

Private management and strategic bidding behavior in electricity markets

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Outline

- ① Introduction
- ② Theoretical Background
- ③ Empirical Strategy
- ④ Data
- ⑤ Results

Introduction

Motivation

- Reforms in the 1980s and 1990s — Privatization served as a tool for ownership separation and the entry of new competitors.
- Important **promise of reform**: Privatization improves welfare (Cost effect dominates market power effect). **Lower prices** expected (Joskow, 1998).

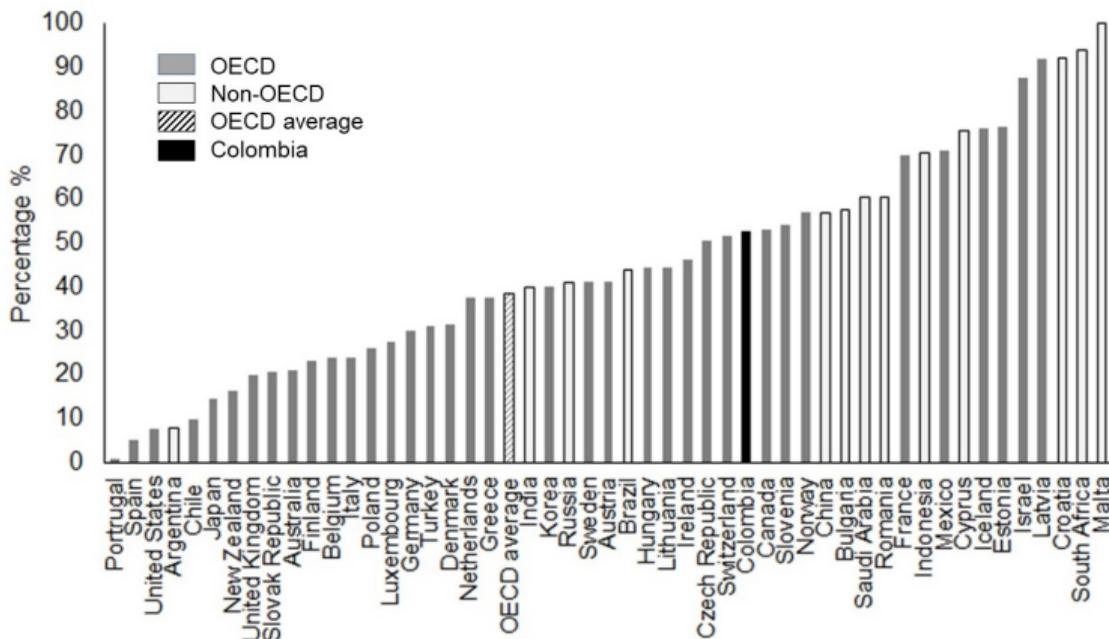
However...

- **Not conclusive empirical evidence** of the effect of privatization on competition and **final prices**.
- Impact of reforms: Not conclusive in **developing countries**.
- Although, privatization is **ongoing processes** in these countries.

Introduction

Motivation

Figure: Public ownership of electricity generation



Source: Prag, Röttgers and Scherrer (2018). OECD document, SOEs and the Low Carbon Transition, based on OECD data and World Electric Power Plant Database. I made the computation for Colombia using the information of installed capacity available in the web page of the market operator XM.

Introduction

About this paper

- This paper measure the impact of the **switch of management (from public to private)** in bidding prices in the electricity market in Colombia. I adopt a **diff-in-diff methodology** (staggered adoption and propensity score matching).

I want to contribute to answer the following questions:

- Are predictions of advocates of reforms right?
- Is the change in bidding behavior aligned with comparative static predictions of MOM?

Contribution

- **New empirical evidence on mixed oligopoly models**
- **More focused on strategic component** (Less focused on productive efficiency).
- **Public and private compete in the same relevant market** — Oligopoly framework.
- Policy evaluation study with focuses in the specific aspect of private management **(in a framework of advanced market liberalization)**.

Related Literature

- Mixed oligopoly models (Beato and Mas-Colell, 1984; Cremer et al., 1989; De Fraja and Delbono, 1989; Barros, 1995; Matsumura, 1998).
- Empirical studies of the effects of privatization on firm efficiency (Frydman et al., 1999; La Porta and Lopez-de Silanes, 1999; Megginson and Netter, 2001).
- Policy evaluation of liberalization of electricity markets (Fabrizio, Rose and Wolfram, 2007; Davis and Wolfram, 2012; Cicala, 2015).

Theoretical Background

- Mixed oligopoly model: competition between **private** firms (sub index i) and **public** firms (sub index 0) in the **same relevant market**.
- Key assumptions:
 - **Behavioral assumption:** Private = Profit maximizing ; Public = Welfare maximizing.
 - **Performance assumption:** Private firms are more cost efficient $C_o(q) > C_i(q)$

Theoretical Background

- Private = Profit maximizing:

$$\pi_i = p_i^{RD}(q_i)(q_i - q_i^c) + p_i^c q_i^c - C_i(q_i)$$

Cournot competition FOC:

$$p^{RD}(q_i) = \frac{\partial C_i(q_i)}{\partial q_i} - \underbrace{\frac{\partial p^{RD}(q_i)}{\partial q_i}(q_i - q_i^c)}_{\text{strategic element}} \quad (1)$$

Theoretical Background

- Public = Welfare maximizing.

$$W = \underbrace{\int_0^Q p(x(q_0)) dx - p(x) \sum_{j=0}^N (q_j - q_j^c) - \sum_{j=0}^N p_j^c q_j^c}_{\text{Consumer Surplus}} + \underbrace{\sum_{j=0}^N (p(x)(q_j - q_j^c) + p_j^c q_j^c - C_j(q_j))}_{\text{Industry Profits}}$$

Cournot competition FOC:

$$p(Q) = \frac{\partial C_0(q_0)}{\partial q_0} \quad (2)$$

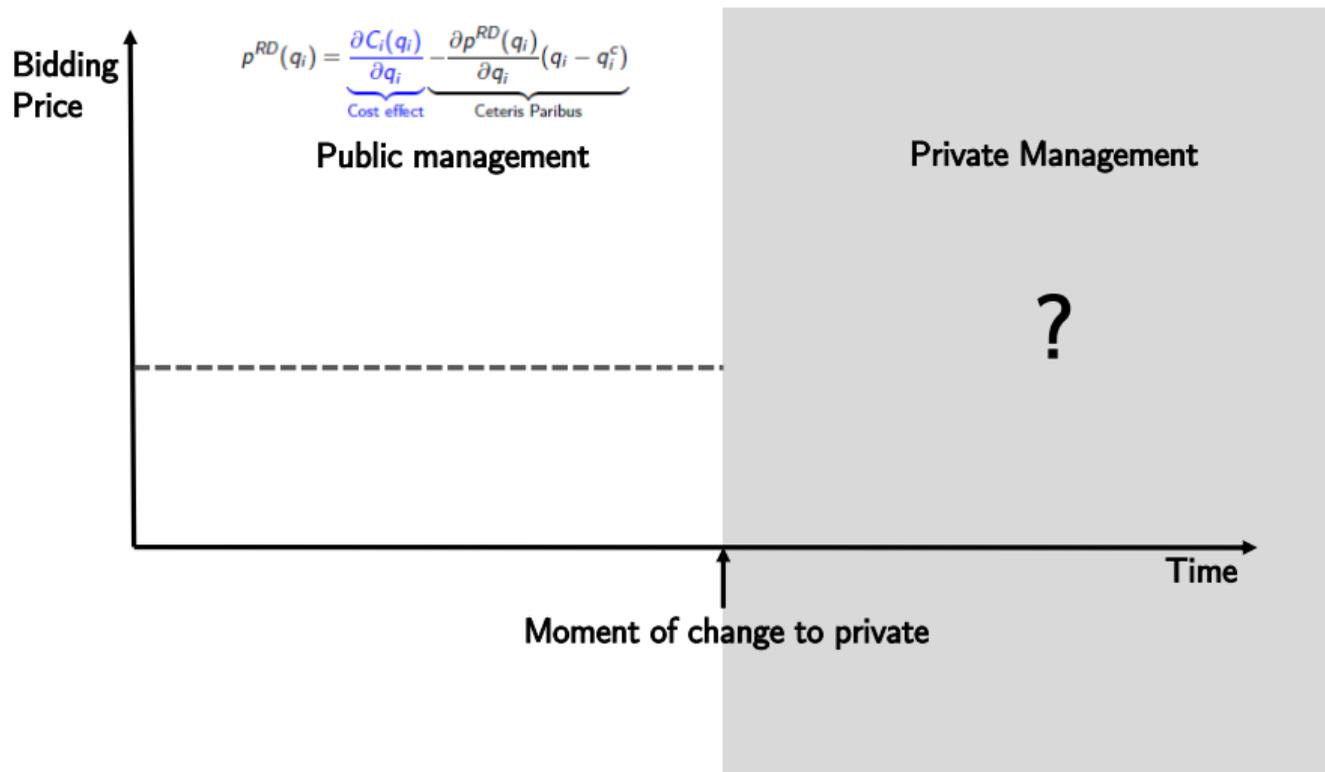
Theoretical Background

- The mixed oligopoly model provides comparative static predictions of switching from public to private management
- Effect on bidding prices: Trade off between cost reduction and market power in profit maximizing firms.
- What is expected in electricity markets?

$$p^{RD}(q_i) = \underbrace{\frac{\partial C_i(q_i)}{\partial q_i}}_{\text{Cost effect}} - \underbrace{\frac{\partial p^{RD}(q_i)}{\partial q_i} (q_i - q_i^c)}_{\text{strategic element}}$$

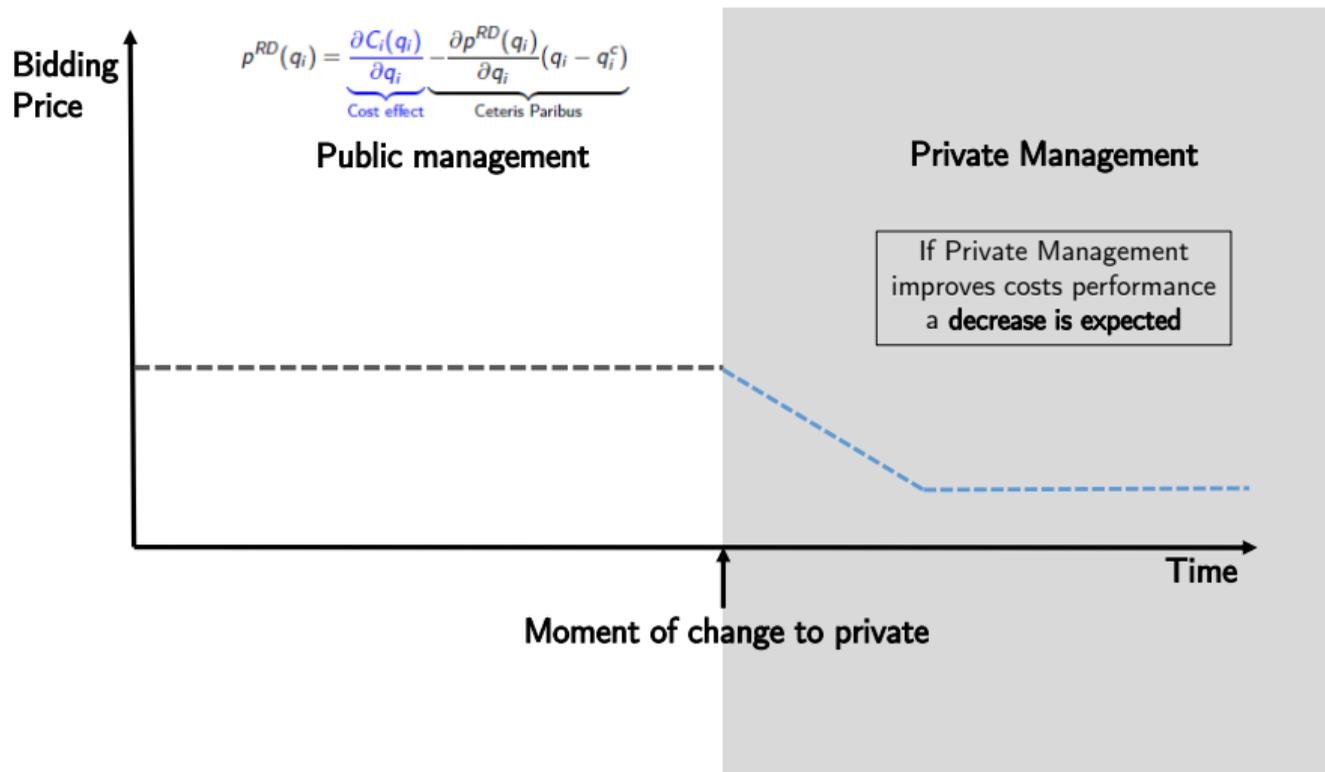
Theoretical prediction

Comparative static predictions of MOM — Cost effect



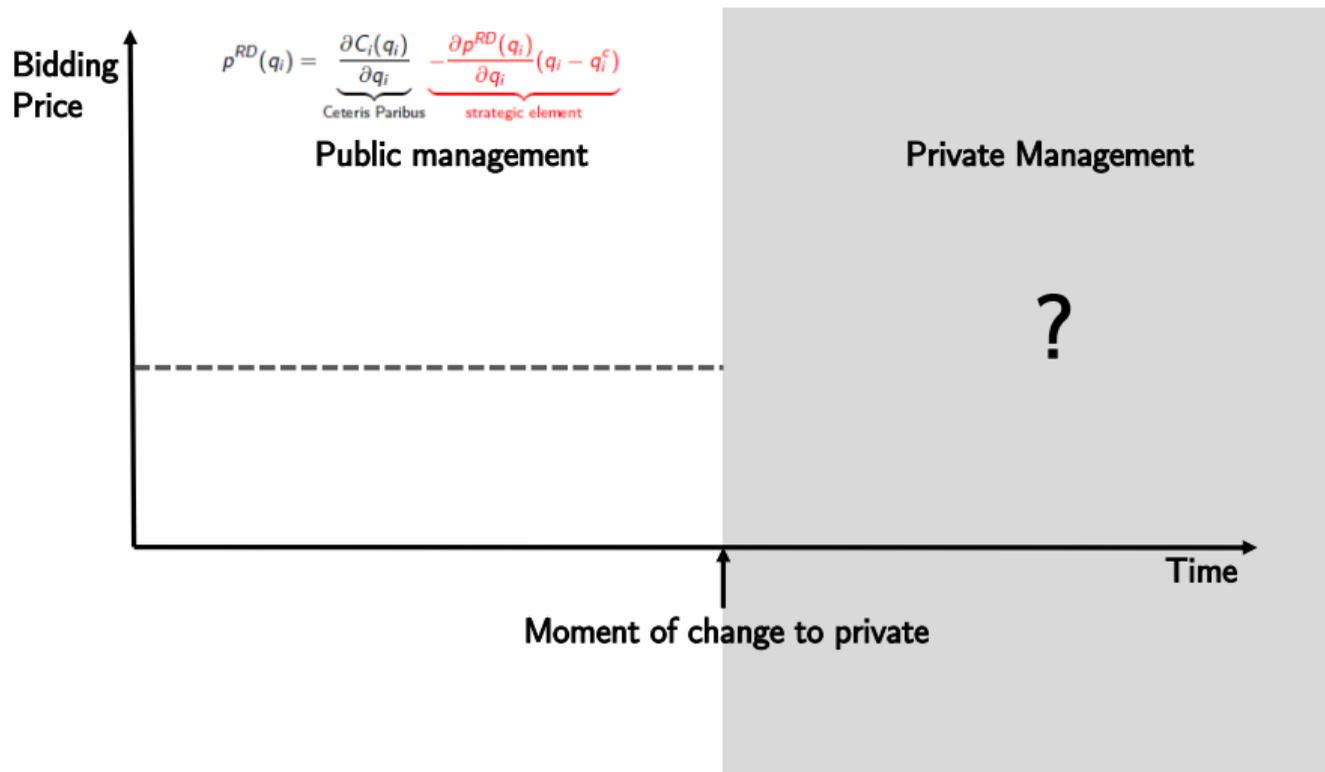
Theoretical prediction

Comparative static predictions of MOM — Cost effect



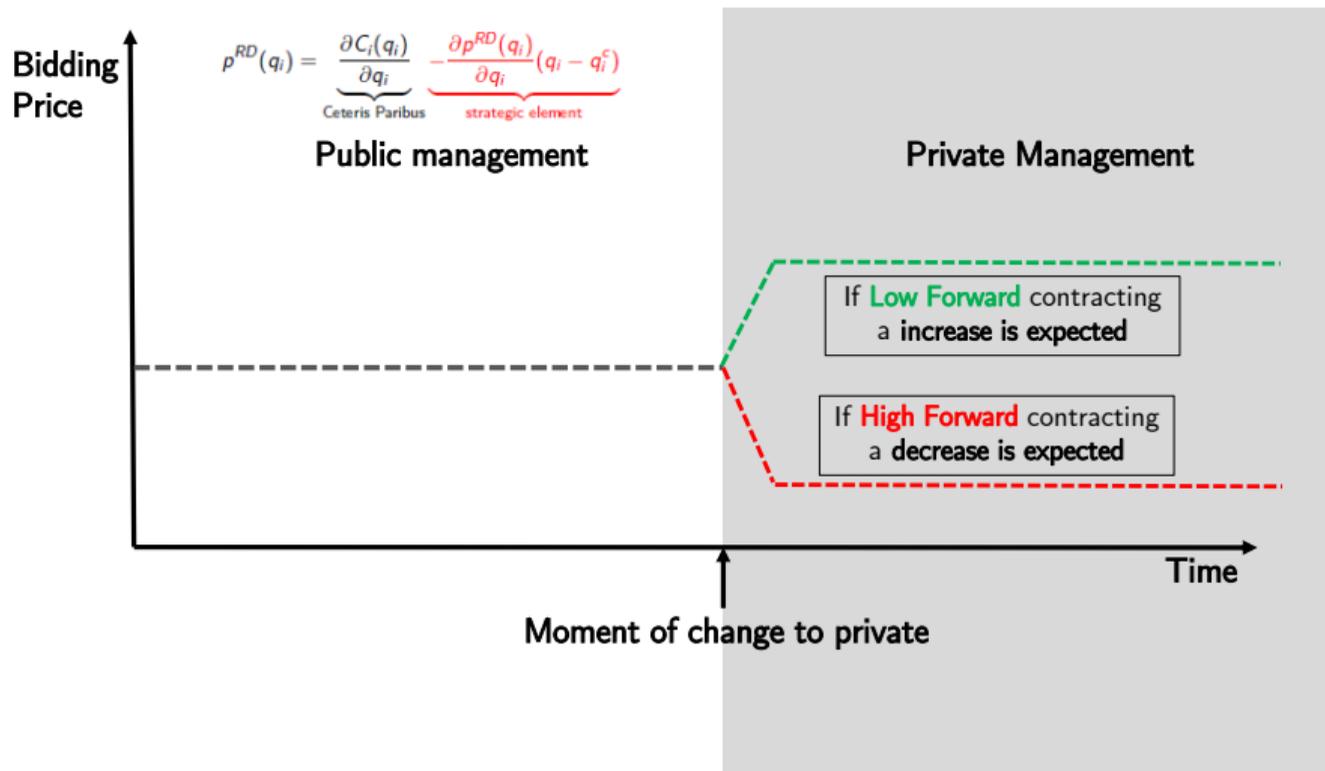
Theoretical prediction

Comparative static predictions of MOM — Strategic element



Theoretical prediction

Comparative static predictions of MOM — Strategic element



Empirical strategy

Econometric model

Differences-in-Differences methodology.

Public → control.

Change to private → treatment.

- **Staggered adoption:** Different date of treatment. Effects with reference to the moment of the implementation.
- **Propensity Score Matching Model** (Selection bias): Matching observations from the treatment group with similar observations in the control, conditional on observable characteristics (Rosenbaum and Rubin, 1983).

$$Pr[T_i = 1|X_i] = \Phi(X_i^T \beta)$$

$Pr[T_i = 1|X_i]$ probability of switching, T_i is a dummy of treatment, $\Phi(\cdot)$ cumulative standard normal distribution, X_i is a set of observable technical characteristics and forward contract.

Empirical strategy

Staggered Differences-in-Differences Models

- Do private management has a significant effect on the bidding price?

$$b_{it} = \beta_0 + \beta_1 D_{it} + \sum_{k=2}^N \beta_k x_{it}^k + \gamma_i + \sigma_t + \epsilon_{it}$$

- Do the change in the bidding strategy depends on the increase in market concentration (market power)?

$$b_{it} = \beta_0 + \beta_1 D_{it} \cdot Big_{it} + \beta_2 D_{it} \cdot New_{it} + \sum_{k=3}^N \beta_k x_{it}^k + \gamma_i + \sigma_t + \epsilon_{it} \quad (3)$$

- Do the change in the bidding strategy is coherent with the predictions regarding forward contracting?

$$b_{it} = \beta_0 + \beta_1 D_{it} \cdot L_{it} + \beta_2 D_{it} \cdot H_{it} + \sum_{k=3}^N \beta_k x_{it}^k + \gamma_i + \sigma_t + \epsilon_{it}$$

Data

Daily data from the market operator (XM) - 36 generation Units - 18 Years (2000 to 2018).

- Daily Data:
 - Bid Prices
 - Marginal Costs
 - Forward Contracts
 - Ideal generation
- Time Invariant Variables:
 - Installed Capacity
 - Maximum Power in critical conditions (ENFICC)
 - Technological Dummies
 - Average Forward Contracts exposition during 2005 and 2006 (Prior to privatization)

▸ Descriptive Statistics

- **Marginal cost** — Engineering accounting approach (Green and Newbery, 1992; Wolfram, 1998, 1999; Wolak, 2000; Fabra and Reguant, 2014). [▸ Details](#)

Table: Generation Units switching from public to private management

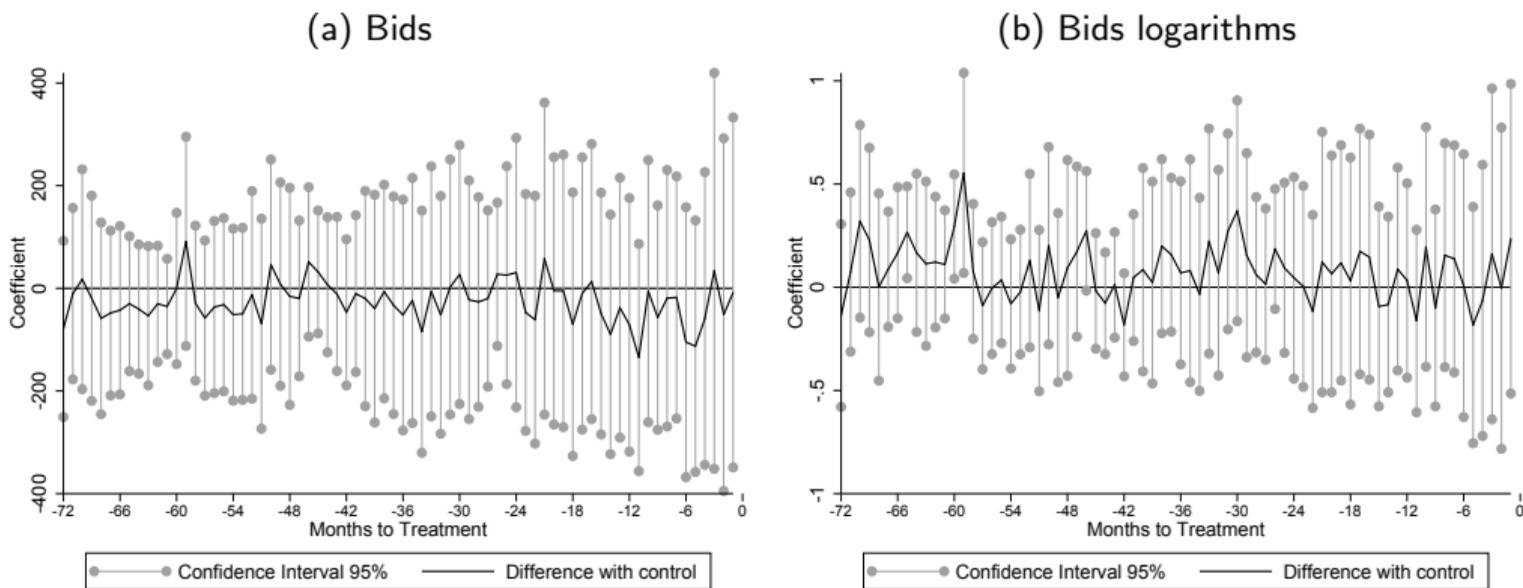
Date	Unit	Technology	Installed Capacity (MW)	From State Owner	To Private Owner
August 2007	Hidroprado	Hydro	56	GENSA	EPSA
August 2007	Prado IV	Hydro	5.7	GENSA	EPSA
November 2008	Termoflores	Thermal, Gas fired, combined cycle	150	GECELCA	COLINVERSIONES
June 2010	Termoemcali I	Thermal, Gas fired, combined cycle	213	EMCALI	Holdings Col., Ashmore I, and Maguro LTD
January 2016	Calderas	Hydro	26	ISAGEN (57.6% Ministry of Finance)	ISAGEN (57.6% Brookfield Fund)
January 2016	Miel	Hydro	396	ISAGEN (57.6% Ministry of Finance)	ISAGEN (57.6% Brookfield Fund)
January 2016	Jaguas	Hydro	170	ISAGEN (57.6% Ministry of Finance)	ISAGEN (57.6% Brookfield Fund)
January 2016	San Carlos	Hydro	1.240	ISAGEN (57.6% Ministry of Finance)	ISAGEN (57.6% Brookfield Fund)
January 2016	Sogamoso	Hydro	820	ISAGEN (57.6% Ministry of Finance)	ISAGEN (57.6% Brookfield Fund)
January 2016	Termocentro	Thermal, Gas fired, combined cycle	300	ISAGEN (57.6% Ministry of Finance)	ISAGEN (57.6% Brookfield Fund)
April 2016	Termobarranquilla 3	Thermal, Gas fired, simple cycle	64	GECELCA	TEBSA
April 2016	Termobarranquilla 4	Thermal, Gas fired, simple cycle	63	GECELCA	TEBSA
April 2016	TEBSA	Thermal, Gas fired, combined cycle	791	GECELCA	TEBSA

Source: own elaboration

Results

Parallel Trends Assumption

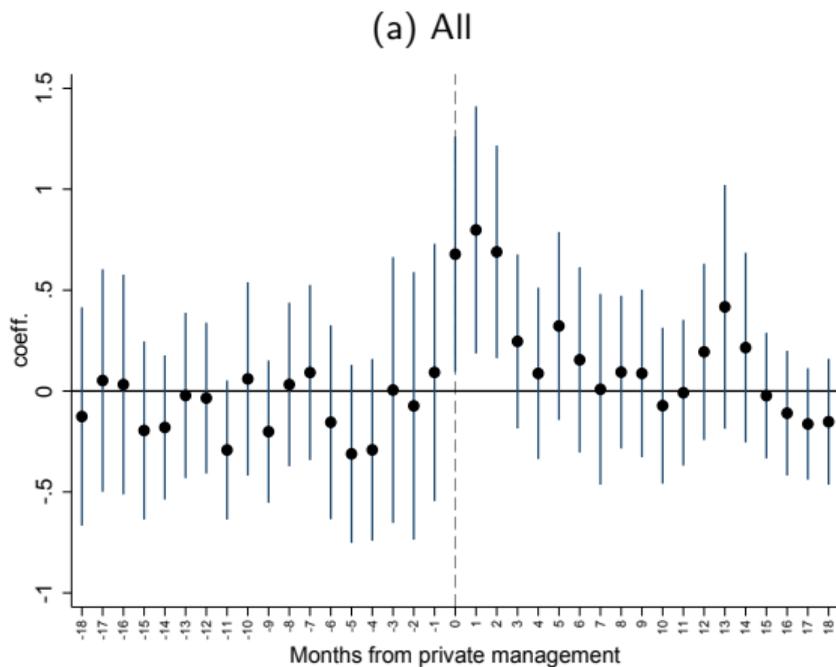
Figure: Parallel trends in pre-treatment months



Source: Data from XM - Calculations and elaboration: Author.

Results

Figure: Dynamic effects of private management



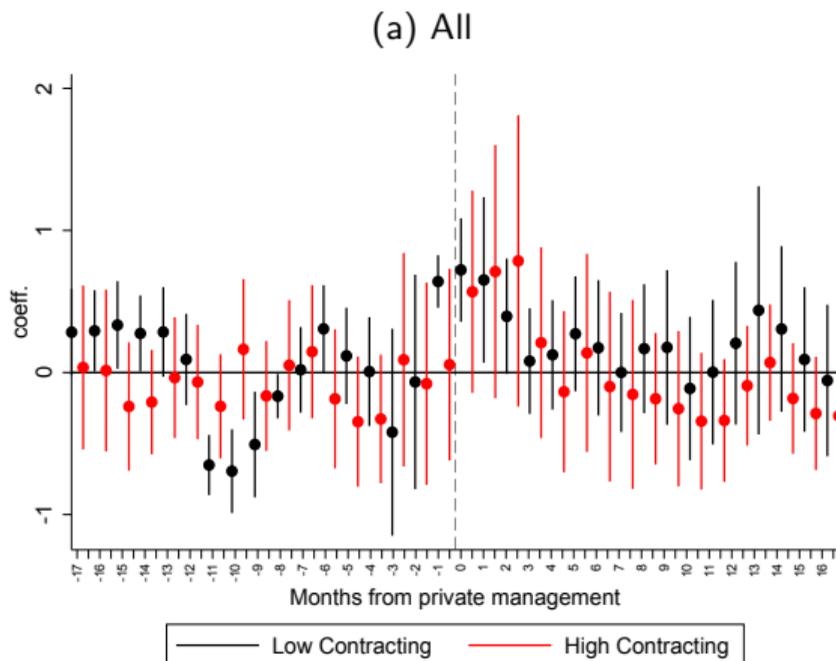
Source: Data from XM - Calculations and elaboration: Author.

▶ Table Diff-in-Diff

▶ Incumbents and New comp.

Results

Figure: Dynamic effects and forward contracts



Source: Data from XM - Calculations and elaboration: Author.

Conclusions

- **No permanent increase or decrease** in the bidding price in firms switching to private management.
- Results are coherent with the **behavioral differences** of mixed oligopoly models. Greater impact in changes that increase market concentration.
- **No Systematic differences** in the impact of switching to private management depending on the **contract position**.
- This results are **robust** to changes in econometric specifications.

Thank You

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Empirical Strategy

Data and Implementation — Marginal Costs estimation

- Accounting approach. I computed the marginal costs of thermal plants taking account of the heat rate, fuel costs and fuel transportation costs according to the following formula:

$$\underbrace{\text{Exchange } R_t}_{\frac{\text{COP\$}}{\text{US\$}}} \times \left[\underbrace{\text{Heat } R_i}_{\frac{\text{MBTU}}{\text{KWh}}} \times \underbrace{(\text{Transp. fuel cost}_i + \text{Fuel cost}_t)}_{\frac{\text{US\$}}{\text{MBTU}}} \right] = \underbrace{\text{Marginal Cost}_{it}}_{\frac{\text{COP\$}}{\text{kWh}}}$$

Empirical Strategy

Criteria for considering the contracting position of a firm as high or low

$$F_{jt} = \sum_{h=1}^{24} F_{jth}$$

$$A_{jt} = \sum_{h=1}^{24} \sum_{i=1}^{N_j} A_{ijth}$$

where F_{jth} forward contracts. A_{ijth} commercial availability. N_j number of units of firm j . Index of contracting IC_{jt} :

$$IC_{jt} = \frac{F_{jt}}{A_{jt}}$$

I consider the contracting position of a firm as high (low) when IC_{jt} of firm j is greater (less) than the average IC_{jt} of private firms prior to the first period of treatment (0.26).

Data and Implementation

Table: Variables in the econometric model

Variable	Units	Obs	Mean	Std. Dev.	Min	Max
Bid Price (b)	Pesos/KWh	348332	403.32	451.98	37.06	22552.48
Logarithm Bid Price ($\ln(b)$)	Ln(Pesos/KWh)	348332	5.51	1.01	3.61	10.02
Marginal Costs (C)	Pesos/KWh	348332	66.17	67.34	0.00	558.64
Daily Commercial Availability (A)	GWh	348334	29.35	24.29	0.00	75.22
Daily Forward Contracts (F)	GWh	348334	14.70	13.31	0.00	52.10
Index of contracting (IC)	Percentage	343456	0.66	1.37	0.00	39.98
Indicator of under contracting (L)	Dummy	348334	0.21	0.41	0.00	1.00
Indicator of over contracting (H)	Dummy	348334	0.79	0.41	0.00	1.00

Source: XM - Colombian Market Operator

Data and Implementation

Table: Variables in the econometric model

Control Group						
Variable	Units	Obs	Mean	Std. Dev.	Min	Max
Bid Price	Pesos/KWh	277289	401.53	449.75	37.06	22552.48
Logarithm Bid Price	Ln(Pesos/KWh)	277289	5.51	1.01	3.61	10.02
Marginal Costs	Pesos/KWh	277289	69.32	68.46	0.00	558.64
Daily Commercial Availability	GWh	277289	29.49	25.80	0.00	75.22
Daily Forward Contracts	GWh	277289	14.90	13.97	0.00	52.10
Index of contracting	Percentage	272848	0.72	1.53	0.00	39.98
Indicator of under contracting	Dummy	277289	0.21	0.41	0.00	1.00
Indicator of over contracting	Dummy	277289	0.79	0.41	0.00	1.00
Treated Group						
Variable	Units	Obs	Mean	Std. Dev.	Min	Max
Bid Price	Pesos/KWh	71043	410.31	460.51	40.57	12387.83
Logarithm Bid Price	Ln(Pesos/KWh)	71043	5.53	1.01	3.70	9.42
Marginal Costs	Pesos/KWh	71043	53.90	61.23	0.00	528.70
Daily Commercial Availability	GWh	71043	28.78	17.17	0.00	69.70
Daily Forward Contracts	GWh	71043	13.92	10.31	0.00	35.91
Index of contracting	Percentage	70608	0.45	0.29	0.00	18.57
Indicator of under contracting	Dummy	71043	0.20	0.40	0.00	1.00
Indicator of over contracting	Dummy	71043	0.80	0.40	0.00	1.00

Source: XM - Colombian Market Operator

Results

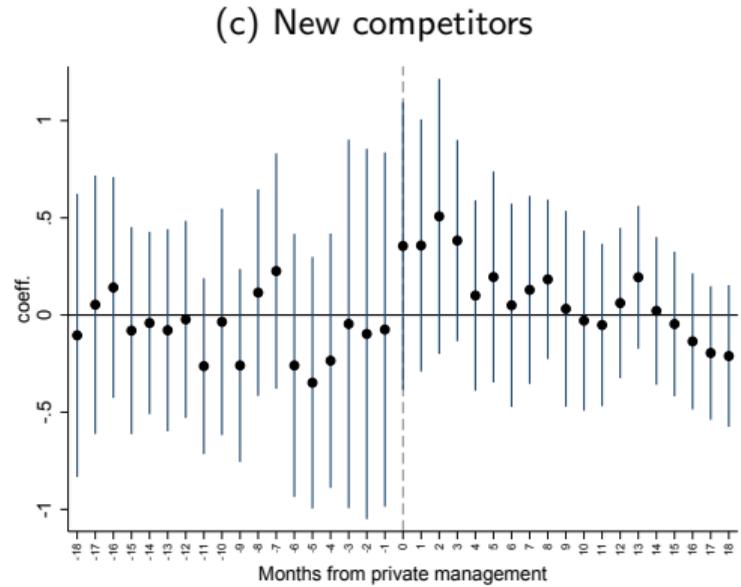
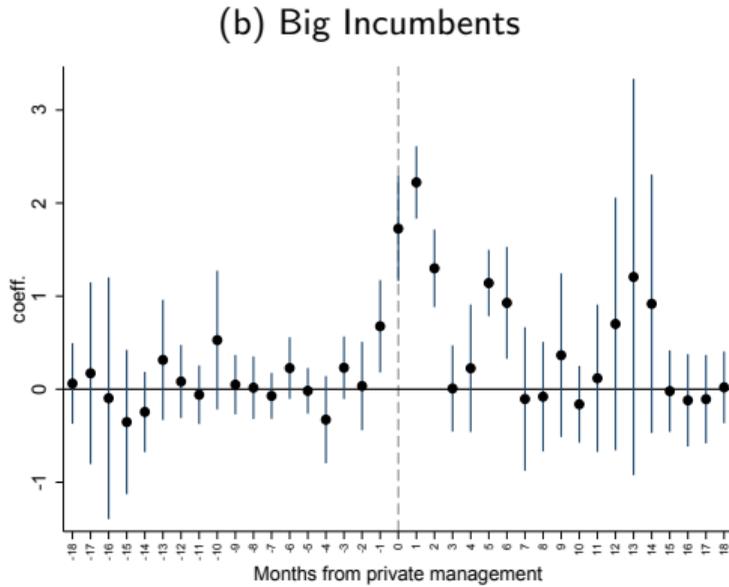
Table: Impact of private management - Bid price and Logarithm

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Bid	Bid	Bid	Bid	Ln (Bid)	Ln (Bid)	Ln (Bid)	Ln (Bid)
Change to Private	105.853 (85.255)				0.224 (0.143)			
Ch. to P. Small to big		316.301*** (75.774)		315.679*** (41.648)		0.618*** (0.143)		0.584*** (0.098)
Ch. to P. New comp.			-47.517 (51.941)	-19.042 (59.347)			-0.017 (0.114)	0.010 (0.119)
Marginal Costs	-1.053* (0.576)	-0.545 (1.053)	-1.094* (0.620)	-0.944 (0.569)	-0.003** (0.001)	-0.002 (0.003)	-0.003* (0.002)	-0.003* (0.001)
Unit FE	Y	Y	Y	Y	Y	Y	Y	Y
Date FE	Y	Y	Y	Y	Y	Y	Y	Y
N	142253	87737	125726	142253	142253	87737	125726	142253
R-sq	0.383	0.363	0.446	0.394	0.577	0.544	0.606	0.581

Note: Statistical significance at standard levels (***) at 1%, ** at 5% and * at 10%). SE in parentheses clustered by generation unit.

Results

Figure: Dynamic effects of private management



Source: Data from XM - Calculations and elaboration: Author.

Results

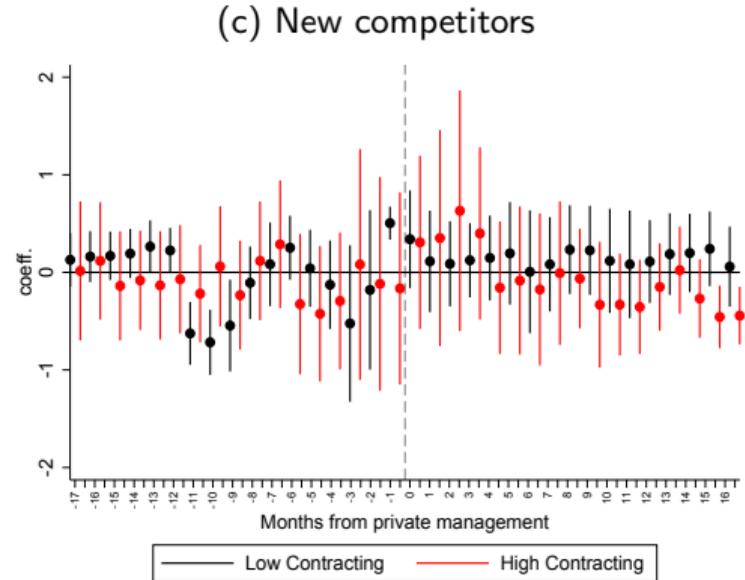
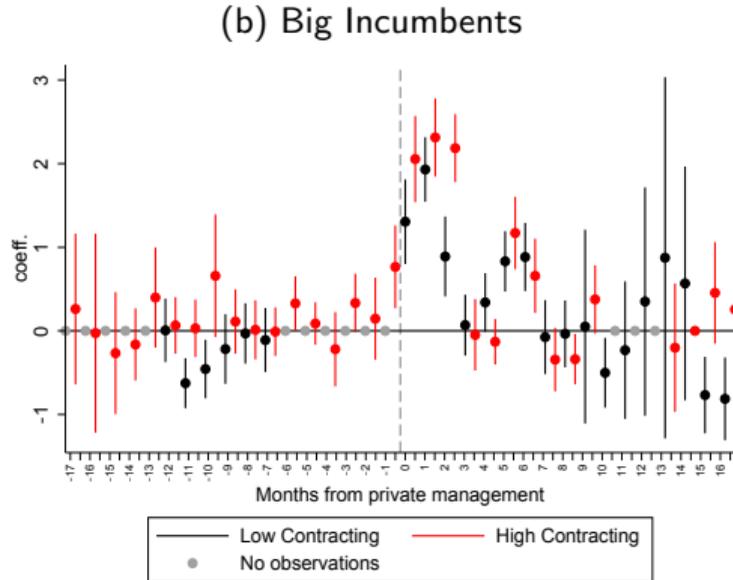
Table: Impact of private management and forward contracts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Bid	Bid	Bid	Bid	Ln (Bid)	Ln (Bid)	Ln (Bid)	Ln (Bid)
Ch. to P./C. Low	89.818 (115.441)				0.131 (0.176)			
Ch. to P./C. High	64.694 (83.542)				0.107 (0.134)			
Ch. to P./C. Low Small to big		321.068* (150.882)		355.534*** (123.976)		0.473** (0.168)		0.534*** (0.124)
Ch. to P./C. High Small to big		236.543*** (57.691)		221.770*** (37.338)		0.480*** (0.121)		0.424*** (0.086)
Ch. to P./C. Low New comp.			-80.507 (75.278)	-46.011 (74.693)			-0.113 (0.153)	-0.079 (0.149)
Ch. to P./C. High New comp.			-55.119 (79.084)	-25.299 (82.392)			-0.105 (0.103)	-0.075 (0.104)
Contracts Low	87.848** (40.300)	112.546** (42.912)	78.339 (51.931)	65.149* (35.225)	0.300*** (0.072)	0.396*** (0.096)	0.286** (0.111)	0.271*** (0.082)
Marginal Costs	-1.375*** (0.489)	-1.107 (0.889)	-1.333** (0.521)	-1.267** (0.477)	-0.004*** (0.001)	-0.003 (0.002)	-0.004** (0.001)	-0.004** (0.001)
Unit FE	Y	Y	Y	Y	Y	Y	Y	Y
Date FE	Y	Y	Y	Y	Y	Y	Y	Y
N	140647	86220	124466	140647	140647	86220	124466	140647
R-sq	0.382	0.357	0.443	0.393	0.578	0.543	0.605	0.583

Note: Statistical significance at standard levels (*** at 1%, ** at 5% and * at 10%). SE in parentheses clustered by generation unit.

Results

Figure: Dynamic effects and forward contracts



Source: Data from XM - Calculations and elaboration: Author.

Results

Robustness Checks

- Levels or Logarithms
- Estimation Methods
 - Prais-Winsten Regression
 - Random Effects generalized least squares. Robust SE clustering by unit.
- Matching criteria
 - No Matching
 - Probit and Logit models for estimating the propensity score.
 - Propensity score with pooled data panel.
 - Nearest neighbor algorithm
- Serial correlation checks
 - Placebo tests - potential problem of over-rejection of the null hypothesis
 - Bootstrapping clustering by unit for SE calculation — Conservative (Athey and Imbens, 2018).
- High time dimension of data → serial correlation biases may well arise.