Dealing with Expropriations:
General Guidelines for Oil Production Contracts\textsuperscript{1}

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1 Introduction

In the last decade, a new round of renegotiation of contracts occurred in the oil industry. In fact, most contracts involved some form of expropriation, and certainly all of them implied some degree of conflict. Bolivia and Venezuela where perhaps the most notorious ones. In these cases their governments violated significant portions of the production contracts, and sizeable expropriations took place. On the other hand, less publicized cases (such as England) mostly changed the tax rates. This is not the first round of contract renegotiations that has taken place in the industry, nor the last one. Contracts in the oil industry are indeed as volatile as its price.

One attitude toward the recontracting is simply that contracts are meant to be violated. In other words, it is possible to argue that writing a complete contract is extremely difficult (or impossible); and therefore it is well understood, ex-ante, that it will be violated. In this sense, renegotiation is just the natural outcome of the incompleteness. However, there are several features of the oil industry that hint to alternative explanations. First, the renegotiation of these contracts seems to be more disruptive than other private ones. In fact, institutions to deal with the “exceptions” are not guaranteeing the rights of one of the agents involved in the transaction. Most of these renegotiations are occurring between governments and foreign firms, which are not equally treated (or represented) within the judicial system on several of these countries. Second, renegotiations occur within heavily politicized environments – which usually leads to the most visible action as opposed to the most efficient renegotiation. For instance, new government with populists messages are the ones expropriating. Third, and equally important, when contracts are analyzed in detail there are several dimensions in which they could have been improved to reduce the incentives for expropriation.

In this paper, I want to understand the motives behind the contracting problem faced

\[1\] See Aguion’s paper in this sema volume.
by the government, try to rationalize the choices of instruments that are used in practice, and find areas of improvement in the “typical” contract. This is a simulation exercise; and therefore, no precise enough to offer implications to actual contracts. The objective is to indicate how some elements of the contract can be introduced in the discussion in order to reduce the incentives to renegotiate, and to reduce the disruptions.

Of course this task cannot take into consideration all possible elements – nor activities in the oil industry. The first simplification is that I will concentrate exclusively in production contracts. Exploration and development of oil fields is an important activity in the industry. However, the problems in those are different in nature to the production one. Furthermore, most of the expropriations and renegotiations are affecting the production activity by itself. Nevertheless, this is a dimension that is not included in the present discussion.\(^2\)

Which elements I consider in the design of a contract for production of hydrocarbons? First, efficiency. Production of hydrocarbons is heavily distorted by the choice of taxes. Indeed, hydrocarbon contracts always involve an over-tax, and the private response to such structure significantly affects production plans. Most of the time, this distortion is reflected in under-exploitation of the natural resource. This is extremely costly because recovery operations are very expensive; and therefore, resources left under the ground are likely to remain there. One important question is why oil contracts need the over-tax. I discuss this in detail in the paper, but the short explanation is that when a project is being auctioned to the private sector, governments collect less than its social value. The government has credibility and commitment problems, and the private sector pay less than the social value in anticipation of a renegotiation. In this environment, the private sector assigns a probability of default, that lowers the revenue collected by the government, making expropriation a desirable social outcome. For this reason, the private sector makes abnormal returns and governments try

\(^2\)See Manzano (2001) for a comprehensive discussion of the exploration and development of reserves. Future research should continue studying these important aspects.
to extract those rents through the tax system. Those taxes create inefficiencies and choosing the optimal structure is an important part of the contract design.

Second, rents. The main motivation behind expropriation is the perception (by the public sector) that the private sector is receiving “excessive” rents in some states of the world. This is in general why the round of expropriations usually happen when commodity prices are very high, and this is why the recontracting has a heavy load of politics and populism. In fact, contracts that leave “too many” rents in the hand of the private sector, at least in some state of nature, are more likely to be renegotiated when it becomes evident that those states will be reached. A good contract is one that leaves reasonable rents in the hand of the private sector in all states of nature, reducing the incentives of both sides to renegotiate.

Third, agency costs. Taxes and rents transferred to the public sector can be significantly reduced by companies expenditure and investment behavior. For instance, several oil and gas contracts have incentives for investment, which are (mis)used by the private sector to reduce the tax burden. The case of Bolivia is one of the most interesting ones in this regard. The contracts on gas included investment incentives that the firms used when prices where increasing as means to reduce the tax pressure. For instance, the fiscal burden was 37 percent of the international price in 96-98 when international prices were relatively low. It decreased to 24 percent between 99-01, and further down to 15 percent in 02-04. The effective tax rate as a percentage of the price was declining with price increases! Given that an important part of the taxation were levied on profits this can only be explained if the costs increased faster than international prices in the last decade. This is unlikely. The most plausible explanation is that in times of high prices the firms found easy to incur in large investment projects that reduced the tax burden. Some of these investment might have been profitable, but not all of them were.

Fourth, stability of revenues. Several countries design their tax systems to smooth rev-

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3 See Manzano and Monaldi (2007) for a political economy explanation of this phenomenon.
4 See Manzano and Monaldi (2007) for a detail description of the events.
enues. Although fiscal revenue stability might be a desired feature of any economy, it is not clear why the smoothness should be achieved through the tax system as opposed to other institutions providing the necessary insurance. In other words, stabilization funds and transactions in future markets are clearly more efficient mechanisms to stabilize revenues than the tax code. Nevertheless, few governments use alternative institutions to stabilize fiscal revenues, and most of the stability objectives end up affecting the way tax codes are designed. For instance, one of the most cited benefits of royalties is that – a sales tax – is that it is more stable than income taxes – which can be affected by agency costs, and other sources of fluctuation. Regardless if this argument is true or not, the point is that in general the pursuit of stabilization has affected the contract design.

In this paper I take this last point seriously. I compare how the contract is affected by the stabilization objective, and study how it interacts with expropriations. In fact, these two objectives are inherently opposing each other. A very simple example highlights this tension. Assume that the only uncertainty is in prices, and for simplicity assume that production is fixed. The most stable revenue is one in which the government collects a fix tax per unit of production. However, this means that when prices are very high the firm will have large profits. This could motivate an expropriation based on the fact that the firm is earning “too much”. On the other hand, assume that the government collects taxes in such a way that the firm receives a fix profit in all states of the world. In this contract the firm has constant profits and will never be expropriated (or less likely), but all the uncertainty of the price fluctuation is bared by the government revenues. In this example, minimizing the probability of expropriation increases the revenue variance, while minimizing the volatility of taxes increases the probability of expropriation. In this paper I extend this simple intuition to the case when the firm is solving a dynamic stochastic problem choosing its production level.

The paper starts with a simple setup where income taxes are non-distorsionary and there is almost no efficiency lost. The problems start when the government is concerned about
revenue stabilization. Income taxes produce a more volatile revenue than royalties and a
government worried with revenue volatility shifts the tax mixture toward royalties – a more
distorsionary tax. Not only production plans are affected, but more importantly private
profits become more extreme, and price paths in which private profits are “extremely” large
are more likely. This increases the probability of expropriation.

The paper has the following main recommendations.

1. Use a stabilization fund to deal with revenue uncertainty. Changes in the tax structure
   produce undesirable outcomes.

2. Build a local constituency to mitigate the expropriation incentives. If the transfers
to the locals is procyclical – which is equivalent to have a procyclical tax rate – then
expropriation incentives are reduced.

3. Government sharing ownership has been highlighted as a possible vehicle to reduce
agency costs. This assumes that the government incurs in less agency costs than the
private sector – which seems as a strong assumption. The problems of agency costs
are reduced by relying on sales taxes, and indeed that has been the response of several
government. The elimination of investment subsidies, and depreciation subsidies will
go a long way in reducing the agency costs that plague the industry, and they are more
efficient that involving the government in the production process or shifting to less
than optimal taxes.

As mentioned above several aspects have been excluded from the analysis. The political
economy of the expropriation has been severely simplified. I assume that expropriation oc-
curs when private profits are “too large". This is clearly part of the expropriation decision,
but certainly it is not enough. As is discussed in this volume repeatedly aspects of fairness,
efficiency, and composition of investment have indeed being part of the expropriation. Sec-
ond, the model I solve has no investment at all. Exploration and development are expression
of some of those investments. This is an important simplification. I believe a first step toward understanding the optimal contract requires analyzing the simplest problem when investment is not part of the decision problem, although future research has to address this important issue.

The paper is organized as follows: Section 2 presents the simple model and discusses the assumptions by summarizing the relevant theoretical and empirical literature. Section 3 presents the results from the simulations. Section 4, concludes.

2 A simple organizing framework

I assume that a foreign firm contracts with a government to produce a mineral – which for most of the discussion is going to be oil. I abstract from all interactions at the firm level. Indeed, several problems that arise in the exploitation of natural resources refer to externalities at the firm level. I will abstract from all those issues and consider exclusively the problem between the firm and the government.

2.1 Setup

An infinitively lived firm is a price taker in the international markets and can only make the choice of production, and later in this paper about “wasted expenditures”. The firm has a known amount of reserves to exploit. These reserves are certain and cannot be changed. The decision of exploration and development of oil fields, for example, relaxes this assumption. This is an important simplification of this paper – I do not deal with the problems that arise from the investment in reserves. Hence, in the baseline model, the firm just chooses how much to produce.
2.1.1 Prices

I assume the price of the commodity is described by a random walk with no drift. This assumption is not essential for the analysis, although mean reversion might diminish some of the effects highlighted here. Prices are given by

\[ p_t = \begin{cases} 
    p_{t-1} + \delta \frac{w}{p} & \alpha \\
    p_{t-1} - \delta \frac{w}{p} & 1 - \alpha 
\end{cases} \]

where \( p_t = 0 \) is an absorbing barrier. I assume that there is a maximum price \( \bar{p} \) which is also an absorbing barrier. This price is large enough that the firm will produce the entire field in one period, meaning that higher prices are just not interesting for the present analysis. Furthermore, I initialize the model and simulations at a point in which the upper bound price is never reached.

2.1.2 Cost structure

The firm has a cost of production that has increasing marginal costs on two arguments: the production in each period and the amount of reserves left. The idea of the second assumption is to capture the fact that in general the marginal cost of the production increases the lower the reserves are underground. Not only this assumption is reasonable given the properties of most natural resource exploitation, but most importantly, it is a crucial assumption to generate significant distortions by the different taxes.

The cost function is

\[ c(q_t, Q_t, \bar{Q}) = c_0 \cdot q_t + c_1(\frac{Q_t}{\bar{Q}}) \cdot q_t^2 \]  

where \( q_t \) is the quantity produced at time \( t \), \( Q_t \) is the cumulative production that has taken until time \( t \), and \( \bar{Q} \) is the total original reserves in the field. I assume that the cost function is convex and that its degree of convexity is what changes when the reserves are being depleted.
From the practical point of view, making the function $c_1$ increasing in enough to capture the distortions the paper is trying to highlight.

### 2.1.3 Taxes in the typical contract

One of the objectives of this paper is to study the impact that different taxes have on the production plan, the tax revenue volatility, and the profits left in the hands of the private sector. There are literally thousands of possible taxes and arrangements between the private sector and the government. Just to reflect some of the diversity, Table 1 summarizes some of the aspects in oil and gas contracts in Latin America. Trying to design the optimal contract by looking at the actual clauses is an impossible task. Contracts usually involve taxes (sales, royalties, assets and income), depreciation clauses, investment incentives, participation shares, and fees. Far too many dimensions to consider.

In this paper, I concentrate on two forms of taxation: royalties and income. These are possibly the two most prevalent forms of taxation in natural resources. The royalties are taxes levied on sales. Sometimes they are a fixed payment for unit produced – similar to the fees – but nowadays most of the royalties are similar to sales taxes – where the tax rate is constant. The other tax, income tax, is always part of the contract. Sometimes the tax rate is the same as the corporate taxes, however, most contracts always specify an overtax.

These contracts do not include all the possible mechanisms that are now used. For instance, profit sharing arrangements are becoming more prevalent – in the form of join ventures, or specific sharing rules. From the taxation point of view, a profit sharing rule might seem similar to an income tax, but the fact that one pays taxes for sure, and the other one just declares dividends makes the distortions of the second one smaller. Having a government as a partner in the production of oil and gas produces other distortions that I do not discuss in this paper. Indeed, it is not clear that the literature has an agreement on the type of distortions that might arise because of JV’s.
The other important ingredient missing in the discussion are investment incentives – given that I do not have investment, investment subsidies would be irrelevant. Nevertheless, I will try to capture the “bad” aspect of those subsidies – meaning the agency costs that arise from them. The reason is that income taxes and investment incentives create similar behaviors to the firm and I can capture them with the income tax alone.

In summary, I consider the choice of two tax rates. Royalties levied on the total sales, and income taxes levied on total private profits. I assume that the tax rates are not contingent to prices, production, or reserves – which is mostly how contracts are specified in reality.

2.2 Maximization Problem

The firm maximizes expected profits given prices, taxes, and the total reserves. The firm operates, initially, under the assumption that there is no default on the contract. The objective is to analyze the impact of the different taxes on the production plan, expected profits, etc.

The firm solves the following Bellman equation

\[ V(Q_t, p_t) = \max_q \left( \pi(q_t, Q_t, \tilde{Q}, p_t, \tau_r, \tau_\pi) + \frac{1}{1 + \beta} E[V(Q_{t+1}, q_t, p_t)] \right) \]

where \( \tau_r \) is the royalty tax rate, and \( \tau_\pi \) is the income tax rate. Profits at the firm level are given by

\[ \pi(q_t, Q_t, \tilde{Q}, p_t, \tau_r, \tau_\pi) = [p_t q_t (1 - \tau_r) - c(q_t, Q_t, \tilde{Q})] (1 - \tau_\pi) \]

I solve this standard maximization problem by discretization of the state space and solving for the fixed point problem of the value and policy functions.

2.2.1 Agency costs

When I add agency costs to the problem I assume that the firm can take actions that are costly from the profit stand point of view, but that they can lower the tax burden.
In reality those actions involve deviating from the optimal investment plan, or increasing expenditures, they mostly reduce the tax burden of income taxes, and rarely they have an impact on royalties. Indeed, several policy makers indicate that one of the benefit of royalties is the fact that they are subject to less manipulation by the firms.

In this paper I capture the agency costs in a very stark form. I assume that the firm can take an action that has a cost in terms of private profits, but reduces the income taxes that have to be paid. My assumption is that these actions are useless from the production point of view, they only reduce the tax burden.

2.2.2 Government’s Problem

The problem of the government is to determine which combination of taxes maximizes its objective function. I will assume that in that objective function enter tax revenues, stabilization objectives, and probability of default.

In particular, assume the government chooses fixed tax rate. Fixed in terms of the state variable (which includes the price of the commodity). In fact, the optimal contract would always imply a contingent income tax, where the tax burden is procyclical. However, as is clear from Section 2.1.3, production contracts involve constant fees and tax rates. I keep this assumption through out the paper.

Assume that the government cares about the efficiency (minimizes the distorsion in the production plan) subject to a minimum expected tax revenue and a maximum expected tax burden.

\footnote{See, for instance, Rigobon (2006).}
variance in the tax revenue constraints. Specifically,

\[
\min_{\tau_r, \tau} \left( \hat{Q} - E \sum_{t=0}^{\infty} q_t \right) \\
E \sum_{t=0}^{\infty} \frac{1}{(1 + \beta)^t} \tau_t \geq \bar{\tau} \\
Var \left( \sum_{t=0}^{\infty} \frac{1}{(1 + \beta)^t} \tau_t \right) \leq \bar{\nu}
\]

where \( \bar{\tau} \) is the target tax collection, and \( \bar{\nu} \) is the maximum variance the government is willing to suffer. In this problem I have not specified how agency costs enter the problem and how the probability of expropriation affects the government choices. I leave that extension for later when I clarify how the expropriation decision is made. Let me concentrate for the moment in how the concern for stabilization affect the tax mixture.

In the set up I have specified, the optimal tax, the one that reduces the distortion when there are no concerns for stabilization \( (\bar{\nu} \to \infty) \) implies a mixture where only income taxes are used. The reason is that income taxes do not change the first order condition of the firm, while royalties do.

However, in this model income tax revenues are more volatile than royalty revenues. Therefore, when the variance constraint binds, the optimal choice of taxes is extremely simple, royalties are increased and income tax rates reduced to keep total revenue constant and reduce its variability. The solution is always a corner solution given the assumptions I have made.

3 Simulations

The first step of the simulation is to show the degree of distortion that the different taxes – and mixture of taxes – generates. The second step is to solve the problem of the government and study volatility of tax revenues, efficiency, and probability of default.
In the simulation I assume that the price of the commodity fluctuates between 0.1 and 2, where the initial price is 1. I assume that the step in the random walk (δ) is 0.1 every period. The probabilities of increases and decreases are equal (1/2) – hence there is no drift. The discount rate is assumed to be equal to 5 percent. The initial reserves are equal to 20, and the cost function has parameter $c_0 = 0.75$; while the function $c_1$ is $0.1 \left(1 + \frac{Q_t}{Q}\right)$. As was mentioned above the choice of the $c_1$ function highlights the increasing marginal cost when reserves are depleted.

The first step in the simulation is to solve the firm problem given taxes and the parameters and functional choices just highlighted. The solution for the problem are not discussed here and the value function, as well as the policy functions for the no tax case are shown in the appendix.\(^6\)

As opposed to studying the policy functions and their changes when taxes are modified, here I analyze how the pattern of production and tax revenues changes in a Monte-Carlo exercise. The simulation consists of 500 histories of 50 periods. All simulations start at the same state (price of commodity and reserves left).

### 3.1 Tax distortions

The first step is to highlight the different distortions that the taxes produce. These aspects have been heavily discuss in the regulatory literature. Here, I just want to just indicate the different problems that appear.

The simulation involves two exercises. First, assuming that the income taxes are zero, royalties are increased from zero to 30 percent. Second, I set royalties to zero and vary

\(^6\)There is nothing particularly interesting in the policy choices. The solutions are very standard indeed. The interesting aspects is how those policy choices interact with the taxes, and that exercise is what is highlighted in the paper.
income taxes in the same range.

After solving for the value and policy functions for each tax rate I simulate the dynamic response of the firm using Monte-Carlo. The price process feed to all simulations is exactly the same. Each history has 50 periods, and start exactly at the same point.

3.1.1 Measures

There are several measures I am interested in evaluating. First, what is the expected total production. As I said in the beginning, the firm starts with 20 units under the ground. The question is how much of that is actually extracted for each price path. Assuming all paths are equally likely, it is possible to compute the total expected quantity that has being exploited.

This is an important measure of the distortions that the tax system produces. In fact, most of the distortions are reflected in under exploitation of the field. This is because the assumptions I have made will lead to this conclusion. If investment incentives are included in the discussion and they affect the development of reserves, then overproduction is possible. Nevertheless, here I am more concern with understanding the degree of the distortion rather than its direction, and have chosen the most conventional one.

Second, what is the expected net present value of tax revenues. This is a measure of how much is unconditionally collected by the government. One salient issue is the Laffer curve that arises in the royalty case. This is because at certain tax level the quantity distortion is so severe that reduces total revenues.

Finally, I study how the different combinations of taxes affect the volatility of the tax revenues. In this case, I compute the taxes for each of the Monte-Carlo simulations, and compute the net present value for each of them. The variance is then computed across all 500 paths. In other words, I do not compute the time series variation as part of this measure. The reason is that I believe that governments are primarily concern with the
total collection of taxes first, and then its timing second. This is clearly an assumption but I wanted to concentrate on only one of the sources of variation. Otherwise the analysis becomes cumbersome and it is hard to separate what is actually changing the variance of the tax revenues. In this case, I am certain the variation is coming across the different paths of prices.

3.1.2 Results

Figure 1 shows the expected total production for the different royalties and the income taxes. In the x-axis I present the tax rate (for both the royalties and the income taxes). The continuous line corresponds to the expected production under income taxes, while the dashed line is the total expected production for the royalty case.

Even in the absence of taxes, the firm leaves some resources under the ground. Given the parameters chosen the optimal total extraction is 19.86. The reason why some resources are left is because there are some paths in which the prices are so small that do not pay the marginal cost. Furthermore, the more has been exploited the larger the marginal cost of the next unit – exacerbating the problem.

As can be seen, the income taxes have a negligible distortion. This is by construction. The way income taxes enter is by proportionally changing all profits in all states of the world, not affecting the first order conditions faced by the firm. Indeed, the small differences that actually exist in the simulation are of the fourth order of magnitude, and I believe they are mostly the outcome of the approximation.

On the other hand, notice the severe distortion that exists when royalties are levied. In fact, there are tax rates that are so high that almost no production takes place. For taxes above 30 percent production is indeed zero. This is a standard problem in regulation of natural resources.

Having seen the impact of the tax rates on the firm choices, it should be obvious that
Figure 1: Expected Total Production
a Laffer curve exists for the royalties. Figure 2 shows the net present value tax revenue for each simulation. The x-axis is as before, and similar to the previous graph the continuous line reflects the tax revenues from using only income taxes, while the dashed one is the tax revenues from royalties.

As should have been expected, notice the Laffer curve in the royalties. Nevertheless, also notice that collection of revenues is much faster – and effective – using royalty taxes rather than income taxes.

Figure 3 presents the volatility of those taxes. Although for the same tax rates the royalty is more volatile than the income taxes, the real question to compare the two different forms of taxation is to fix the expected total revenues collected, and compare the variances. This
Figure 3: Variance of Tax Revenues

is the objective of the next subsection.

### 3.2 Volatility and expropriation

In this subsection as opposed to move independently the two taxes, I fixed the total expected tax revenues (I choose 0.75), and determine the different mixtures of taxes that achieve such revenue. I vary the royalties from 0 to 10 percent, and compute what is the income tax that will set the expected revenue to the target.

This is a very time consuming process. The optimization is done by searching along the different income taxes. For each proposed tax the whole value and policy functions are solved, the Monte-Carlo exercises are computed, and the expected revenue is calculated.
That means that each proposed pair requires the full solution of the problem.

The tax mixtures are shown in Figure 4. The thick continuous line on the top is the expected total taxes (almost constant at 0.75, the only errors are for numerical approximation and are of the order of the fourth decimal). The thin continuous line is the royalty tax rates, and the dashed line is the income taxes.

Notice that for very high royalties actually there is a income subsidy. This is innocuous in terms of the message that the section pretends to convey. As the royalties are increase, as it should be obvious, the income taxes are reduced.

In Figure 5 the expected production is shown. The x-axis indicates the royalty rate. As the royalties are increased, the mixture of taxes moves away from income taxes (less
distorsionary) toward royalties (more distortionary) reducing the expected production of the field.

The next step is to compare the tax revenue volatility and the sensitivity of the production plan. Figure 6 shows the variance of tax revenues (the thick line measured in the right hand side axis) and the variance of the production plan (dashed line measured in the left hand side).

The variance of the tax revenues is computed path by path. Interestingly, when royalties are increased the variance of the tax revenues drops. The intuition of this result is that royalties because they are levied on sales has a smaller volatility than profits. In fact, the coefficient of variation of royalties is smaller than the coefficient of variation of income taxes.\footnote{By forcing the tax mixture to collect exactly the same amount of resources the exercise is comparing the}
At the same time, the variance of the quantity produced increases with the royalties. The reason is that when royalties are higher, quantities are more sensitive to price fluctuations. In fact, there are several paths in which quantities are severely reduced – almost zero. This sensitivity of the quantities produced is reflected in the increase of the unconditional variance of the total production.

In general government care about the variance of the tax revenues as opposed to the volatility of production and the degree of inefficiency. In other words, here it can be seen that an increase in the reliance of royalties stabilizes fiscal revenues – some stabilization – sacrificing on efficiency – lower production and higher sensitivity of production to price implicit coefficients of variation.

Figure 6: Tax Mixtures and Volatility: Tax Revenues and production plan.
fluctuations. Because the cost of the inefficiency is mostly bared by the private sector the government cares very little about it.

In Figure 7 I present the expected private profits. As should have been expected, they are decreasing with the royalty rate. This is a reflection that the private sector is the one paying for the distortion.

There is, however, another dimension that the royalty affects negatively. In Figure 8 I present two measures of the profits of the firm that reflect extreme events. The continuous thick line represents the number of times the profits in the private sector are excessively high. The thick line is measured in the left vertical exis. The dashed line measures the

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Figure 7: Tax Mixtures and Expected Private Profits.

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\[\text{In this simulation the assumption is that the profits are above 0.10 in any given period.}\]
maximum profit across all times and paths and is measured in the right vertical axis.

As can be seen, even though the average profit by the private sector drops with the increase in the royalty rate, the “extreme” events are more frequent. As was discussed before, if the probability of expropriation depends on conditional private profits, the change in the tax mixture toward royalties increases the frequency of larger profits, rising the expropriation motives.

In summary, the shift from pure income taxes toward royalties has one advantage – so far. The royalties provide a more stable source of income to the government. On the other hand, they bring bigger distortions in the production plan, and higher dispersion of private profits – which might end up implying more probability of default. In the following section I extend the present model to discuss another “positive” aspect of the royalties – mainly the interaction between the tax code and the agency costs.

3.2.1 New maximization problem

When the probability of default or expropriation is introduced in the problem the maximization that the firm and the government face is as follows:

\[
V(Q_t, p_t) = \max_q \left( \pi(q_t, Q_t, \bar{Q}, p_t, \tau_r, \tau_\pi, \Phi_t) + \frac{1}{1 + \beta} E[V(Q_{t+1} + q_{t+1}, p_{t+1}) | p_t] \right)
\]

\[
\pi(q_t, Q_t, \bar{Q}, p_t, \tau_r, \tau_\pi) = \left[ p_t q_t (1 - \tau_r) - c(q_t, Q_t, \bar{Q}) \right] (1 - \tau_\pi) \Phi_t
\]

where \( \Phi_t \) is the probability of expropriation. I assume that the firm looses everything and collects zero after the expropriation takes place.
Figure 8: Tax Mixtures and Expropriation. Maximum profit and number of path with profits larger than threshold.
The government solves the exact same problem as before

\[
\min_{\tau_r, \tau_\pi} \left( \bar{Q} - E \sum_{t=0}^{\infty} q_t \right)
\]

\[
E \sum_{t=0}^{\infty} \frac{1}{(1 + \beta)^t} \tau_t \geq \bar{\tau}
\]

\[
Var \left( \sum_{t=0}^{\infty} \frac{1}{(1 + \beta)^t} \tau_t \right) \leq \bar{\nu}
\]

where it cares about the expropriation only to the extent that it affect the distorsion, the tax revenue, and its volatility.

As I said before, the expropriation decision has been simplified;

\[
\exp = \begin{cases} 
1 & \text{if } \pi_t > \bar{\pi} \\
0 & \text{o.w.}
\end{cases}
\]

where \( \bar{\pi} \) is some threshold. The idea is that the expropriation (or default on the contract) occurs when the government perceives that the private sector is receiving “excess” profits.

Notice that the impact of this problem only affects the firm choices. Because the expropriation is very costly for the firm, the firm chooses a production plan that makes profits in all states of the world less or equal than \( \bar{\pi} \).

When this constraint is added to the maximization problem it is possible that no solution is found for particular price paths. The intuition is as follows: assume there are only two price paths, one that implies very high profits and the other one very low. Because tax rates are not contingent to the price level, expropriation takes place when prices are high. The firm reduces its profits in that path by cutting down production, which reduces tax revenue. If the government wants to keep taxes constant and volatility at the limit, then it has to increase both taxes, but it has to increase royalties more than income taxes. The change in the tax mixture increases the probability of entering a default state, and depending on parameter values this increase can be sufficiently large that the shift deteriorates the probability of default. In those cases, there is no solution.
In sum, the problem of expropriation cannot be solved using the standard contracting tricks; contingent taxes, and taxes that drive profits in the private sector to zero. Both are unrealistic and have not been used in practice. Which means that in the end other arrangements are required. Those arrangements have to take into consideration that the government will set fixed taxes. In this case, it is in the best interest of the firms to create a local constituency that could be damaged in case of an expropriation. This is the same solution that has been given to the problem of highways. In fact, some oil companies indeed spend on local services. But the experience in Alaska might suggest that transferring lump sum to local agents could be a more efficient and long lasting strategy. Furthermore, if those transfers are tax deductible (like expenditures) then it is profitable – beyond reducing the probability of expropriation – to implement the transfer.

### 3.3 Introducing small agency costs

In this section, I introduce small agency costs. The main reason why I concentrate on smaller costs is because if agency incentives are severe, then the income tax also exhibits a Laffer curve; complicating significantly the analysis.

The idea behind the agency costs is to model private decisions that are wasteful but are able to reduce the tax burden. As I argued before, most of those actions are “expenditures” and therefore affect the income tax efficiency more than sales taxes. In this paper the wasteful expenditure is costly in terms of profits, but reduces the tax burden proportionally to the tax rate. Therefore, if the income tax rate is large, the benefits of the wasteful expenditure are bigger and the firm find profitable to incur on them.

The only source of inefficiency that I study is the reduction in taxation that takes place because of the agency costs. Figure 9 shows the ratio between the tax collection without agency costs and the tax collection when agency costs are present. This figure is similar to those in Section 3.1.2. Each tax was increased independently from zero up to 15 percent.
Figure 9: Reduction in expected tax revenue when small agency costs are introduced.

On the x-axis the tax rate is presented. The thick continuous line is the tax reduction when income taxes are used and it is measured on the right vertical axis. The dashed line is the ratio when royalties are used. It is measured on the left axis.

Notice that the drop in taxes when royalties are present is extremely small. It is always less than 1.2 percent. The reason why this is not exactly one is because there are some paths in which the reduction in taxes is beneficial given the extremely high price level. This reduction in taxes allows for further production, and therefore, only on those extremes the firm finds profitable to throw away money.

On the other hand, when income taxes are in place, the distortions are much larger. All taxes drop by more than 10 percent, and the drop increases with the tax rate. Meaning, that higher tax rates incentivate worse behavior.
3.3.1 Solving the agency costs?
[to be completed]

4 Lessons and Conclusions

This paper has discussed how optimal taxation is affected by three issues that are likely to appear in natural resource extractions. The desire to stabilize revenues, the need to reduce agency costs, and the expropriation incentive.

This paper argues that those aspects have negative effects on efficiency, and that trying to find a solution by changing the mixture of taxes is probably inappropriate. Although, in practice this is the solution most countries pursue.

In this paper, problems start when the government is concerned about revenue stabilization. Indeed, one lesson from this exercise is that stabilization should be achieve by a different institution. Taxes, in the case of natural resource extraction, cannot handle the task. The implementation of a stabilization fund is crucial to be able to design a proper production contract. If the stabilization fund does not exist, or it is not credible, the implication is that the government will have incentives to distort the tax mixture making agency costs and expropriation more likely.

The problem of expropriation cannot be solved using the standard contracting tricks; taxes are contingent, and profits in the private sector are driven to zero. Both are unrealistic. Which means that in the end other arrangements are required. Government will set fit taxes and therfore, it is in the best interest of the firms to create a local constituency that could be severly damaged in case of an expropriation. Some oil companies indeed spend on local services, but the experience in Alaska might suggest that trasfering lump sum to local agents could be a more efficient and long lasting strategy. Furthermore, if those transfers are tax deductible (like expenditures) then it is in the best interest of the firm to actually develop
the local support.

Finally, sharing ownership has been highlighted as a possible vehicle to mitigate agency costs. This assumes that the government incurs in less agency costs than the private sector.\footnote{Maybe possible in Switzerland, but hard to believe in Latin America} The problems of agency costs are reduced by relying on sales taxes, and indeed, that has been easily one of its most important benefits. Although this is an alternative, it is clear that future research should continue in this area. Nevertheless, the elimination of investment subsidies, and depreciation subsidies will go a long way in reducing the agency costs that plague the industry.
References


### Table 1: Typical contracts: World Bank

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<thead>
<tr>
<th></th>
<th>Argentina</th>
<th>Bolivia</th>
<th>Colombia</th>
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</thead>
<tbody>
<tr>
<td><strong>Fees Exploration</strong></td>
<td>~20$ per sq.km.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fees Production</strong></td>
<td>~420$ per sq.km.</td>
<td>~200$ per sq.km.</td>
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<tr>
<td>Royalties Oil</td>
<td>12%</td>
<td>18%</td>
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</tr>
<tr>
<td>Royalties Gas</td>
<td>15% to 30%</td>
<td>18%</td>
<td>5% to 25%</td>
</tr>
<tr>
<td>Income Tax</td>
<td>35%</td>
<td>25%</td>
<td>35%</td>
</tr>
<tr>
<td>Depreciation Development</td>
<td>10% straight line</td>
<td>20% straight line</td>
<td>20% straight line</td>
</tr>
<tr>
<td>Depreciation Facility</td>
<td>10% straight line</td>
<td>12.5% straight line</td>
<td>14.3% straight line</td>
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<tr>
<td>Sales Tax</td>
<td>1% to 3%</td>
<td>13% (VAT)</td>
<td>0.2% to 0.7%</td>
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<td>Asset Tax</td>
<td>1%</td>
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<tr>
<td>Participation or Profit Shares</td>
<td></td>
<td>25%</td>
<td>30% after royalties</td>
</tr>
<tr>
<td>Investment Uplift</td>
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<td>100%</td>
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<tr>
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<th>Venezuela</th>
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<tbody>
<tr>
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<tr>
<td><strong>Fees Production</strong></td>
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