Political Economy of Resource Taxation in Petroleum-Producing Countries

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Abstract

Tax rates on resource extraction vary widely between different countries. This paper develops a political economy model of resource taxation, in order to explain the differences in *government take*, i.e., the share of resource revenues that governments of resource-rich countries claim from the producing companies. The theoretical economic model is confirmed empirically for the case of petroleum: a regression on a data set of 46 countries shows that government take increases when the country's government is *autonomous* (as opposed to *factional*), but decreases when the government is *benevolent* (as opposed to *predatory*). Government take increases when a country is a petroleum *exporter* or has large *discovered* petroleum reserves, but decreases with the size of *undiscovered* petroleum reserves.

1 Introduction

There is a wide variation between the fiscal systems for resource extraction in different countries. This is for example the case for petroleum extraction. On the one hand, for example, oil companies that produce oil in the US or the UK typically face resource taxes of roughly 40% of the oil revenues. On the other hand, oil companies that are active in Southeast Asian countries such as Indonesia, Malaysia or Timor face tax rates of 80% to 90%. This paper aims to examine the underlying causes of these large differences.

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More specifically, this paper aims to explain the differences in *government take* between different countries. Government take is defined as the share of resource revenues that governments of resource-rich countries claim from the producing companies. In order to explain government take, we construct a political economy model of a country that possesses resources. The results of the model are tested empirically on a data set of 46 countries, which is compiled from multiple sources. Although the theoretical model is applicable to a wide range of resources (petroleum, metals, precious minerals, etc.), the empirical work is focused on petroleum.

The academic interest in economic policies of resource-abundant countries mainly took off after the oil price rises of the 70s and subsequent drops in the oil price during the 80s. Most of the literature focuses on the development aspect and relates to what Auty (1993) called the *resource curse*: although natural resources seem desirable at first sight, abundance of natural resources can distort a country's economy and make the country on balance worse off. As a matter of fact, it turns out that economies with abundant natural resources have tended to grow less rapidly than natural-resource-scarce economies (Sachs and Warner, 1995). One of the most frequently cited underlying mechanisms is the well-known *Dutch disease*, as described for example by van Wijnbergen (1984) and Krugman (1987) and many other authors. The Dutch disease refers to the effect that abundance of natural resources may shift production factors away from other sectors (in particular: non-resource-based traded goods), thereby reducing "learning-by-doing" in those sectors, which ultimately leads to lower overall productivity growth and reduced long-term welfare.

Besides the Dutch disease, other factors contribute to the resource curse (Davis, 1995): misguided protection or industrialization efforts, overly optimistic resource price and export revenue forecasts from governments (leading to sticky overspending, and recession when prices drop), and rent-seeking. Logically, several authors therefore linked the resource curse to the political economy of the resource-abundant states. Karl (1997) argues that *"dependence on petroleum revenues produces a distinctive type of institutional setting, the petro-state, which encourages the political distribution of rents. Such* *a state is characterized by fiscal reliance on petrodollars, which expands state jurisdiction and weakens authority as other extractive capabilities wither. As a result, when faced with competing pressures, state officials become habituated to relying on the progressive substitution of public spending for statecraft, thereby further weakening state capacity".* In a similar vein, Auty and Gelb (2001) use an extension of Lal's (1995) typology of governments and argue that resource-abundant countries are more likely to have factional or predatory governments, which tend to distort the economy in the pursuit of rents. As a result, the economy does not follow a competitive industrialization model, but falls into a "staple trap".

The political economy models of Karl (1997) and Auty and Gelb (2001) remain qualitative (unformalized), unlike models about rent seeking, such as the model of Torvik (2002). The latter develops a simple model in which resource-abundance increases the number of entrepreneurs engaged in rent seeking and reduces the number of entrepreneurs running productive firms. With a demand externality, the drop in income is higher than the increase in income from the natural resource. Robinson et al. (2006) build the first explicitly political, formal model to explain the resource curse. In a two-period probabilistic voting model, they explain public sector clientelism (paid from natural resource rents) as a way to influence election outcomes. The model integrates an endogenous choice of natural resource extraction rate, and studies the effects of resource booms on resource extraction, and on factor misallocation. Deviation from the optimal extraction path as a result of political economy effects, is also studied by van der Ploeg (2008), who argues that the fact that resource-rich countries often save less than the marginal resource rents can be due to either anticipation of more favorable conditions (lower extraction costs, higher resource prices, higher interest income) or political distortions in fractionalized societies with imperfect property rights.

The main contribution of this paper is that it combines a formal approach – such as the approach used by Robinson et al. (2006) or van der Ploeg (2008) – with a statistically significant analysis of actual data for 46 countries. In a similar vein as Robinson et al. (2006), we use a (simplified) probabilistic voting model to describe the decision process of the governments of resource-producing countries, thereby formally including the elements of the government typology developed by Lal (1995). The statistical analysis is based on the government typology of Lal (1995) and on geological data assembled from various sources in the petroleum literature.

This paper is structured as follows. First, section 2 develops a theoretical model of the political economy of taxation of resource extraction. Next, section 3 describes our data set, defines our regression analysis, and presents the regression results. Finally, section 4 summarizes the main conclusions from the analysis, and suggests potential directions for further research.

2 A political economy model of resource taxation

This section develops a political model of resource taxation. First, section 2.1 provides an overview of the main modelling assumptions. In the next two sections, we analyze two important components the model more in detail: the re-election probability (section 2.2), and the incentives for firms (section 2.3). Finally, section 2.4 analyzes the solution of the model and develops conclusions that can be tested empirically in section 3.

2.1 Model set-up

Similar to the set-up of Robinson et al. (2006), we consider a two-period probabilistic voting model for a given country. The two periods are labelled 1 and 2, and correspond to the medium term and the long term, respectively. The country has an amount q_R of already *existing* petroleum reserves[1]. In period 1, these reserves get extracted, and the government collects revenues T_R from the taxation of resource extraction. In addition, the country has an amount q_U of *undiscovered* reserves. In petroleum engineering, undiscovered reserves are reserves that are estimated to exist in a country – based on a combination of geology and statistics – but that have not been found yet. Firms will perform exploration activities to find these reserves. Depending on the amount of exploration in period 1, firms will find an amount $q_{U,f} < q_U$. The resources found (i.e.,

[1] As mentioned before, the model can also be applied to other resources than petroleum, but we will focus our thoughts on petroleum because the regression results of section 3 are about petroleum.

$q_{U,f}$) will be extracted in period 1 and will provide the government with revenues $T_{U,1}$ in period 1 (on top of the revenues T_R from the already existing reserves). In the long term, the remaining undiscovered resources $q_U - q_{U,f}$ will be found, thereby yielding government revenues of $T_{U,2}$ in period 2. To summarize, the government revenues from the petroleum sector in periods 1 and 2, respectively, are given by:

$$T_1 = T_R + T_{U,1} \quad (1)$$

$$T_2 = T_{U,2} \quad (2)$$

Note that we will focus only on the petroleum sector, and not consider any other government revenues.

In this model, the key parameter that the government needs to decide on, is the government take of petroleum extraction, which we will label τ. If p denotes the price of one unit of the resource (in the case of petroleum, p is the price of one barrel of oil), then government revenues on one unit of the resource are τp and firms' after-tax revenues on the unit are $(1-\tau)p$. We assume that the government needs to set the parameter τ only once, before the two periods 1 and 2. In other words, it is as if the choice of τ happens upfront in a separate period '0'[2]. In between the periods 1 and 2, there is an election round. During that election round, the government has a probability P_r to be re-elected. As we will see later, the government can influence P_r. Figure 1 summarizes the definitions of the variables q_R, q_U, T_R, $T_{U,1}$, $T_{U,2}$, τ, p and P_r.

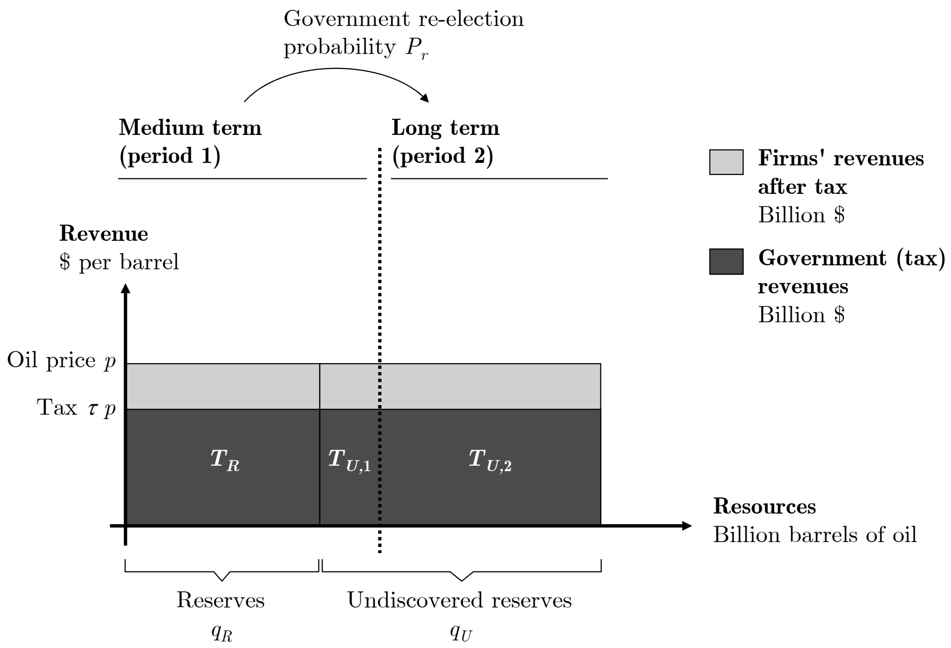
A *benevolent* government, i.e. a government that seeks to maximize social welfare, would maximize $T_{\text{benevolent}}$:

$$T_{\text{benevolent}} = T_1 + T_2 = T_R + T_{U,1} + T_{U,2} \quad (3)$$

where we have ignored any intertemporal preferences, i.e. the 'discount rate' is set to zero, for simplicity.

[2]One could argue that a government may have an incentive to change its choice of τ in the course of the periods 1 or 2. In particular, a government could promise a low τ for exploration in period 1, so that firms perform a large amount of exploration. Once the exploration is done, the government could raise τ again. This type of strategic behavior is an artefact of a finite-period model. Since our aim is to find an explanation for countries' average long-term value of τ, we will not consider this here. We will therefore assume that governments choose one fixed, non-renegotiable τ.

Figure 1: **Definitions of resource-related model variables**



A *predatory* government, i.e. a government in which officials seek to maximize their own profit, would have a different objective function. Assuming that government officials are able to (mis)appropriate a fixed share of government revenues, they would still try to maximize tax revenues, just like the benevolent government. However, the officials will take into account that they only get access to the tax revenues of period 2 if they get re-elected. Assuming risk-neutral officials, the predatory government would therefore maximize $T_{\text{predatory}}$:

$$T_{\text{predatory}} = T_1 + P_r \cdot T_2 = T_R + T_{U,1} + P_r \cdot T_{U,2} \tag{4}$$

In reality, the government of the country may not be fully benevolent or fully predatory, but somewhere in between the two. Let β denote the level of 'benevolence' of the government, with $\beta = 1$ representing a benevolent government and $\beta = 0$ representing a predatory government. Such a government would maximize T, a weighted average of $T_{\text{benevolent}}$ and $T_{\text{predatory}}$:

$$\begin{aligned} T &= \beta T_{\text{benevolent}} + (1-\beta) T_{\text{predatory}} && (5) \\ &= T_R + T_{U,1} + [\beta + (1-\beta) P_r] T_{U,2} && (6) \end{aligned}$$

Finally, the tax revenues T_R from existing reserves in period 1 are simply a fraction τ of the petroleum sales from existing reserves:

$$T_R = q_R \cdot p \cdot \tau \tag{7}$$

where p is the price of petroleum. Similarly, we have:

$$T_U = T_{U,1} + T_{U,2} = q_U \cdot p \cdot \tau \tag{8}$$

2.2 Re-election probability

As stated in section 2.1, the periods 1 and 2 are separated by an election round. The incumbent government's re-election probability P_r depends on (i) the political system of the country, and (ii) the extent to which the citizens are satisfied with the government. For the sake of simplicity, we will assume that item (i) is represented by the number n of eligible parties in the country: for large n, there are many parties, and government officials will have a low probability P_r of being re-elected to the same post. For $n = 1$, there is only one party, and the government is, in the typology of Lal (1995), *autonomous*. In that case, P_r will be high, but not necessarily 1, because there is always a possibility that citizens overthrow the government (depending on citizens' satisfaction level). We assume that, both for high and low levels of n, the level of satisfaction of citizens depends on their net financial benefits F during the period the government was in power (period 1). Combining (i) and (ii), we propose the following expression for P_r:

$$P_r = \frac{1}{n} \cdot g(F) \tag{9}$$

in which g is a continuous, sufficiently differentiable function with $g > 0$, $g' > 0$ and $g'' < 0$. In words: g is a monotonic increasing function with a saturation effect[3].

In our analysis of the citizens' net financial benefits F, we focus on the petroleum sector. Assuming that citizens receive[4] a fraction γ of government revenues (after subtraction of government operating costs and rent-siphoning) and that they consume a

[3] In addition we obviously need to assume that g is scaled such that $0 \leq P_r \leq 1$.
[4] This can be in various forms: public sector jobs, allowances, public services etc.

quantity q_C of petroleum, the citizens' net financial benefit in the petroleum sector during period 1 is:

$$
\begin{aligned}
F &= \gamma \cdot T_1 - p \cdot q_C && (10)\\
&\approx \gamma \cdot T_R - p \cdot q_C && (11)\\
&= (\gamma \cdot \tau \cdot q_R - q_C) \cdot p && (12)
\end{aligned}
$$

in which the approximation stems from the fact that in the medium term, government revenues from existing reserves are much larger that revenues from undiscovered reserves (i.e., $T_R \gg T_{U,1}$). An additional interesting observation is that petroleum resources are very unevenly distributed across the world: typically for petroleum exporting countries $q_R \gg q_C$, while for other countries typically $q_R \ll q_C$. Let ξ denote whether a country is a petroleum exporter or not: for $\xi = 1$ it is an exporter and for $\xi = 0$ it is an importer. For $\xi = 0$ (importing country), the term $\gamma\tau q_R$ is irrelevant and $F \approx -q_C p$, which is not dependent on τ. Since we are focusing on τ, we can therefore consider $g(F)$ equal to a constant $g_0 > 0$. The intuition is that for petroleum importing countries, the tax revenues from petroleum extraction are so small that even a large proportional change does not significantly impact the overall budget of the government or the citizens.

For $\xi = 1$ (exporting country), the term q_C is irrelevant ($F \approx \gamma\tau q_R p$), and we can write $g(F)$ as:

$$g(F) \approx g_0 + \tilde{g}(\tau q_R p) = g_0 + \tilde{g}(T_R) \tag{13}$$

where we have used the same constant g_0 (without loss of generality). We assume $\tilde{g} > 0$, $\tilde{g}' > 0$, $\tilde{g}'' < 0$. Note that the factor γ has been included in $\tilde{g}$. If we combine the expressions for $\xi = 0$ and $\xi = 1$ and substitute the result into equation (9), we obtain:

$$P_r = \frac{1}{n} \cdot (g_0 + \xi\tilde{g}(T_R)) \tag{14}$$

For convenience, let us define $\alpha = 1/n$. Hence, $\alpha = 1$ corresponds to an autonomous government, and $\alpha = 0$ (i.e., $n \to \infty$) corresponds to the factional, multi-party limit. Equation (6) becomes:

$$T = T_R + T_{U,1} + [\beta + (1-\beta)[g_0 + \xi\tilde{g}(T_R)]\alpha]T_{U,2} \tag{15}$$

2.3 Incentives for firms

The split of tax revenues T_U from undiscovered reserves (equation (8)) between period 1 ($T_{U,1}$) and period 2 ($T_{U,2}$) depends on the amount of petroleum found during the exploration efforts of the firms in period 1, which depends on the number of 'blocks' explored (a block is a piece of land for which an exploration licence is given to a firm). The number of blocks depends on the tax rate τ: if τ is very high, only the 'best' blocks (the blocks with the highest 'success probability', i.e., the highest probability of finding petroleum in period 1) will be explored in period 1. Indeed, given that firms only get a small share of the petroleum revenues in the event of a discovery (because τ is high), it is not profitable to search for petroleum in blocks where the success probability is low. If, on the other hand, τ is low, firms will explore a large number of blocks in period 1 – even if the probability of finding petroleum resources on the marginal blocks is very low – because the potential benefits are large.

To model the impact of τ on firms' exploration activities, we assume that the undiscovered reserves q_U represent a continuum of blocks, with success probabilities ranging between 0 and 1. More practically, we assume that the continuum of blocks can be ranked according to decreasing success probability along an axis from $q = 0$ to $q = q_U$. The infinitesimal block dq at $q = 0$ has success probability 1 (i.e., firms investing in this block will find petroleum with probability 1), while the infinitesimal block dq at $q = q_U$ has success probability 0. Between $q = 0$ and $q = q_U$, the success probability is assumed to decrease linearly. In a formula:

$$P_s(q) = 1 - \frac{q}{q_U} \tag{16}$$

where $P_s(q)$ is the success probability of the infinitesimal block dq. The profit dπ obtained on this infinitesimal block dq is:

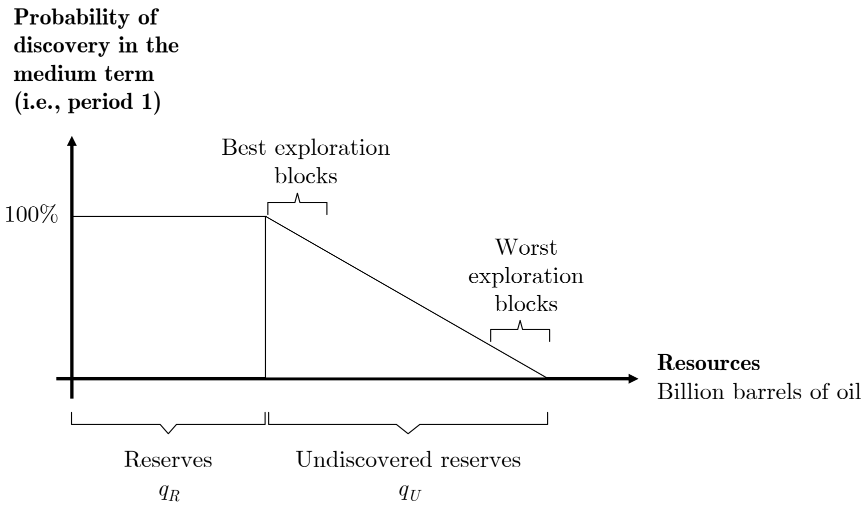
$$\mathrm{d}\pi = P_s(q) \cdot p \cdot (1 - \tau) \cdot \mathrm{d}q - i\mathrm{d}q \tag{17}$$

in which idq is the investment needed to explore the block dq, regardless of whether petroleum is found[5]. Figure 2 summarizes the assumptions with respect to success

[5]In equation (17) we ignore the operating costs necessary to extract the petroleum once it is found.

probabilities. The success probability of (existing) reserves is obviously 1 (=100%).

Figure 2: **Success probability along the spectrum of resources**



Firms will invest in blocks up to the point when $\mathrm{d}\pi = 0$, hence the total quantity of blocks explored is:

$$q_{U,x} = \frac{(1-\tau)p - i}{(1-\tau)p} q_U \tag{18}$$

Government revenues on each block $\mathrm{d}q$ are:

$$\mathrm{d}T_{U,1} = \tau \cdot p \cdot P_s(q) \cdot \mathrm{d}q \tag{19}$$

and therefore:

$$\begin{aligned} T_{U,1} &= \int_0^{q_{U,x}} \mathrm{d}T_{U,1} = \frac{1}{2} q_U \left[p - \frac{i^2}{(1-\tau)^2 p} \right] \tau && (20) \\ T_{U,2} &= T_U - T_{U,1} = q_U \cdot p \cdot \tau - T_{U,1} = \frac{1}{2} q_U \left[p + \frac{i^2}{(1-\tau)^2 p} \right] \tau && (21) \end{aligned}$$

which can be substituted into equation (15):

$$\begin{aligned} T &= q_R \cdot p \cdot \tau + \frac{1}{2} q_U \left[p - \frac{i^2}{(1-\tau)^2 p} \right] \tau + \\ &\quad + \frac{1}{2} q_U [\beta + (1-\beta)[g_0 + \xi \tilde{g}(T_R)]\alpha] \left[p + \frac{i^2}{(1-\tau)^2 p} \right] \tau && (22) \end{aligned}$$

We also ignore the capital expenditure needed for the development of the reserves once the presence of a commercial quantity of petroleum is established. These costs can be substantial, but a detailed modelling of the economics of petroleum exploration is not the objective of this paper.

Note that we have assumed that p does not change as a function of $q_{U,x}$. This means that we assume that the country under consideration has no market power on the global oil market. For most countries, this is a good approximation, and it allows us to focus our attention on the political economy aspects of the problem.

2.4 Theoretical effect of political and geological characteristics

The government chooses the value of τ so as to maximize its objective function T, as given in equation (15), or equivalently, equation (22). Let $\hat{\tau}$ denote this optimal value of τ. In this section we will analyze in what way $\hat{\tau}$ depends on a country's political characteristics (α, β) and geological characteristics (ξ, q_R, q_U). Our main objective will be to determine the sign of the partial derivatives $\partial\hat{\tau}/\partial\xi$, $\partial\hat{\tau}/\partial\alpha$, $\partial\hat{\tau}/\partial\beta$, $\partial\hat{\tau}/\partial q_R$ and $\partial\hat{\tau}/\partial q_U$. Section 3 will then allow us to test these relationships.

The main results of this section are in proposition 2.4.3. However, before we can develop proposition 2.4.3, we need to introduce two lemmata: one lemma about the sign of the derivatives of $T_{U,1}$ and $T_{U,2}$, and one lemma which substantiates our general approach for the determination of the sign of the above-mentioned partial derivatives.

Lemma 2.4.1 (Sign of the derivatives of $T_{U,1}$ and $T_{U,2}$) *For the optimal $\tau = \hat{\tau}$, the first derivatives of $T_{U,1}$ and $T_{U,2}$ with respect to τ are negative and positive, respectively:*

$$T'_{U,1}(\hat{\tau}) = \frac{\mathrm{d}T_{U,1}}{\mathrm{d}\tau}(\hat{\tau}) < 0 \quad , \quad T'_{U,2}(\hat{\tau}) = \frac{\mathrm{d}T_{U,2}}{\mathrm{d}\tau}(\hat{\tau}) > 0 \tag{23}$$

Proof: First of all, note that T from equation (6) can be written as:

$$T = T_R + T_{U,1} + P_a \cdot T_{U,2} \tag{24}$$

with:

$$P_a = \beta + (1-\beta)P_r = \beta + (1-\beta)[g_0 + \xi\tilde{g}(T_R)]\alpha \tag{25}$$

Since P_a is in fact a weighted average of 1 and a probability, we have $0 \leq P_a \leq 1$, which justifies its notation using the letter P. In addition, since T_R is given by equation (7) and $\tilde{g}' > 0$, we have $P'_a = \mathrm{d}P_a/\mathrm{d}\tau > 0$. A necessary condition for $\tau = \hat{\tau}$ to be optimal, is that:

$$\frac{\mathrm{d}T}{\mathrm{d}\tau}(\hat{\tau}) = 0 \tag{26}$$

Substituting equation (24) into equation (26), we get:

$$q_R \cdot p + T'_{U,1}(\hat{\tau}) + P'_a(\hat{\tau}) \cdot T_{U,2}(\hat{\tau}) + P_a(\hat{\tau}) \cdot T'_{U,2}(\hat{\tau}) = 0 \tag{27}$$

Furthermore, the derivative of equation (8), evaluated at $\tau = \hat{\tau}$, yields:

$$T'_{U,1}(\hat{\tau}) + T'_{U,2}(\hat{\tau}) = q_U \cdot p \tag{28}$$

Solving the system of two equations (27) and (28) for $T'_{U,1}(\hat{\tau})$ and $T'_{U,2}(\hat{\tau})$, gives

$$T'_{U,1}(\hat{\tau}) = -\frac{q_R \cdot p + q_U \cdot p \cdot P_a(\hat{\tau}) + P'_a(\hat{\tau}) \cdot T_{U,2}(\hat{\tau})}{1 - P_a(\hat{\tau})} \tag{29}$$

$$T'_{U,2}(\hat{\tau}) = \frac{q_R \cdot p + q_U \cdot p + P'_a(\hat{\tau}) \cdot T_{U,2}(\hat{\tau})}{1 - P_a(\hat{\tau})} \tag{30}$$

Apart from the minus sign upfront in $T'_{U,1}(\hat{\tau})$, the numerators and the denominators of both equations are positive (in particular: the numerators are positive because all of their terms are positive). Therefore $T'_{U,1}(\hat{\tau}) < 0$ and $T'_{U,2}(\hat{\tau}) > 0$. ∎

Lemma 2.4.2 (Implicit derivatives) *The sign of the derivative of $\hat{\tau}$ with respect to a parameter x ($x \in \{\xi, \alpha, \beta, q_R, q_U\}$), is given by:*

$$\operatorname{sgn} \frac{\partial \hat{\tau}}{\partial x} = \operatorname{sgn} \frac{\partial^2 T}{\partial \tau \partial x}(\hat{\tau}) \tag{31}$$

Proof: The result is obtained directly by applying the Implicit Function Theorem to equation (26):

$$\frac{\partial \hat{\tau}}{\partial x} = -\frac{\frac{\partial^2 T}{\partial \tau \partial x}(\hat{\tau})}{\frac{\partial^2 T}{\partial \tau^2}(\hat{\tau})} \tag{32}$$

and observing that $\hat{\tau}$ maximizes T and hence $\partial^2 T/\partial \tau^2(\hat{\tau}) < 0$. ∎

Proposition 2.4.3 (Signs of the derivatives of $\hat{\tau}$) *The optimal $\tau = \hat{\tau}$ depends on the parameters ξ, α and q_U as follows: $\partial \hat{\tau}/\partial \xi > 0$, $\partial \hat{\tau}/\partial \alpha > 0$, and $\partial \hat{\tau}/\partial q_U < 0$.*

Proof: Applying lemma 2.4.2, the sign of $\partial \hat{\tau}/\partial \xi$ is the sign of:

$$(1-\beta)\tilde{g}'(q_R \hat{\tau} p) \cdot q_R \cdot p \cdot \alpha \cdot T_{U,2}(\hat{\tau}) + (1-\beta)\tilde{g}(q_R \hat{\tau} p) \cdot \alpha \cdot T'_{U,2}(\hat{\tau}) \tag{33}$$

in which all terms are positive (thanks to lemma 2.4.1 for the second term).

Again applying lemma 2.4.2, the sign of $\partial\hat{\tau}/\partial\alpha$ is:

$$(1-\beta)\xi\tilde{g}'(q_R\hat{\tau}p)\cdot q_R\cdot p\cdot T_{U,2}(\hat{\tau})+(1-\beta)(g_0+\xi\tilde{g}(q_R\hat{\tau}p))T'_{U,2}(\hat{\tau}) \tag{34}$$

which is again positive thanks to lemma 2.4.1.

Before analyzing $\partial\hat{\tau}/\partial q_U$, it is important to note that:

$$\frac{\partial T_{U,1}}{\partial q_U}=\frac{T_{U,1}}{q_U} \quad \text{and} \quad \frac{\partial T_{U,2}}{\partial q_U}=\frac{T_{U,2}}{q_U} \tag{35}$$

which follows directly from equations (20) and (21). By using (35), one can easily calculate that:

$$\begin{aligned}
\frac{\partial^2 T}{\partial\tau\partial q_U}(\hat{\tau}) &= \left[\frac{\mathrm{d}}{\mathrm{d}\tau}\left(\frac{T_{U,1}}{q_U}+P_a\cdot\frac{T_{U,2}}{q_U}\right)\right]_{\tau=\hat{\tau}} \\
&= \frac{1}{q_U}\left[\frac{\mathrm{d}}{\mathrm{d}\tau}(T-T_R)\right]_{\tau=\hat{\tau}} \\
&= \frac{1}{q_U}\left(\frac{\mathrm{d}T}{\mathrm{d}\tau}(\hat{\tau})-q_R\cdot p\right) \\
&= -\frac{q_R}{q_U}p<0
\end{aligned} \tag{36}$$

hence $\partial\hat{\tau}/\partial q_U<0$. ■

The intuition behind proposition 2.4.3 in the current model setting is interesting. $\partial\hat{\tau}/\partial\xi>0$ has to do with the fact that in exporting countries, tax revenues from petroleum extraction are an important element in the power of the government: an increase in taxation on resources generates significant additional government revenue, thereby providing a powerful lever to increase re-election probability through generous subsidies, allowances, public sector employment etc. $\partial\hat{\tau}/\partial\alpha>0$ is due to the fact that factional (multi-party) countries create an incentive for the ruling class to overexploit the resources in the medium term at the expense of long-term revenues, because long-term revenues are likely to end up with another faction. This result is similar to the work of van der Ploeg (2008), who finds that 'fractionalized' countries (countries with different rival groups) tend to have faster-than-optimal resource depletion in the short term. In van der Ploeg (2008), this is due to imperfect property rights on natural resources, in particular 'seepage' of oil between resources owned by different groups.

In the present paper, the same effect is observed, not because of seepage, but because of uncertainty of allocation over time: different groups may control the government at different points in time, leading to an incentive for the ruling group to overexploit the resource. Overexploiting the resource in the context of this paper, means lowering τ in order to attract exploration investments by firms. As a result, more of the resource will be extracted in the medium term at a lower tax rate τ, leaving less revenue potential in the long term. $\partial\hat{\tau}/\partial q_U < 0$ has a similar explanation: the more undiscovered reserves a country has, the more it benefits from a lower τ, because a lower τ attracts exploration investments by firms. At the same time, when undiscovered reserves are large compared to existing reserves, the opportunity cost of lowering τ is smaller because T_R is smaller.

The dependence of the optimal $\tau = \hat{\tau}$ on the parameters β and q_R is subject of ongoing research.

3 Empirical testing

This section performs an empirical test of the theoretical model of section 2. Section 3.1 describes the data set we use, and section 3.2 presents the definition of the regression and the regression results.

3.1 Data set

The data set consists of 46 countries, and contains for each country the values of ξ, α, β, q_R, q_U and $\hat{\tau}$, which are compiled from different sources. The values of ξ (representing whether a country is a petroleum exporter) are based on petroleum production and consumption numbers from BP (2008). The values of α and β (representing whether a country's government is *autonomous* and *benevolent*, respectively) are based on Auty and Gelb (2001), who use the typology of Lal (1995) to classify political systems in countries. For countries for which Auty and Gelb (2001) do not provide an assessment, an own assessment is made based on available public information. Note that ξ, α and β are interpreted as binary dummy variables to simplify the classification, despite the fact that ξ, α and β are continuous variables in the model of section 2. The values q_R

and q_U (corresponding to the *reserves* and *undiscovered reserves*, respectively) are based on BP (2008) and USGS (2000), respectively. The value of $\hat{\tau}$ (the actual *government take*) is based on a combination of Himona (2005) and Tordo (2006). Table 1 provides descriptive statistics of the sample. The notation $\bar{x}$ refers to the average of a variable x over the set of 46 countries. Note that 'bn bbl' is short-hand for 'billion barrels of oil'.

Table 1: **Descriptive statistics of the data set of 46 countries**

Characteristic	**Value**	**Unit**	**Symbol**
Number of countries	46		
Average government take	0.64		$\bar{\hat{\tau}}$
Fraction of exporting countries	48	%	$\bar{\xi}$
Fraction of autonomous countries	35	%	$\bar{\alpha}$
Fraction of benevolent countries	41	%	$\bar{\beta}$
Average reserves per country	9.5	bn bbl	$\bar{q_R}$
Average undiscovered reserves per country	8.4	bn bbl	$\bar{q_U}$

3.2 Regression definition and results

We start from the first-order Taylor approximation of $\hat{\tau}$ as a function of ξ, α, β, q_R and q_U:

$$\hat{\tau} = \hat{\tau}_0 + \left(\frac{\partial\hat{\tau}}{\partial\xi}\right)_{\hat{\tau}=\hat{\tau}_0}\xi + \left(\frac{\partial\hat{\tau}}{\partial\alpha}\right)_{\hat{\tau}=\hat{\tau}_0}\alpha + \left(\frac{\partial\hat{\tau}}{\partial\beta}\right)_{\hat{\tau}=\hat{\tau}_0}\beta + \left(\frac{\partial\hat{\tau}}{\partial q_R}\right)_{\hat{\tau}=\hat{\tau}_0}q_R + \left(\frac{\partial\hat{\tau}}{\partial q_U}\right)_{\hat{\tau}=\hat{\tau}_0}q_U \quad (37)$$

where $\hat{\tau}_0$ is the value of $\hat{\tau}$ at the point $(\xi, \alpha, \beta, q_R, q_U) = (0, 0, 0, 0, 0)$. Equation (37) can be estimated using OLS based on the following equation:

$$\hat{\tau} = a_0 + a_1\xi + a_2\alpha + a_3\beta + a_4 q_R + a_5 q_U + \varepsilon \quad (38)$$

with ε an error term. The regression results can be found in table 2. The results are in line with the theoretical results of section 2.4. Nearly all of the coefficient are statistically significant: all of them have p-values of approximately 10% or less, except the coefficient of government benevolence. The results are discussed as part of the conclusions in section 4.

Table 2: **Regression results**

	Coefficient	**Unit**	**Estimator of ...**	t **statistic**	p **value**
Intercept	$a_0 = 0.5883$		$\hat{\tau}_0$	19.6	0.000
Exporting	$a_1 = 0.1011$		$\partial\hat{\tau}/\partial\xi$	2.6	0.014
Autonomous	$a_2 = 0.0791$		$\partial\hat{\tau}/\partial\alpha$	2.1	0.045
Benevolent	$a_3 = -0.0206$	–	$\partial\hat{\tau}/\partial\beta$	-0.6	0.558
Reserves	$a_4 = 0.0024$	(bn bbl)$^{-1}$	$\partial\hat{\tau}/\partial q_R$	1.6	0.108
Undiscovered reserves	$a_5 = -0.0041$	(bn bbl)$^{-1}$	$\partial\hat{\tau}/\partial q_U$	-2.4	0.020

4 Conclusions

This paper develops a model of the political economy of countries with resource extraction. Based on a model of the impact of resource taxation on medium and long-term government revenues, re-election probability and medium-term firm behavior, a relation is established between government take on the one hand, and a country's political and geological characteristics on the other hand. The relationship is tested empirically for the case of petroleum, using a data set of 46 countries. A regression shows that government take increases when a country has an autonomous (as opposed to factional) government, but decreases when a country has a benevolent (as opposed to predatory) government. Government take increases when a country is a petroleum exporter or has large discovered petroleum reserves, but decreases with the size of undiscovered petroleum reserves. All coefficients are significant at 10% level or below, except for government benevolence. The results are in line with the conclusions of the theoretical model.

The model of this paper can be further improved by modelling the behavior of voters in a more detailed way. At the same time, the analytical translation of the distinction between an autonomous government and a multi-party government can be enhanced. Furthermore, the multi-period character of the model can be emphasized more by allowing different decisions in different periods (in particular: a different level of τ). Finally, an extension to more than two periods would allow a more refined modelling of the complex trade-off between current and future earnings.

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