Regulation changes and auction performance

Oil leases in Brazil

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Question

- 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?

This paper

- 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.

Brazil Context

- 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

- Scoring auctions and ex-post outcomes: Sant'Anna (2018), Bajari and Lewis (2011), Bajari, Houghton, Tadelis (2014).
  - **Contribution:** Adds a 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.
- Optimal development of an oil field and taxation: Smith (2014), Lin (2013), Smith (2013) for a review.
  - **Contribution:** Adding an auction stage and non-parametric estimation of winning probabilities.
- Brazil comparisons of PSC and concessions: Furtado et. al (2019), Hernandez-Perez (2011), Leveque and Hallack (2013), Barboza et. al (2018).

Data and institutional context

- Focus on exploratory blocks.
- Score for bidder i and block j is calculated as:

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

- 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.

Data and institutional context

Comparison Concessions and PSC

- 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).

- Ravagnani et. al (2012): Different contracts could induce different exploitation strategies.
- Decisions at the intensive margin could be important.

Data and institutional context

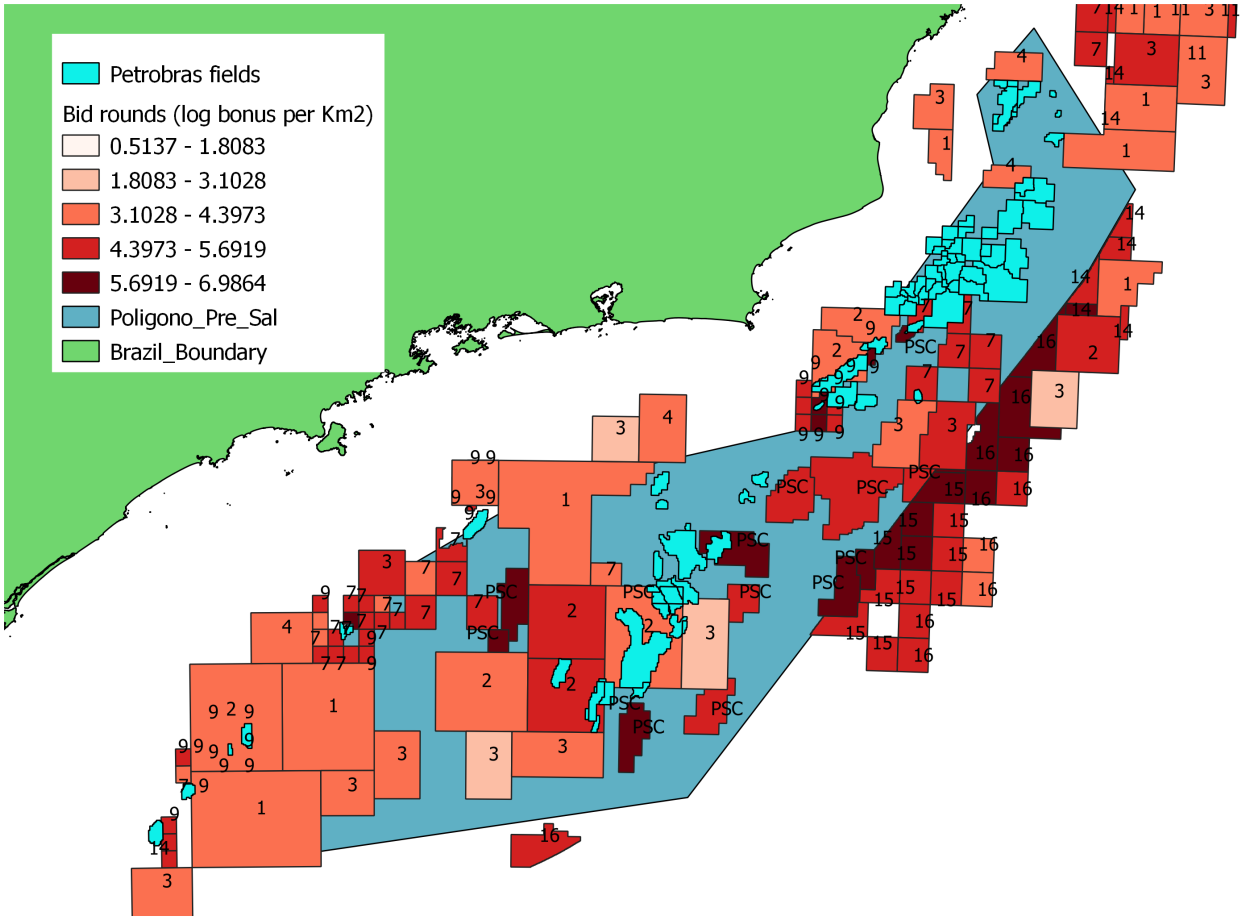
Comparison Concessions and PSC

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

- 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.

	Abandoned	Developed	Still exploring
Number of blocks	173	23	36

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)

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

Government revenues

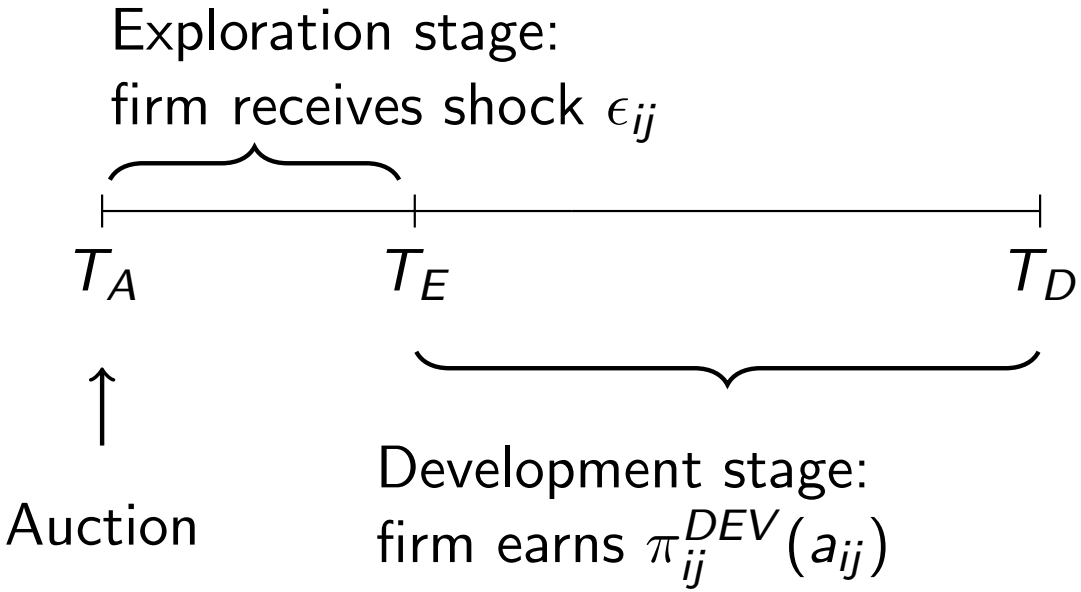
- Industry estimates from the projects already in the development stage:
  - Government revenues forecasts (adjusted by inflation).
  - Production forecasts.
  - Estimate government revenues per barrel produced for both types of contracts.
- Production sharing contracts have higher government revenues per barrel.

	Concession	Production Sharing
Average ($/$boe^*$)	11.59	26.82
Std. Deviation ($/$boe^*$)	4.15	9.11

* boe: barrels of oil equivalent. 2019 dollars

Model

Stages



- 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 ϵ_{ij}).
- Development stage (25 years): build infrastructure and choose extraction rate a_{ij} (receive ϵ_{ij}).

- Each bidder i learns the following (private information):
  - c_{ij} operating cost in development stage $\sim H_c(.)$.
  - γ_{ij}: investment cost in exploration stage $\sim H_\gamma(.)$
- c_{ij}, γ_{ij} is independent across i and block j and identically distributed.
- Shock ϵ_{ij} at the evaluation stage reflects geological uncertainty. This shock has distribution H_ϵ 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.

Model

Auction Stage

- Each bidder i submits a multiple bid $(b_{ij}, e_{ij}, Lx_{ij}, Ld_{ij})$, where:
  - b_{ij} is a signature bonus (in local currency)
  - e_{ij} is an investment commitment (in work units).
  - Lx_{ij} is a percentage local content commitment for exploration.
  - Ld_{ij} is a percentage local content commitment for development.
- Score for bidder i and block j is calculated as:

$$S_{ij}(\mathbf{b}, \mathbf{e.Lx}, .\mathbf{Ld}) = \rho_b \frac{b_{ij}}{\max_i b_{ij}} + \rho_e \frac{e_{ij}}{\max_i e_{ij}} + \rho_{Lx} \frac{Lx_{ij}}{\max_i Lx_{ij}} + \rho_{Ld} \frac{Ld_{ij}}{\max_i Ld_{ij}}$$

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

- I assume Lx_{ij} and Ld_{ij} for the remainder (not enough variation in data).

Model

Exploration Stage

- Value of a block after winning the auction ω_{ij} is given by

$$\omega_{ij} = \omega(.) = - \underbrace{b_{ij}}_{\text{Signature bonus}} + 1[\epsilon_{ij} < \underline{\epsilon}](\underbrace{-e_{ij} U_j}_{\text{Penalty}}) +$$

$$1[\epsilon_{ij} \geq \underline{\epsilon}](\underbrace{-e_{ij}\gamma_{ij}}_{\text{Exploration commitments}} + \beta^{TE-TA} \underbrace{\Pi_{ij}^{CON}(a_{ij} \mid R_j + \epsilon_{ij}, .)}_{\text{profits development stage}}) \quad (1)$$

- 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

$$\max_{b_{ij},e_{ij}} \underbrace{G(b_{ij},e_{ij})}\ \underbrace{W(b_{ij},e_{ij})} \tag{2}$$

$$W(b_{ij},e_{ij}) = E_{\epsilon}[\omega(b_{ij},e_{ij})] = -e_{ij}\gamma_{ij} - b_{ij} + \beta^{TE-TA}\Pi^{CON} + E[\epsilon|\beta^{TE-TP}\Pi^{CON}_{ij}(a_{ij} \mid R_j + \epsilon_{ij},.) - e_{ij}\gamma_{ij} - e_{ij}U_j \geq -e_{ij}U_j]\}$$

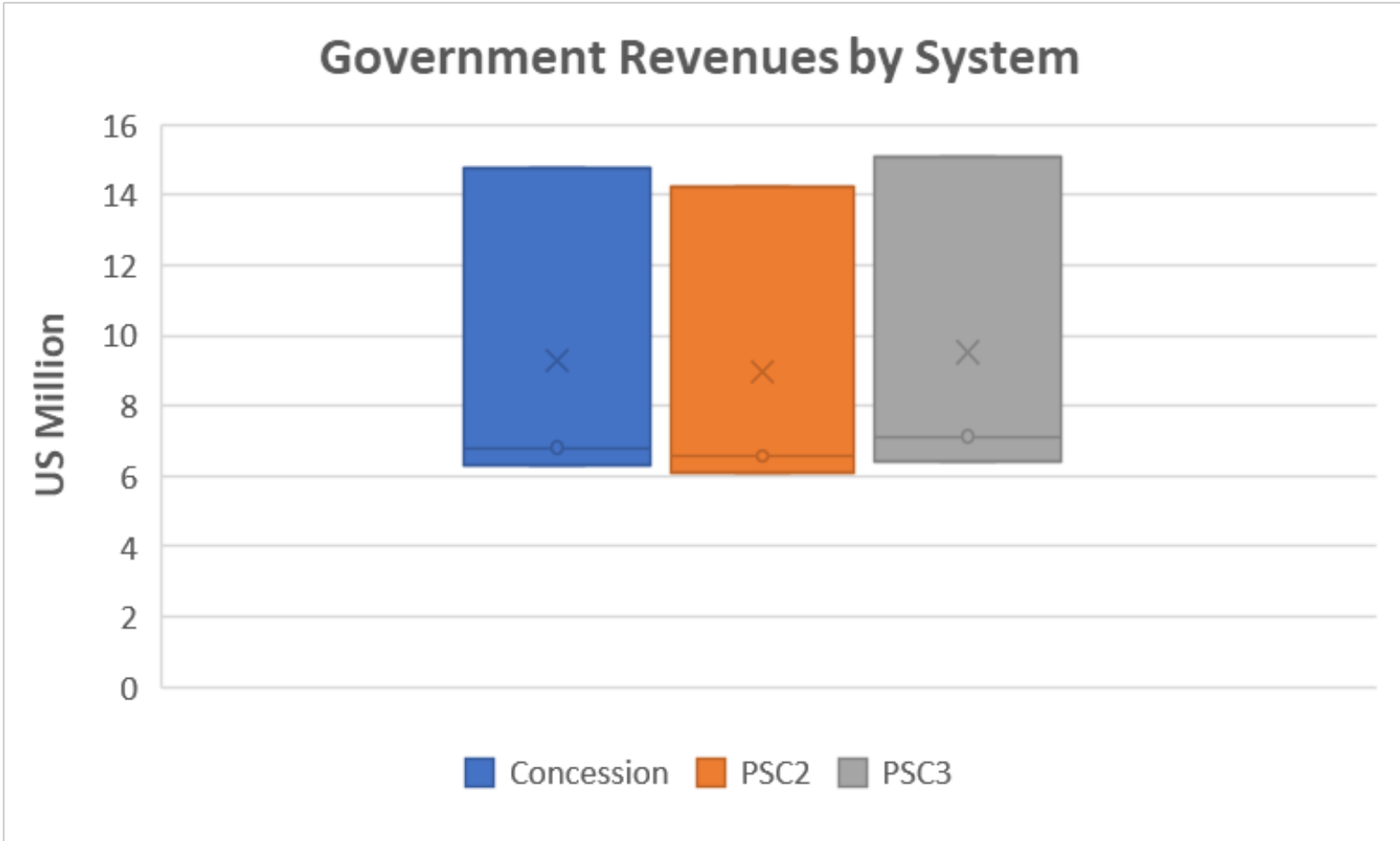
  is an expected value over ϵ.
- If the firm knows oil prices and firm investment and operational costs, the value of block depends on the bids and the extraction rate a_{ij}.
- Variation in e_{ij} allows identification of γ_{ij} and variation in b_{ij} allows identification of c_{ij}

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 ϵ 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.

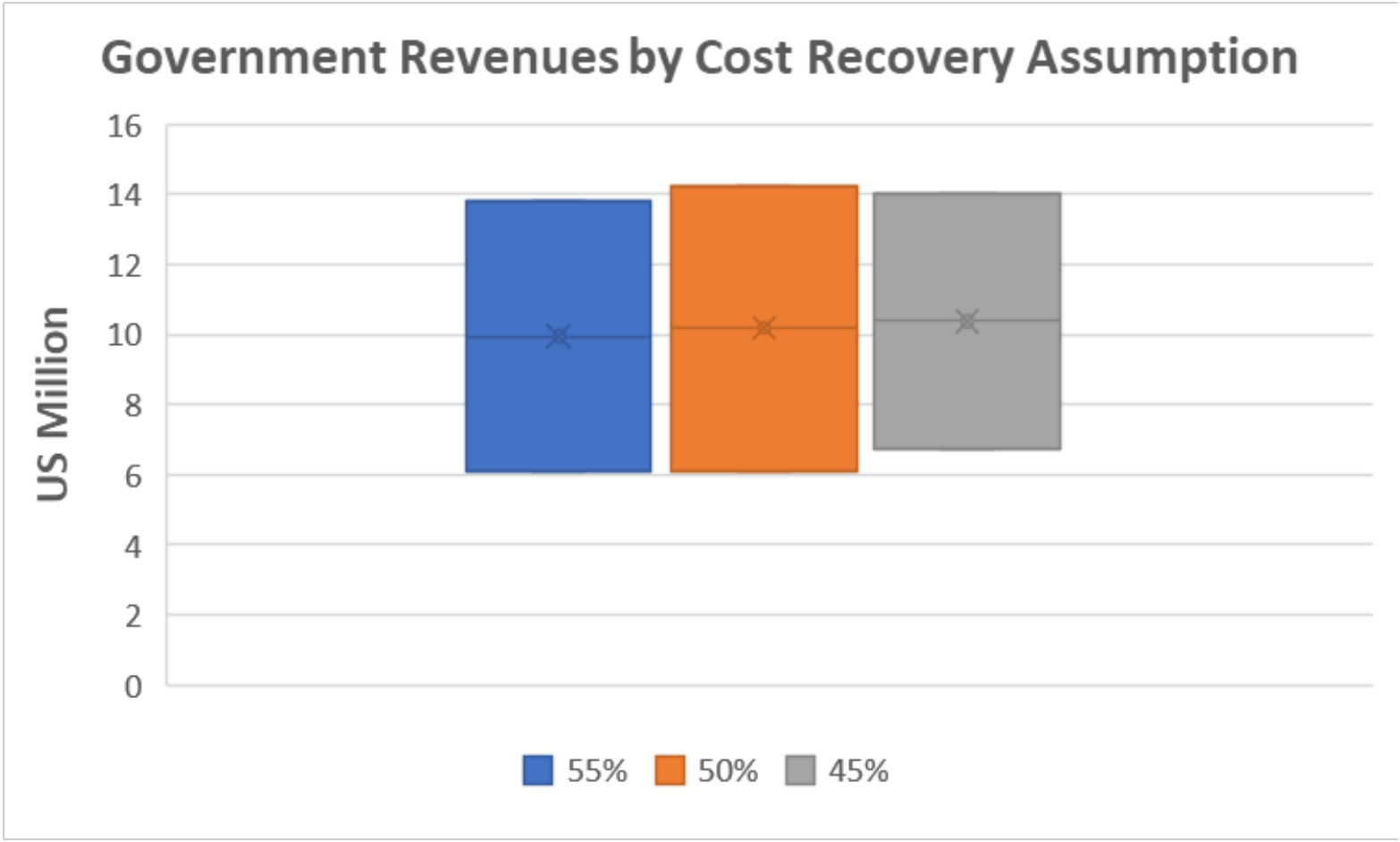
Simulation

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



Simulation

- On average, the lower cost recovery allows for slightly higher revenues for the PSC



Concluding remarks

- 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.