Regulation changes and auction performance

Oil leases in Brazil

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Oil companies face several risks:

- Commercial (Example: oil prices)
- Geological (Size of the resource base)
- Political

Fiscal frameworks may adapt to economic conditions.

Extraction and investment decisions can change if fiscal or contractual conditions change.

In countries that use auctions to allocate leases, bidder strategies may also change.

How changes in fiscal regimes affect company behavior?
Brazil opened the oil sector to private investment in 1997.

Initial Concession system mainly relied on royalties and taxes, and use multidimensional (scoring) auctions.

Massive discovery leads to changes for specific areas with large resources.

- Production sharing regime.
- Auctions with profit share as bid parameter.

My paper integrates a model of exploration and development of an oil field into an auction model.

- Recover investment and operational costs from auction and production data.
- Compare government revenues under the two different regimes.
Two types of regime in Brazil: concession contracts and production sharing contracts

Concession contracts:
- Company assumes the exploration risk, but could get reimbursed through tax credits.
- Companies pay a combination of royalties and taxes.
- Scoring auction.

Production Sharing Contracts (PSC):
- Company assumes the exploration risk and only gets reimbursed with a successful discovery.
- Company splits the profits with the government after being reimbursed.
- **Auction based on the profit share.**

Globally, profit taxes or profit shares are on average between 70 – 80% of government revenues (Johnston and Johnston, 2003).
Related literature

  - **Contribution:** Adds an explicit model of development of a field to model value of a block.

- Contingent payment auctions: Bhattacharya, Ordin, Roberts (2018), Kong, Perrigne and Vuong (2019)
  - **Contribution:** Adds an intensive margin decision from the contractual design.

  - **Contribution:** Adding an auction stage and non-parametric estimation of winning probabilities.

Focus on exploratory blocks.

Score for bidder $i$ and block $j$ is calculated as:

$$S_i(b, e, l) = \rho_b \frac{b_i}{\max_j b_j} + \rho_e \frac{e_i}{\max_j e_j} + \rho_{Lx} \frac{Lx_i}{\max_j Lx_j} + \rho_{Ld} \frac{Ld_i}{\max_j Ld_j}$$

- $b_i$ is a signature bonus (in reals)
- $e_i$ is an investment commitment (in work units).
- $L_i$ is a local content commitment (in percentage).
- $\rho_b + \rho_e + \rho_{Lx} + \rho_{Ld} = 1$
Exploration stage: exploration commitment, pay the signature bonus, pay a fraction of their exploration costs to local companies.

Company decides to move to the development stage.

- Concession: royalties, special participation tax, surface fees, corporate income tax. Can get tax credit from exploration and development expenditures.
- PSC: main difference is the split (profit oil) after recovering part of the costs, is determined at the auction stage.

Both in the concession contracts and the PSC, the company chooses how much oil to extract in the development stage.
Companies in both cases are the residual claimant.

Hernandez-Perez (2011): Both contracts have cost reimbursement mechanisms that can induce investment (tax credits or cost recovery).


Decisions at the intensive margin could be important.
### Data and institutional context

**Comparison Concessions and PSC**

<table>
<thead>
<tr>
<th></th>
<th>Rounds 7,9,11</th>
<th>Rounds PSC 1-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Bonus</td>
<td>0.126</td>
<td>2.792</td>
</tr>
<tr>
<td>((MM \text{ R$ \per Km^2}))</td>
<td>(0.143)</td>
<td>(3.533)</td>
</tr>
<tr>
<td>Average Exploratory Effort</td>
<td>0.102</td>
<td>0.441</td>
</tr>
<tr>
<td>((MM \text{ R$ \per Km^2}))</td>
<td>(0.121)</td>
<td>(0.567)</td>
</tr>
<tr>
<td>Average local content Exploration</td>
<td>0.675</td>
<td>0.236</td>
</tr>
<tr>
<td>Average local content Development</td>
<td>0.77</td>
<td>0.342</td>
</tr>
<tr>
<td>Average Production (barrels per day)</td>
<td>8,908.66</td>
<td>219,700</td>
</tr>
<tr>
<td>Average Reserves (million barrels)</td>
<td>45.82</td>
<td>1,230</td>
</tr>
</tbody>
</table>

- Std deviation in parenthesis.
- Production sharing contracts are assigned to the areas that are most productive.
Data and institutional context

- Observed bonus spatially correlated and in some cases higher for the concession contracts.
After the auction

• Around 2/3 of companies extend their exploration period.
• Around 11% of projects with extended exploration go to the development stage.

<table>
<thead>
<tr>
<th>Number of blocks</th>
<th>Abandoned</th>
<th>Developed</th>
<th>Still exploring</th>
</tr>
</thead>
<tbody>
<tr>
<td>173</td>
<td>23</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

Table: Exploration stage decision

• I only get to watch production and reserves data for those fields that were developed.
Robust estimation

- Linear regression for signature bonus.
- Dummy variables for different scoring rules:
  - Scoring rule 1: 1 for Rounds 1-4 (bonus weight $\rho_b = 85\%$)
  - Scoring rule 2: 1 for Rounds 5-6 (bonus weight $\rho_b = 30\%$)
  - Scoring rule 3: 1 for Rounds 14-16 (bonus weight $\rho_b = 80\%$)
- Dummy variable PSC: 1 if the bid corresponds to a Production Sharing Contract
- Minimum bonus, set by the government based on block characteristics.
- Oil prices
Robust estimation: Signature bonus

- **Dependent variable:** Signature bonus ($R\$$ per $Km^2$)

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Bonus ($R$$ per $Km^2$)</td>
<td>1.019 ***</td>
<td>0.018</td>
</tr>
<tr>
<td>Scoring rule 1</td>
<td>-65,110.71</td>
<td>66,118.71</td>
</tr>
<tr>
<td>Scoring rule 2</td>
<td>-171,218***</td>
<td>53,339.17</td>
</tr>
<tr>
<td>Scoring rule 3</td>
<td>416,558</td>
<td>143,530.5</td>
</tr>
<tr>
<td>Oil Price</td>
<td>1,442.85**</td>
<td>565.82</td>
</tr>
<tr>
<td>PSC</td>
<td>-292,406.1***</td>
<td>76,400.49</td>
</tr>
</tbody>
</table>

*** p-value < 0.01

- **R-squared:** 0.7963

- **PSC** is statistically significant, so that the signature bonus is lower in areas under Production Sharing Contracts.
Industry estimates from the projects already in the development stage:
- Government revenues forecasts (adjusted by inflation).
- Production forecasts.
- Estimate government revenues per barrel produced for both types of contracts.

Production sharing contracts have higher government revenues per barrel.

<table>
<thead>
<tr>
<th></th>
<th>Concession</th>
<th>Production Sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average ($/boe*)</td>
<td>11.59</td>
<td>26.82</td>
</tr>
<tr>
<td>Std. Deviation ($/boe*)</td>
<td>4.15</td>
<td>9.11</td>
</tr>
</tbody>
</table>

* boe: barrels of oil equivalent. 2019 dollars
Model

Stages

- **Exploration stage:**
  - Firm receives shock \( \epsilon_{ij} \)

- **Development stage:**
  - Firm earns \( \pi_{ij}^{DEV}(a_{ij}) \)

- **Auction:**
  - Firms choose bonus \( b_{ij} \) and investment \( e_{ij} \) (Concession) or profit share (PSC).

- **Evaluation stage (3 years):**
  - Firms honor investment commitment and bonus and decide if they move to development (learn \( \epsilon_{ij} \)).

- **Development stage (25 years):**
  - Build infrastructure and choose extraction rate \( a_{ij} \) (receive \( \epsilon_{ij} \)).
Each bidder $i$ learns the following (private information):

- $c_{ij}$ operating cost in development stage $\sim H_c(.)$.
- $\gamma_{ij}$: investment cost in exploration stage $\sim H_\gamma(.)$

$c_{ij}$, $\gamma_{ij}$ is independent across $i$ and block $j$ and identically distributed.

Shock $\epsilon_{ij}$ at the evaluation stage reflects geological uncertainty. This shock has distribution $H_\epsilon$ known to bidders.

Development stage profit $\pi^{DEV}(a_{ij},.)$ is similar to Smith (2014): firms choose extraction rate $a_{ij}$ given tax structure, prices, resources.
Each bidder $i$ submits a multiple bid ($b_{ij}$, $e_{ij}$, $L_{xij}$, $L_{dij}$), where:

- $b_{ij}$ is a signature bonus (in local currency)
- $e_{ij}$ is an investment commitment (in work units).
- $L_{xij}$ is a percentage local content commitment for exploration.
- $L_{dij}$ is a percentage local content commitment for development.

Score for bidder $i$ and block $j$ is calculated as:

$$S_{ij}(b, e, L_x, L_d) = \rho_b \frac{b_{ij}}{\max_i b_{ij}} + \rho_e \frac{e_{ij}}{\max_i e_{ij}} + \rho_{Lx} \frac{L_{xij}}{\max_i L_{xij}} + \rho_{Ld} \frac{L_{dij}}{\max_i L_{dij}}$$

$$\rho_b + \rho_e + \rho_{Lx} + \rho_{Ld} = 1$$

I assume $L_{xij}$ and $L_{dij}$ for the remainder (not enough variation in data).
Model

Exploration Stage

- Value of a block after winning the auction $\omega_{ij}$ is given by

$$\omega_{ij} = \omega(.) = -b_{ij} + 1[\epsilon_{ij} < \epsilon]( -\epsilon_{ij} U_j ) + $$

\text{Signature bonus} + 1[\epsilon_{ij} \geq \epsilon] ( -\epsilon_{ij} \gamma_{ij} + \beta^{TE-TA} \Pi_{ij}^{CON}(a_{ij} \mid R_j + \epsilon_{ij}, .) ) \quad (1)

\text{Penalty}

\text{Exploration commitments}

\text{profits development stage}

- The shock $\epsilon_{ij} \sim H_{\epsilon}(.)$ is known after the company wins the auction.
- Company pays penalty $U_j$ per unit of work committed (investment) in the auction stage if the project is abandoned at time $T_E$
- Company gets $\Pi_{ij}^{CON}(a_{ij} \mid R_j + \epsilon_{ij}, .)$ if it decides to develop the project at time $T_E$. 
The problem of bidder $i$, can be written as

$$\max_{b_{ij}, e_{ij}} G(b_{ij}, e_{ij}) W(b_{ij}, e_{ij})$$

$$W(b_{ij}, e_{ij}) = E_\epsilon[\omega(b_{ij}, e_{ij})] = -e_{ij} \gamma_{ij} - b_{ij}$$

$$+ \beta^{TE-TP} \Pi^{CON} + E[\epsilon | \beta^{TE-TP} \Pi_{ij}^{CON} (a_{ij} | R_j + \epsilon_{ij}, .) - e_{ij} \gamma_{ij} - e_{ij} U_j \geq -e_{ij} U_j]$$

is an expected value over $\epsilon$.

- If the firm knows oil prices and firm investment and operational costs, the value of block depends on the bids and the extraction rate $a_{ij}$.
- Variation in $e_{ij}$ allows identification of $\gamma_{ij}$ and variation in $b_{ij}$ allows identification of $c_{ij}$.
Simulation

- Estimate distribution of resources $R_j$ and with price forecasts and tax structure, compare ex-post profits from both concession contracts and production sharing contracts.
  - Shocks $\epsilon$ come from the distribution of resources $R_j$

- Optimal bidding strategy for PSC is estimated using De Marzo et. al (2005).
  - Estimate probability of winning the PSC auction using cost data for Pre-Salt projects.
  - Simulate scenarios with 2 or 3 firms competing.
Simulation

- Results are sensitive to the distribution of the probability of winning
- Execution of projects around 70% of the time.

![Government Revenues by System](image-url)
On average, the lower cost recovery allows for slightly higher revenues for the PSC.
Next steps include the estimation of the distribution of private costs in order to conduct counterfactuals.

Need to consider stochastic prices and how they affect the extraction decisions.

Including the auction stage could lead to different results in government revenues.

Including profit shares as bid dimensions may induce problems of adverse selection.