,017	1,030	1,030

Notes. For variable measures see Appendix G. *,**,***Significant at 10%, 5%, and 1%. Standard errors in parentheses. All regressions use dynamic panel system GMM (xtabond2 command on stata), errors correct for heteroskedasticity and autocorrelation; all columns include time fixed effects. Hansen overidentification $p > 0.05$ mean we cannot reject the null hypothesis which states that instruments *are* valid. We use the lag of tax revenue because the initial specification without lags fails serial correlation test at the second lag. This resolves the second-order serial correlation for all columns reported. All columns capture the second path, i.e., the effects of transparency or rule of law on tax revenue as a proxy for tax compliance (see text) with each column using estimates generated from corresponding columns of Table 2 (e.g., column 1 uses estimates of transparency from column 1 of Table 2, etc.). This is done to test for the tax payers' optimal response to the government's chosen level of transparency or tax enforcement (in turn impacted by oil revenue). (We do not use the "matching sample" columns of Table 2 since including rule of law as a control already reduces the sample). Unlike Table 3, however, columns 1 and 2 have rule of law as a control for transparency and columns 3 and 4 have transparency as a control for rule of law. (In such cases, the control takes its value from the actual data, rather than its predicted value in Table 2.) We see that the coefficients of the logs of transparency and rule of law fall between 0 and 1 confirming concavity. For columns 5 and 6, the estimates of transparency and rule of law from stage 1 are *both* used to see which effect dominates when both are optimally chosen by the government. We see that transparency clearly dominates as its coefficient is between 0 and 1 and significant.

note that greater democracy, as captured by Polity2, is associated with more transparency and more rule of law.

6.3 | Effects of transparency and rule of law on tax compliance

We now examine the hypothesis that tax payers' compliance behavior is an optimal *response* to government transparency and/or enforcement of taxes (the latter indicated by rule of law). Results are reported in Tables 3 and 4 with transparency and the rule of law showing up in log forms, consistent with Equation (36) (or Equations 24 and 25 from the model) and the "increasing but diminishing returns" behavior of tax payers' response to T and L. The difference between the two tables is that (a) in Table 3, T and L show up separately, whereas in Table 4 (last two columns), they also show up together and (b) in the first 4 columns of Table 4 the log form of each variable is accompanied by the non-log form of the other variable. This is to "control" for the role of one variable when examining the optimal response of the other. Because compliance is supposed to capture tax payer response to the government's chosen levels of transparency or rule of law (first mover), it is the *predicted* values of transparency and rule of law from Table 2 that are used Tables 3 and 4. Thus, each column uses the values of transparency or rule of law as predicted from the corresponding columns of Table 2. Results indicate that the response of tax payer compliance to transparency *and* rule of law is highly significant, positive and diminishing, confirming hypothesis H2. This means that our estimates of the corresponding coefficients in Equation (36) are in fact as expected: $0 < \hat{b}_4, \hat{c}_4 < 1$. However, notice that despite both variables, transparency and rule of law, being normalized and having same scale, transparency is the stronger and the more robust of the two: First, $\hat{b}_4 > \hat{b}_3$ in all cases, i.e., the taxpayers respond more strongly to transparency than to they do to rule of law. Second, when both variables are introduced simultaneously (columns 5 and 6 of Table 4), rule of law loses all significance and falls outside of the range (0,1). The fact that the these results are obtained with Polity2 being controlled for throughout different variations, gives us greater confidence that we are actually capturing something about transparency and not democracy per se.

Table 5 allows us to examine an important assumption of the model. It repeats the specification of Table 3 but *excludes* g: To explain, we have assumed that government spending decisions drive the "tax rate," broadly defined (see theory section for details). If so, this would mean that by controlling for the variations in g in our regressions, we in effect control for the variations in t in the expression $t\mu^*(t, T, L)$. This way, our dependent variable, which is tax revenue as a share of national income in Tables 3 and 4, would be a good proxy for underlying compliance. (In fact Proposition 4 showed that a positive $d(t\mu^*)/dT$ indicates a positive $d\mu^*/dT > 0$.) We will now see if this argument really holds. First note that in the absence of g, the variations in the implied tax rate t in the compliance expression $\mu^*(t, T, L)$ are no longer controlled for. Further, note that tax rate t and compliance rate μ move in opposite directions (see Equation 15). Focusing on transparency first, we have $d(t\mu^*)/dT = t{\cdot}d\mu^*/dT + \mu^*{\cdot}dt/dT$. Since $dt/dT < 0$ (Lemma 1), it follows that $d(t\mu^*)/dT < t{\cdot}d\mu^*/dT$. If controlling for g is a proxy for controlling for t, the left hand side of this inequality would be the coefficient of the transparency variable when g is *not* controlled for, while the right hand side is the slope of the compliance variable μ^* times t when g *is* controlled for. Following this logic, Table 5, which does not control for g, should provide the estimates of $d(t\mu^*)/dT$ while Table 3, which controls for g, would give estimates of $d\mu^*/dT$. The difference is of course the tax rate t. But we also know that $t{\cdot}d\mu^*/dT < d\mu^*/dT$. Putting the two inequalities together, we find, $d(t\mu^*)/dT < d\mu^*/dT$. This last inequality therefore constitutes a *necessary* (but not a sufficient) condition for our argument (i.e., its reverse *would* violate our argument). Comparison of the respective coefficients of $\ln(T)$ between the two tables strongly confirms

TABLE 5 Re-estimate of Table 3 without government expenditures

	Log of tax revenue					
	(1)	(2)	(3)	(4)	(5)	(6)
	Trans_1	Trans_2	Rol._3	Rol._4	Trans_5	Trans_6
Lag of tax revenue	0.958***	0.956***	0.950***	0.951***	0.962***	0.958***
	(0.0104)	(0.0102)	(0.0234)	(0.0233)	(0.0218)	(0.0233)
GDP PC	0.000892	0.00341	−0.0409***	−0.0243*	−0.0144	−0.000484
	(0.00784)	(0.00815)	(0.0124)	(0.0127)	(0.0128)	(0.0136)
Log of transparency	0.172***	0.184**			0.204***	0.205***
	(0.0493)	(0.0704)			(0.0776)	(0.0759)
Log of rule of law			0.315***	0.236***		
			(0.0437)	(0.0296)		
Polity2	−0.00435**	−0.00370**	−0.00519**	−0.00358	−0.00220	−0.00356
	(0.00170)	(0.00181)	(0.00240)	(0.00257)	(0.00250)	(0.00287)
International trade taxes	0.00263*	0.00485***	0.00112	0.00208	0.00238	0.00546*
	(0.00156)	(0.00170)	(0.00273)	(0.00285)	(0.00266)	(0.00305)
Hansen specification test (p values)	1	1	1	1	1	1
Serial correlation (p values)						
1st order	0	0	0	0	0	0
2nd order	0.133	0.135	0.135	0.0965	0.117	0.119
No of instr.	1,930	1,929	933	933	933	933
Countries	133	133	128	128	128	128
Observations	2,215	2,215	1,030	1,030	1,030	1,030

Notes. For variable measures see Appendix G. Standard errors in parentheses. *,**,***Significant at 10%, 5%, and 1%. Standard errors are in parentheses. All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification p values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. This table replicates all columns in Table 3 above but omits government expenditure on the right hand side. We use the lag of tax revenue here because the initial specification without lags fails the serial correlation test at the second lag. This resolves the second-order serial correlation for all columns reported. As in Table 3, this table is meant to capture the "second path" (effects of transparency and rule of law on tax revenue) using estimates from Table 2 as a way of testing for the tax payers' optimal response. (See Table 3 for more detail.) We see that the coefficients of the log of transparency and log of rule of law are between 0 and 1 indicating concavity. The coefficients are lower than their counterparts in Table 3 when government expenditure was included.

that this condition is satisfied: the coefficients in Table 3 which represent $d\mu^*/dT$ are anywhere from 1.5 times to 3 times larger than those in Table 5 which represent $d(t\mu^*)/dT$. Focusing next, on the rule of law, L, we find the same pattern except that the differences are much smaller. For robustness check of the above, a comparison of Tables 6 and 4 repeats the comparison of Tables 5 and 3. Thus, Table 6 repeats the pattern of Table 4 but *without* government spending g. The differences in the respective coefficients of transparency between the two tables are even more dramatic with the coefficients in Table 4 ranging anywhere from 2.5 times to nearly 4 times those in Table 6. Similar differences in the coefficients of the two tables are found with respect to the rule of law, but again the differences are somewhat smaller.

TABLE 6 Re-estimate of Table 4 without government expenditures

	Log of tax revenue					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Lag of tax revenue	0.955***	0.955***	0.954***	0.952***	0.959***	0.957***
	(0.0206)	(0.0220)	(0.0223)	(0.0221)	(0.0221)	(0.0214)
Log of transparency	0.185***	0.213***			0.205***	0.252***
	(0.0482)	(0.0601)			(0.0348)	(0.0465)
Log of rule of law			0.296***	0.227***	0.0858	0.0294
			(0.0650)	(0.0362)	(0.0654)	(0.0476)
Rule of law	0.304***	0.294**				
	(0.113)	(0.114)				
Transparency			−0.092	−0.059		
			(0.068)	(0.07)		
GDP PC	−0.048***	−0.044**	−0.0335**	−0.0243**	−0.0230	−0.0120
	(0.018)	(0.019)	(0.0138)	(0.0115)	(0.0164)	(0.0146)
Polity2	−0.004	−0.005*	−0.00495*	−0.00284	−0.00478*	−0.00385
	(0.003)	(0.003)	(0.00258)	(0.00267)	(0.00270)	(0.00236)
International trade taxes	0.002	0.004	0.00182	0.00213	0.00279	0.00556**
	(0.003)	(0.003)	(0.00306)	(0.00296)	(0.00286)	(0.00272)
Hansen specification test (*p* values)	1	1	1	1	1	1
Serial correlation (*p* values)						
1st order	0.001	0.003	0.00	0.00	0.00	0.00
2nd order	0.726	0.733	0.142	0.0868	0.146	0.146
No of instr.	940	940	975	975	985	985
Countries	128	128	126	126	128	128
Observations	1,030	1,030	1,017	1,017	1,030	1,030

Notes. For variable measures see Appendix G. Standard errors in parentheses. Errors corrected for MENA clustering and year-fixed effects. *,**,***Significant at 10%, 5%, and 1%. All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification *p* values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. This table replicates all columns in Table 4 above but omits government expenditure on the right hand side. We use the lag of tax revenue here because the initial specification without lags fails the serial correlation test at the second lag. This resolves the second-order serial correlation for all columns reported. As in Table 4, this table is meant to capture the "second path" (effects of transparency and rule of law on tax revenue) using estimates from Table 2 as a way of testing for the tax payers' optimal response (see Table 4 for more detail). Also, as in Table 4, in columns 5 and 6 neither regressor acts a "control." This is done to see which effect dominates when both are optimally chosen by the government. Results from these two columns show that transparency seems to be the clear "winner" as it remains highly significant, whereas rule of law loses its significance entirely. Further, note that the coefficients for transparency are lower here than their counterparts in Table 4 when government expenditure is included.

We argued in the theory section that the government choice of g does not affect its strategic decisions on T^* and L^*, which we have proxied by rule of law. We now examine this assumption. Before we do, observe that if more public spending were to be used to solicit citizen loyalty, it would act as a *substitute* for the government offering less transparency or rule of law, especially the former. Many rich oil producers seem to spend lavishly on their economy but with little transparency. This would mean a positive correlation between g, on one hand, and T and L on the other so that controlling for the level of g by including it in the regressions should yield *smaller* coefficients of the effect of T and L on tax compliance that excluding g. Comparison of Tables 3 and 5 indicate the precise opposite. Thus, while more spending does occur with more oil revenue, verifying Ross (2012), g does not seem to be a strategic substitute to "buy" citizen goodwill.

6.4 | Endogenous *g*

The design and discussion of the empirical model in Section 5.1 led to two different issues involving g and thus two different ways of treating g. One set of issues was addressed by including and excluding g from a regression model as we have done. The second set of issues involved possible endogeneity of g. So far we have assumed g to be exogenous in loyalty to the theoretical model. Now we will relax that assumption. An appendix, available from the authors reestimates the above tables with g as endogenous. None of our results are affected by this. The fact that allowing g to be endogenous maintains the structural integrity of the results and by implication the model, suggests that a more general model in which g is endogenous would also work. We have avoided the additional complexities of such a model for greater parsimony.

6.5 | Other effects

6.5.1 | Per capita income and Polity2

Richer and more democratic countries experience higher tax revenue share of their national incomes (Table 1) as well as greater transparency and rule of law (Table 2). Neither outcome is surprising. What is interesting is that both these effects are actually captured in the transparency and the rule of law variables so that when the predicted values of the latter are used in Table 3, Polity2 and per capita income exhibit a reverse effect: the residual effect of being rich and more democratic on tax compliance behavior of their citizens is actually negative, among countries that enjoy similar levels of transparency and the rule of law. (Tables 4–6 which replicate Table 3 patterns in different ways, show similar but slightly weaker tendency).

6.5.2 | Trade taxes

We had argued that the inclusion of trade taxes addresses the potential influence that a weak income tax environment can lead to increased resource extraction by the government. Several implications follow: First the selection of a strong instrument for oil should alleviate concerns about the endogeneity of oil revenues from this source. Hence, the inclusion or the exclusion of trade taxes should not influence the size of the coefficients of oil revenue too much. In Table 1, a comparison of columns 3 and 4, as well as 7 and 8, and in Table 2 comparison of columns 1 and 2, columns 3 and 4, and columns 5 and 6 verify that the size of the coefficients of oil revenues do not change very much whether trade taxes are included or excluded. The second and third implications of including trade taxes have to do with the direct influence of trade taxes themselves. These are interesting to examine. Since trade taxes are easier to impose and collect in most developing economies with weak income tax environments, they would be expected to be higher in such environments. Thus, one should expect (a) negative correlation between trade taxes and income taxes; and (b) negative correlation between trade taxes and other factors that influence income tax compliance, i.e., transparency and rule of law. Our findings are rather weak in both regards: Table 1 (columns 4 and 8) shows no significant effect of expectation (a) while Table 2 (column 2) verifies expectation; and (b) with respect to transparency only. Interestingly Table 3 (columns 2 and 6) tells us that once institutions (e.g., transparency) are controlled for, trade taxes do not act as a substitute but as a complement to income taxes. On the whole, however, the sporadic nature of these last sets of results should serve as a caution in overinterpreting them.

6.6. | Robustness test 1: Direct tax compliance

Two types of robustness tests are conducted. First, we use a limited dataset that is available on tax compliance from the Fraser Chain Linked index (Gwartney, et al. 2013) for 2004–2010 to examine tax compliance behavior directly, rather than by inferring it from observed tax revenue data. The tradeoff is of course the very limited direct data on tax compliance, hence the reason for presenting it as robustness test rather than as our main results. Table 7 combines the structure of Table 3 in its first four columns with some aspects of Table 4 in its next four columns. We see that the coefficients of the log of transparency in columns 1–2 are between 0 and 1 which shows nondecreasing concavity as the theory required, but the same cannot be said for rule of law (columns 3–4). Columns 5 and 6 introduce both variables as strategic policy choices but neither variable meets the criteria for optimality. But when columns 7 and 8 introduce a dynamic specification, we see that transparency exhibits the hypothesized concavity consistent with government optimal decision, but rule of law shows a negative coefficient. In short, the result from direct tax compliance behavior tends to vindicate our previous treatment of tax revenue as a proxy for tax compliance, both with respect to the sign and the size of the coefficients and the concavity that underlies government's optimal decision, especially with respect to transparency.

6.7 | Robustness test 2: Government accountability plus compliance

In our second robustness test, we use data from Williams (2015) by replacing his Release of Information measure with his new accountability measure. We report accountability results as a robustness check rather than as main regressions in part because, as previously mentioned, accountability turns out to be highly correlated with the rule of law indicator (correlation coefficient about 0.73), understandably because to a large extent accountability almost by definition means abiding by the rule of law. It therefore appears that accountability may not be truly distinct from the rule of law. For this reason using accountability for our main results may undermine the case for rule of law when both variables are present. The second reason for using accountability as a robustness check and not as main results, is because we observed a very high degree of persistence in this index (but not the transparency index) over the years and especially from the mid 1990s on. Given this degree of persistence in the accountability measure we borrowed from the growth literature and opted for 3-year averages for each country to create a dataset with more variability. But this also meant a large drop in the number of observations. For both these reasons, we have opted to report accountability results as robustness check rather than as main results.

Results are reported in Tables 8–10. Table 8 is a rerun of the original Table 1 for the new dataset. The table confirms the adverse effect of oil wealth on tax revenue for this data as well. Tables 9 and 10 are the heart of the robustness check: Table 9 confirms the adverse role of oil wealth on both accountability and rule of law (as a proxy for tax enforcement). Table 10 examines the effects of both accountability and rule of law on tax revenue as well as on tax compliance. Results confirm the increasing and concave effects of accountability on either tax revenue or tax compliance, thus verifying the robustness of the previous findings with respect to our new accountability measure and our new

TABLE 7 Robustness test 1: Replacing tax revenue data with actual tax compliance data

	Log of tax compliance							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lag of tax compliance							0.878***	0.889***
							(0.00544)	(0.00361)
GDP PC	0.0212***	0.0280***	−0.145***	−0.127***	−0.126***	−0.151***	−0.03***	−0.02***
	(0.00515)	(0.00335)	(0.00600)	(0.00561)	(0.00579)	(0.0108)	(0.00522)	(0.00255)
Log of transparency	0.396***	0.280***			−0.992***	−1.384***	0.702***	0.654***
	(0.0551)	(0.0278)			(0.0651)	(0.0633)	(0.0737)	(0.0471)
Log of rule of law			1.238***	1.093***	1.805***	2.004***	−0.142**	−0.134***
			(0.0340)	(0.0214)	(0.0571)	(0.0680)	(0.0554)	(0.0295)
Polity2	−0.007***	−0.005***	−0.0251***	−0.0163***	−0.0159***	−0.0089***	−0.009***	−0.008***
	(0.00116)	(0.000768)	(0.000989)	(0.000512)	(0.000900)	(0.000643)	(0.000753)	(0.0004)
Gov. cons.	0.00609***	0.00549***	0.00565***	0.00599***	−0.009***	−0.0110***	0.00362***	0.00395***
	(0.000295)	(0.000208)	(0.000272)	(0.000346)	(0.000788)	(0.000794)	(0.000595)	(0.000403)
International trade taxes	0.00246***	0.00351***	−0.005***	−0.005***	0.00164***	−0.0122***	0.00312***	0.00876***
	(0.000224)	(0.000447)	(0.000280)	(0.000300)	(0.000241)	(0.000743)	(0.000215)	(0.000351)
Hansen specification test (*p* value)	1	1	1	1	1	1	1	1
Serial correlation (*p* values)								
1st order	0.309	0.335	0.280	0.296	0.315	0.298	0.406	0.419
2nd order	0.204	0.244	0.179	0.200	0.193	0.201	0.829	0.818
No of instr.	547	547	547	547	554	554	445	445
Countries	118	118	118	118	118	118	110	110
Observations	623	623	623	623	623	623	508	508

Notes. For variable measures see Appendix G. *,**,***Significant at 10%, 5%, and 1%. Standard errors are in parentheses. This is a robustness check on Tables 3 and 4 results with tax compliance replacing tax revenue. All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification *p* values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. All columns here capture the second path, effect of transparency and rule of law on tax compliance with each column using estimates generated from corresponding columns in Table 2 above, e.g., transparency in the first column represents the natural log of estimates of transparency obtained from column one in Table 2 above to highlight the fact that the resulting concavity is coming from the oil component part of transparency. We see that the coefficients of the log of transparency in columns 1–2 are between 0 and 1 which shows non-decreasing concavity as the theory required, but the same cannot be said for rule of law (columns 3–4). Columns 5 and 6 introduce both variables as strategic policy choices but neither variable meets the criteria for optimality. Columns 7 and 8 introduce a dynamic specification and here we see that only transparency shows the hypothesized concavity but rule of law shows a negative coefficient.

TABLE 8 Robustness test 2: Repeating Table 1 for the new dataset comprised of accountability and tax compliance data

	(1)	(2)	(3)	(4)
	Tax revenue			
GDP PC	1.702***	1.399***	1.380***	1.538***
	(0.0318)	(0.00968)	(0.0257)	(0.0427)
Oil value	−4.362***	−3.442***	−4.180***	−3.924***
	(0.122)	(0.0443)	(0.0999)	(0.136)
Polity2		0.0657***	0.0549***	0.0464***
		(0.00173)	(0.00272)	(0.00380)
Gov. cons			0.0926***	0.0787***
			(0.00238)	(0.00298)
International trade taxes				0.130***
				(0.00774)
Hansen specification test (*p* value)	0.304	0.654	1	1
Serial correlation (*p* values)				
1st order	0.683	0.940	0.971	0.863
2nd order	0.973	0.821	0.817	0.556
No of instr.	99	143	187	231
Countries	145	138	138	135
Observations	963	920	904	872

Notes. For variable measures see Appendix G. *,**,***Significant at 10%, 5%, and 1%. Standard errors in parentheses. All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification *p* values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. This is a rerun of Table 1: The regressions had to be rerun given that the data has been converted into three year averages to accommodate the peculiarity in the accountability measure (see text). These columns capture the direct effect of oil value on tax revenue. For all variations, we see that oil has a consistently strong and significantly negative effect on tax revenue generation, confirming other works in the literature.

tax compliance measure. What is interesting is that rule of law now loses its robustness, showing up as an insignificant driver of tax revenue and negatively significant driver of tax compliance. The robustness of transparency, whichever way it is measured, now shines even more by the contrast with the non-robust behavior of its kin, the rule of law.

6.8 | An oil shock experiment

We now ask a different question. Suppose that countries experienced a 10% positive oil shock. We would like to know how much their transparency, accountability and tax revenues decline. In Table 11 the left and right panels show the results for "high" and "low" oil dependent economies defined, respectively, as those with oil revenue of at least 10% and at most 2% of their national incomes. The first three columns focus on changes in transparency, the second three columns on changes in accountability, and the last two columns on changes in the tax revenues due to the oil shocks via transparency and accountability, respectively. Note that, with a few exceptions, countries in the high oil dependent group generally experience larger percentage declines in accountability

TABLE 9 Robustness test 2: Repeating Table 2 with accountability data: from oil to accountability and rule of law (Indirect effect stage 1)

	Accountability		Rule of law	
	(1)	(2)	(3)	(4)
GDP PC	0.0335***	0.0360***	0.111***	0.111***
	(0.00115)	(0.000950)	(0.00124)	(0.000920)
Oil value	−0.114***	−0.0479***	−0.206***	−0.220***
	(0.000948)	(0.00192)	(0.00110)	(0.00139)
Polity2	0.0276***	0.0289***	0.0121***	0.0114***
	(0.000145)	(0.000143)	(0.000117)	(0.000125)
Gov. cons	0.00233***	0.000975***	0.00226***	0.00243***
	(0.0000284)	(0.0000446)	(0.0000280)	(0.0000340)
International trade taxes		0.00102***		0.00253***
		(0.000144)		(0.000126)
Hansen specification test (*p* values)	0.22	0.95	0.267	0.977
Serial correlation (*p* values)				
1st order	0.062	0.107	0.302	0.964
2nd order	0.988	0.686	0.294	0.168
No of instr.	151	187	151	187
Countries	157	150	157	150
Observations	887	764	892	769

Notes. For variable measures see Appendix G. *,**,***Significant at 10%, 5%, and 1%. Standard errors in parentheses. All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification *p* values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. This is a rerun of Table 2: The columns capture the first stage effects, i.e., effect of oil on accountability and rule of law. For all variations, we see that oil has a consistently strong and significantly negative effect both. Thus, replacing transparency of Table 2 with accountability here does not change the stage 1 results, pointing to their robustness.

than in transparency while those in the low oil dependent group experience about the same decline in both. In terms of the ranges, transparency declines least in Norway by −2.33% (from 0.71 to 0.69) and most in the newly established country of Timor-Leste by −5% (from 0.15 to 0.14). The decline in transparency in Saudi Arabia from 0.471 to 0.458 brings it closer to Cameroon with a pre-oil shock transparency of 0.454. The change in accountability is somewhat similar with Norway showing least decline (−2.15%) and Syria showing the largest (−8.98%).[25] Similar drops are observed for tax revenues: For "less-transparency-induced" drop in tax revenues, we see a range from −2.35% for Norway to −9.20% for Timor-Leste. For "less-accountability-induced" drop, we see a range from −1.83% for Norway to −11.33% for Congo. The increase in US oil production due to the recent fracking revolution is also instructive. Here, a 10% increase in the US oil production is associated with a drop of −2.49% in transparency, bringing the US approximately to pre-shock level of UK, and a drop of −2.32% in accountability, bringing the US to slightly above the pre-shock level of Portugal.

[25]Our data end at 2010 which precedes the Syrian uprising. Thus, the decline in this index is not caused by the uprising, though one could speculate whether it indicated an unequal application of the law among the emerging dissenting voices.

TABLE 10 Robustness test 2: From accountability and rule of law to tax revenue and tax compliance (Indirect effect stage 2)

	Tax revenue				Tax compliance			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lag of tax revenue	0.808***	0.807***	0.822***	0.798***				
	(0.00868)	(0.00495)	(0.00563)	(0.00570)				
GDP PC	0.0375***	0.0493***	0.0852***	0.105***	−0.0109	0.00607	0.0936***	0.130***
	(0.00424)	(0.00345)	(0.0139)	(0.0142)	(0.0101)	(0.00732)	(0.0109)	(0.0155)
Log of accountability	0.673***	0.249***			0.920***	0.742***		
	(0.0510)	(0.0447)			(0.0529)	(0.0419)		
Log of rule of law			−0.0228	−0.0509			−0.128***	−0.245***
			(0.0600)	(0.0611)			(0.0387)	(0.0591)
Polity2	−0.0457***	−0.0151***	0.0000529	0.00305*	−0.059***	−0.0394***	0.00681***	0.0137***
	(0.00297)	(0.00325)	(0.00200)	(0.00180)	(0.00405)	(0.00281)	(0.00146)	(0.00196)
Gov. cons	−0.006***	−0.004***	−0.004***	−0.0052***	0.0033***	0.00317***	0.00665***	0.00416***
	(0.000157)	(0.000152)	(0.000252)	(0.00026)	(0.0004)	(0.000418)	(0.00060)	(0.00069)
International trade taxes	0.0103***	0.0101***	0.0102***	0.0145***	−0.003***	−0.008***	−0.005***	−0.003***
	(0.00090)	(0.00091)	(0.00086)	(0.00083)	(0.0004)	(0.0004)	(0.0005)	(0.0007)
Hansen specification test (*p* values)	1	1	1	1	0.271	0.332	0.194	0.243
Serial correlation (*p* values)								
1st order	0.02	0.001	0.001	0.001	0.292	0.305	0.289	0.292
2nd order	0.776	0.829	0.528	0.552				

(*Continues*)

TABLE 10 (Continued)

	Tax revenue				Tax compliance			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
No of instr.	227	227	282	282	95	95	95	95
Countries	131	131	134	134	122	122	122	122
Observations	568	568	732	732	299	299	299	299

Notes. For variable measures see Appendix G. *,**,***Significant at 10%, 5%, and 1%. Standard errors in parentheses. All regressions were carried out using dynamic panel system GMM methodology (xtabond2 command on stata), errors are corrected for heteroskedasticity and autocorrelation and all columns include time fixed effects. Hansen overidentification p values greater than 0.05 imply that we cannot reject the null hypothesis which states that instruments used *are* valid. Lag of tax revenue was reintroduced for the first four columns as some of the specifications failed the first-order serial correlation test. This resolved the second-order serial correlation for those columns. All columns here capture the second path, effect of accountability and rule of law on tax revenue as a proxy for tax compliance as well as a direct measure of tax compliance (see the text). Each column uses estimates generated from corresponding columns in Table 9 above, e.g., the log of accountability in the first column represents the natural log of estimates of accountability obtained from column one in Table 9 above to highlight the path from oil to accountability and rule of law and from accountability and rule of law to tax revenue and tax compliance. We see that the coefficients of the log of accountability is between 0 and 1 which shows nondecreasing concavity as the theory required, but the same cannot be said for rule of law.

TABLE 11 Effects of positive oil shock. (a) High oil dependent group. (b) Low oil dependent group.

	Effect on transparency			Effect on accountability			Effect on tax revenue	
							From	From
Country	From	To	%	From	To	%	Transparency (%)	Accountability (%)
(a)								
Algeria	0.484	0.469	−3.10	0.32	0.304	−5.00	−4.07	−5.06
Azerbaijan	0.4	0.387	−3.25	0.221	0.207	−6.33	−4.73	−8.54
Cameroon	0.454	0.437	−3.74	0.269	0.252	−6.32	−4.67	−6.91
Chad	0.421	0.404	−4.04	0.207	0.189	−8.70	−4.75	−6.40
Congo	0.38	0.368	−3.16	0.24	0.227	−5.42	−5.22	−11.33
Egypt	0.422	0.406	−3.79	0.188	0.171	−9.04	−4.63	−9.68
Iran	0.461	0.447	−3.04	0.27	0.254	−5.93	−4.29	−7.92
Kazakhstan	0.476	0.461	−3.15	0.317	0.301	−5.05	−4.10	−6.73
Nigeria	0.419	0.407	−2.86	0.377	0.363	−3.71	−4.69	−4.80
Norway	0.71	0.694	−2.25	0.791	0.774	−2.15	−2.35	−1.83
Russia	0.572	0.558	−2.45	0.637	0.622	−2.35	−3.31	−2.85
S. Arabia	0.471	0.458	−2.76	0.222	0.207	−6.76	−4.12	−8.32
Syria	0.443	0.428	−3.39	0.167	0.152	−8.98	−4.47	−8.54
Timor-Leste	0.148	0.14	−5.41	0.621	0.609	−1.93	−9.20	−2.74
Trinidad	0.608	0.593	−2.47	0.682	0.666	−2.35	−2.98	−1.91
Venezuela	0.572	0.558	−2.45	0.595	0.580	−2.52	−3.31	−3.30
Yemen	0.427	0.414	−3.04	0.339	0.324	−4.42	−4.76	−5.78
(b)								
Belgium	0.701	0.683	−2.57	0.768	0.750	−2.34	−2.53	−2.09
Botswana	0.555	0.537	−3.24	0.637	0.619	−2.83	−4.04	−3.68

(*Continues*)

TABLE 11 (Continued)

	Effect on transparency			Effect on accountability			Effect on tax revenue	
							From	From
Country	From	To	%	From	To	%	Transparency (%)	Accountability (%)
Costa Rica	0.606	0.588	−2.97	0.698	0.680	−2.58	−3.41	−2.93
Finland	0.702	0.684	−2.56	0.777	0.759	−2.32	−2.53	−2.02
Ireland	0.76	0.743	−2.24	0.845	0.827	−2.13	−2.14	−1.65
Korea, Rep.	0.629	0.611	−2.86	0.586	0.568	−3.07	−2.96	−3.14
Luxembourg	0.746	0.728	−2.41	0.795	0.777	−2.26	−2.25	−1.95
Portugal	0.677	0.659	−2.66	0.741	0.723	−2.43	−2.61	−1.94
Switzerland	0.746	0.729	−2.28	0.783	0.766	−2.17	−2.23	−1.98
UK	0.702	0.684	−2.56	0.775	0.757	−2.32	−2.50	−2.02
USA	0.723	0.705	−2.49	0.777	0.759	−2.32	−2.36	−2.00

Notes. The table show the impact of a positive oil shock (an increase in oil value to GDP ratio of 10% points). The first three columns capture the impact on transparency, the second three columns capture the impact on accountability, the last two columns show the impact, on tax revenues, coming from transparency and from accountability. See the text for discussion and insights.

7 | CONCLUSION

The abundance of petroleum wealth is associated both with less transparency and less tax revenue. We explain this outcome and elucidate the mechanism that produces it. The key is the behavior of tax payers. We develop a simple analytic game which produces both outcomes. An extractive (rentier) government moves first, choosing the level of transparency and the enforcement of taxes. The trade-off to the government arises because, on one hand, transparency is costly to a rentier state by making it harder to divert resources and, on the other hand, it is needed to elicit citizen greater tax compliance. Citizens, observing limited transparency, comply only partly with taxation since they cannot tell where their taxes go. A subgame-perfect equilibrium emerges in which the government is opaque and citizens are tax evasive. Besides transparency as an inducement, we also model the role of tax enforcement as a force. Testing the model with extensive data, we find strong support for the model and somewhat greater support for transparency.

Economic historians have suggested that the need for public finance in early modern Europe eventually forced governments to become more accountable to their citizens (Hoffman & Norberg, 1994; North, 1990; North & Weingast, 1989). Seen in this light, our paper extends this insight in reverse in that windfall revenues from oil (and possibly other natural resources) diminish the incentive of governments to make their policies and institutions more transparent.

The relation between resource wealth and transparency is particularly salient in oil-rich Middle East and North Africa (MENA) region. But rigorous empirical analysis of this question is constrained by the paucity of taxation data for this region. Further, by removing the MENA group from the sample and rerunning the regressions to test the MENA effect by its absence, one runs into another difficulty; namely removing the key source of variability, i.e., oil revenues. However, by simply comparing mean values, we find that the oil-rich MENA countries have exceptionally low taxes and low transparency, while the non-oil MENA countries have higher tax and transparency levels similar to the rest of the developing world. From this, we infer that low transparency in the MENA region is largely a function of the region's concentration of oil wealth, rather than cultural or historical traits.[26]

If more oil revenue means less accountability, less taxation and less citizen tax compliance, will the recent collapse in oil prices, if it becomes permanent, lead to a change in reverse by ushering a new era of greater accountability by governments, reliance on taxation, and more tax compliance coming from greater citizen participation? The answer would be affirmative, if the empirical findings were symmetric in either direction. But we cannot know this until more time has passed and more data has been gathered.

What can be said about the policy relevance of these findings? In a world in which the government does act in public interest (for instance if new government comes to power that is less burdened by rentier behavior), the policy relevance of our findings is tied to several proposals (Devarajan, Ehrhart, Le, & Raballand, 2011; Sala-i-Martin & Subramanian, 2003) in which the transfer of oil revenues directly to the public is a way of improving government accountability through greater citizen scrutiny. That more accountability is associated with more efficiency and also improved taxation is not in doubt and is consistent with our model as well. But the difficulty is that first, a rentier and therefore opaque state would resist such proposals since adopting them may be self-defeating; and second, that citizen scrutiny and public action relies on better information which the government may refuse to provide. Citing the Roman poet, Juvenal, the late Nobel laureate Leo Hurwicz, famously asked Hurwicz (2008) “But Who Will Guard the Guardians?”

[26]The analysis is available from the authors but not included here for brevity.

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APPENDIX A
Proof of Lemma 1

Statement of Lemma 1 *: Under reasonable upper bound on the tax rate,* t, ∂b/∂T ≤ *0 implies that* $\partial t/\partial T<0$

Totally differentiate 18 in *T*:

$$(\mu^*+t\mu_t^*)t_T=-t\mu_T^*-g\frac{1-(\alpha+\beta)}{1-\alpha}(1-b)^{-\frac{\alpha}{1-\alpha}}\cdot(-b_T)$$

We have already argued why evidence supports $\alpha+\beta<1$. Since $b_T\le 0$ by assumption and since $\mu_T^*>0$, it follows that RHS <0. Using optimum μ^* from 15 in the expression $\mu^*+t\mu_t^*$ on the LHS, we find $\mu^*+t\mu_t^*=1-2t/[\gamma(T)\cdot f(L)]$. Thus, $\mu^*+t\mu_t^*>0$ if $t<\gamma f/2$ which puts an upper bound on the tax rate. Assuming this upper bound, it follows that,

$$b_T\le 0\rightarrow t_T<0$$

APPENDIX B
Proof of Lemma 2

Statement of Lemma 2 *Under reasonable upper bound on the tax rate,* t, ∂b/∂L ≤ *0 implies* $\partial t/\partial L<0$ *but* $\partial b/\partial L>0$ *implies* $\partial t/\partial L \gtreqqless 0$.

Repeating the above procedure this time for *L* we have,

$$(\mu^*+t\mu_t^*)t_L=-t\mu_L^*-g\frac{1-(\alpha+\beta)}{1-\alpha}(1-b)^{-\frac{\alpha}{1-\alpha}}(-b_L)$$

As with the case of *T*, here assuming same upper bound on tax rate, and also noting that $\mu_L^*>0$, we find that $b_L\le 0$ would imply the RHS <0 so that $t_L<0$ and the response of tax payers is similar to transparency. However, if $b_L>0$, then *RHS* can have any sign and hence $t_L \gtreqqless 0$.

APPENDIX C
Proof of second-order condition for compliance

Differentiating the first-order condition, Equation (23), in *T* and rearranging the terms, we have:

$$Q\equiv b_T(t_T\mu^*+t\mu_T^*+t\mu_t^*t_T)+b_T(t_T\mu^*+t\mu_T^*)+b[2t_T\mu_T^*+t\mu_{TT}^*+t_T^2\mu_t^*+t\mu_{tT}^*t_T]$$

Use the first-order condition Equation (23) once again to substitute for the first two terms $b_T(t_T\mu^*+t\mu_T^*)$ in the above equation. We have:

$$Q = -2\frac{b_T^2}{b}\cdot(\rho + t\mu^*) - t\mu_t^* t_T + tb_T\mu_t^* t_T + b[2t_T\mu_T^* + t\mu_{TT}^* + t_T^2\mu_t^* + t\mu_{tT}^* t_T]$$

In this equation the first term (with minus sign) is negative; the second term, $-t\mu_t^* t_T$ is <0 as μ_t^* and t_T are both <0. In addition, since $b_T < 0$ the third term $tb_T\mu_t^* t_T$ is also <0. As for the last term in the brackets, we know from optimum μ^* that $\mu_T^* > 0$, $\mu_t^* < 0$ and $\mu_{tT}^* > 0$ (Equation 15) Moreover, $t_T < 0$ by Lemma 1. Thus, it is sufficient that $\mu_{TT}^* < 0$ in order that $Q < 0$ and second-order condition be satisfied.[27] Note, however, that $\mu_{TT}^* < 0$ is *not* necessary. For example, a more relaxed condition such as $\mu_{TT}^*/\mu_T^* < -t_T/t$ will also satisfy second-order condition.

APPENDIX D

Proof of non-optimality of law enforcement if $t_L > 0$

The first-order condition for L, if it existed, would derive from differentiating the government's utility function, in L. This would yield:

$$\frac{\partial U_G}{\partial L} = b(\mu^* + t\mu_t^*)t_L + bt\mu_L^* + b_L(\rho + t\mu^*)$$

Recall from Lemma 2 that $\mu^* + t\mu_t^* > 0$ under reasonable upper bound on tax rate. Also recall from that lemma that the case of $t_L > 0$ can only arise from $b_L > 0$. It follows that if $\mu_L^* > 0$ in above equation, then U_G will always be increasing in L i.e., $\partial U_G/\partial L > 0$, and there is no optimum enforcement. Such a government would always benefit from maximum enforcement.

APPENDIX E

Proof of Proposition 4

Using the expression for optimal compliance, $\mu^* = 1 - t/[\gamma(T)\pi(L)]$, we have,

$$\frac{d}{dT}(t\mu^*) = \frac{\gamma' t^2}{\gamma^2\pi} - t_T\left(1 + \frac{2t}{\gamma\pi}\right)$$

Now use the expression for μ^* above again to reexpress this equation in terms of μ^*:

$$\frac{d}{dT}(t\mu^*) = \frac{\gamma' t}{\gamma}(1 - \mu^*) - t_T[1 + 2(1 - \mu^*)]$$

Since $\mu^* < 1$ and since $t_T < 0$, it follows that,

$$\frac{d}{dT}(t\mu^*) > 0 \text{ if } \gamma' > 0$$

APPENDIX F

Proof of Proposition 5

Using the expression for $d(t\mu^*)/dT$ in Appendix E, the second cross differential $d^2(t\mu^*)/dLdT$ becomes,

[27]For analytic simplicity, two simplifying linearity conditions are assumed: $\tau_{TT} = b_{TT} = 0$.

$$\frac{d^2}{dLdT}(t\mu^*) = \frac{\gamma'}{\gamma}[t_L(1-\mu^*) - t\mu_L^*] - t_{TL}[1+2(1-\mu^*)] + 2t_T^*\mu_L^*$$

In this expression, the first bracketed term is <0; the sign of the second term depends on the sign of t_{TL}; and the last term is <0. We shall now show that $t_{TL} > 0$ if $b_{TL} = 0$. To find t_{TL} differentiate the equation of Lemma 1 under Appendix A with respect to L. This yields,

$$\frac{\partial}{\partial L}(\mu^* + t\mu_t^*) \cdot t_T + (\mu^* + t\mu_t^*)t_{TL} = -t_L\mu_T^* - t\mu_{TL}^* + gb_T \cdot \frac{1-\alpha-\beta}{1-\alpha} \cdot \left(-\frac{\alpha}{1-\alpha}\right)$$
$$(1-b)^{-\frac{\alpha}{1-\alpha}-1}(-b_L) + gb_{TL} \cdot \frac{1-\alpha-\beta}{1-\alpha} \cdot (1-b)^{-\frac{\alpha}{1-\alpha}}$$

Note that the first term on the left-hand side involves $\frac{\partial}{\partial L}(\mu^* + t\mu_t^*) = -\frac{2}{\gamma\pi}(t_L - t\frac{\pi'}{\pi}) > 0$ since $t_L < 0$. Therefore, that entire term is <0 since $t_T < 0$. Further, the second term on the right-hand side involves $\mu_{TL}^* = -\frac{\gamma'\pi'}{\gamma^2\pi^2} < 0$. Since the third term is positive ($b_L < 0$, $b_T < 0$), it follows that the right hand side is positive if $b_{TL} = 0$. Thus, $t_{TL} > 0$. With this result, the right hand side of the equation for $\frac{d^2}{dLdT}(t\mu^*)$ is negative. It follows that $\frac{d^2}{dLdT}(t\mu^*) < 0$.

APPENDIX G

Descriptive statistics, variable names, and measures

Variable names as shown in tables	Actual transformed variable, if any, used in regressions	Summary statistics						Variable description	Source
		Obs.	Countries	Mean	*SD*	Min	Max		
Transparency		5,326	184	0.48	0.17	0.01	0.87	An index of transparency ranging from 0 to 1. (The index is linearly transformed without being compacted so that all values are positive)	Release of information index by Williams (2009, 2011)
Tax revenue	Taxes on individuals per GDP (in percent)	2,968	165	4.21	4.62	0	26.26	Gov. tax revenue from individuals. Include taxes on total income, capital gains and profit	ICTD
Oil	Log of (1 + oil value per GDP)	4,743	167	0.06	0.13	0	1.82	Where oil value is the quantity of oil and gas extracted in a given year multiplied by the per-unit world price divided by GDP	Ross (2013)
Oil price	Oil price (const. 2,000 US$)	5,239	169	3.48	0.48	2.61	4.35	Where oil price is the average annual per-unit price of oil	Ross (2013)
Oil reserves	Oil reserves (millions of barrels)	1,550	50	7.68	1.90	4.37	11.47	Where oil reserves is the estimated value of the fraction of recoverable crude oil from underground reservoirs with current petroleum extraction technologies	Horn (2014) giant oil discoveries dataset
Oil reserve value	Log of (oil price × oil reserves)	6,510	203	3.93	5.52	0	16.5		Authors own calculations
GDP per capita	Log of GDP per capita (const. 2,005 US$)	5,480	199	8.01	1.64	3.91	11.98	GDP per capita in constant 2,005 US$	WDI
Gov. cons	Gov't consumption per GDP (in percent)	4,976	186	16.65	8.19	1.38	164.70	Government consumption divided by GDP	WDI

(Continues)

APPENDIX G (Continued)

Variable names as shown in tables	Actual transformed variable, if any, used in regressions	Summary statistics						Variable description	Source
		Obs.	Countries	Mean	*SD*	Min	Max		
Polity2		4,669	165	1.68	7.24	−10	10	Updated combined polity score; measuring on a scale from −10 to +10 the polity of a country	Polity IV PROJECT (2013)
Inter. taxes	Taxes international trade and transactions per GDP (in %)	3,880	182	3.10	3.65	−0.03	39.18	Taxes on international trade and transactions. Including import and export taxes	ICTD
Rule of law		2,396	203	0.56	0.21	0	1	An Index of rule of law ranging from 0 to 1. (The index is linearly transformed without being compacted so that all values are positive)	WDI
Tax compliance		952	146	6.54	2.29	0	9.87	An index of tax compliance “based on the World Bank’s doing business data on the time required per year for a business to prepare, file, and pay taxes on corporate income, value added or sales taxes, and taxes on labor” (Gwartney et al., 2013)	Gwartney et al. (2013) Fraser chain linked index
Accountability		4,896	184	0.52	0.27	0	1	An Index of accountability transparency ranging from 0 to 1. (The index is linearly transformed without being compacted so that all values are positive)	Williams (2015) Final transparency Indices scores