Analysis of the Competition and Market Power in the Colombian Wholesale Electricity Market using an Agent-Based Model

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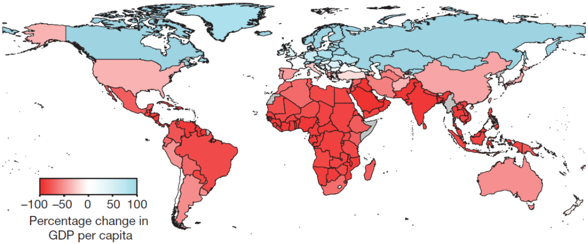

Figure: Country-level estimates in 2100 under BAU. Source: IMF and Nature Journal.

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- In 2017 USD 750 billion invested in the power sector and USD 715 billion in the oil&gas industry. Source: IEA.
- However, the world is only investing 30% to reach a climate stabilization path.

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3. Colombia's production of electricity is clean (70%), but not the overall consumption (70%).

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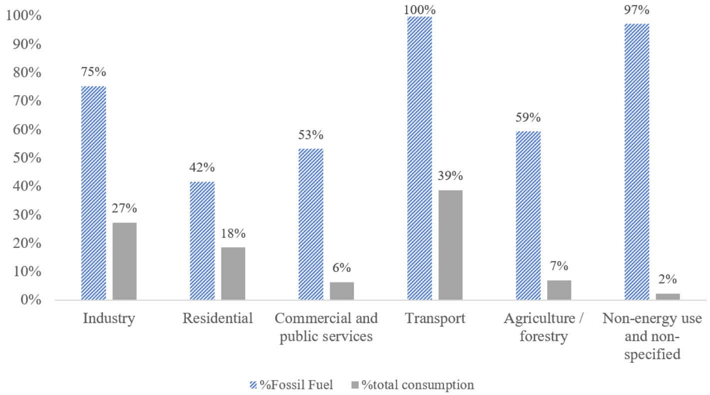

Figure: Fossil fuel participation and share of total consumption per sector

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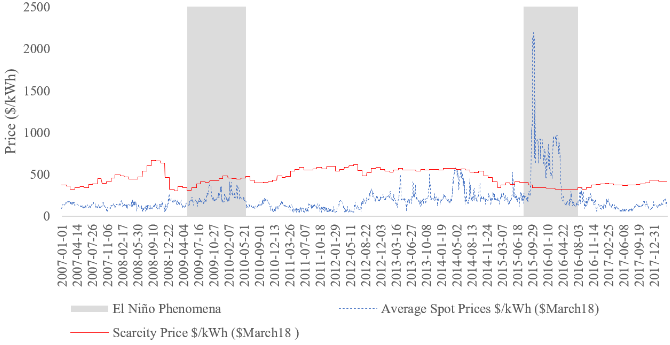

Figure: Average the hourly spot prices and monthly scarcity prices in Colombia ($March18 prices)

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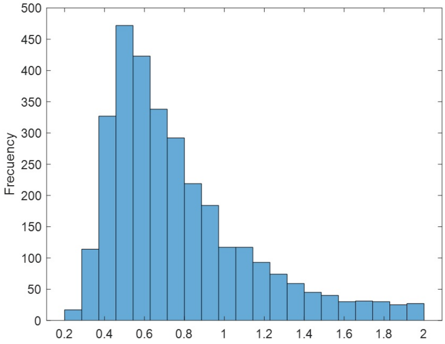

Figure: Hedge Index for Chivor – not a vertical-integrated utility

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Empirical model:

$$P_{hd} = \alpha_{hd} + \beta_1 MPIx_{hd} + \beta_2 D_{hd} + \beta_3 SPrice_{hd} + \beta_4 FrwdCt_{hd} + \theta_{\mathbf{h}} \mathbf{X_{hd}} + \varepsilon_{hd},$$

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Hypotheses: Impact of market power and mitigation strategies.

Note: Endogeneity may be a problem, which was addressed using IV. Durbin score χ^2 *and Wu-Hausman did not have significance.*

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Three different measures of market power:

$$MPIx_{hd} = \left\{ \begin{array}{c} HHI_{hd} = \sum s_i^2, \rightarrow \{1500 - 2500\} \\ \\ RSI_{hd} = 1 - \frac{\sum RealGen - \sum RealGen_{\Omega big4}}{\sum RealGen}, \rightarrow \{0 - 1\} \\ \\ IL_{hd} = \frac{P_{spot} - Cost}{P_{spot}} = \frac{1}{|\varepsilon_{DR,t}|}, \rightarrow \{0 - 1\} \end{array} \right\}$$

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Table 2. Econometric results

	HHI	HHI at Nino	RSI	RSI at Nino	IL	IL at Nino
VARIABLES	Spot Price	Spot Price	Spot Price	Spot Price	Spot Price	Spot Price
Fossil Fuel generation	8.80e-06***	6.55e-06***	8.27e-06***	6.26e-06***	3.08e-06***	4.82e-07***
	(2.48e-07)	(2.53e-07)	(2.22e-07)	(2.52e-07)	(1.45e-07)	(9.93e-08)
Hydro generation	1.45e-06***	1.94e-06***	1.30e-06***	1.73e-06***	-2.74e-07**	-2.85e-07***
	(1.87e-07)	(2.22e-07)	(1.87e-07)	(2.18e-07)	(1.07e-07)	(7.48e-08)
Forward Contracts	-1.20e-06***	-2.28e-06***	-1.04e-06***	-2.12e-06***	1.58e-07	-2.03e-08
	(1.88e-07)	(2.21e-07)	(1.91e-07)	(2.18e-07)	(1.04e-07)	(8.05e-08)
Scarcity Price		-0.188***		-0.191***		-0.0140
		(0.0269)		(0.0267)		(0.00907)
Constant	-208.5***	23.79	-118.4***	33.34	45.60***	32.75***
	(31.13)	(24.79)	(26.88)	(24.55)	(10.36)	(7.559)
Observations	4,108	4,108	4,108	4,108	1,636	1,636
R-squared	0.530	0.583	0.528	0.587	0.554	0.823
FE	Y	Y	Y	Y	Y	Y

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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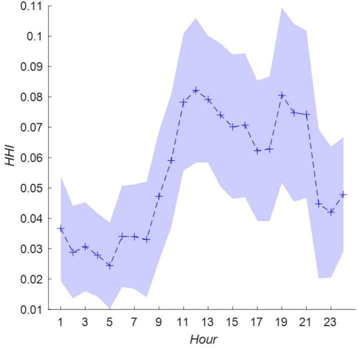

Figure: Hourly econometric estimation when Market Power = HHI. Confidence intervals at 95%

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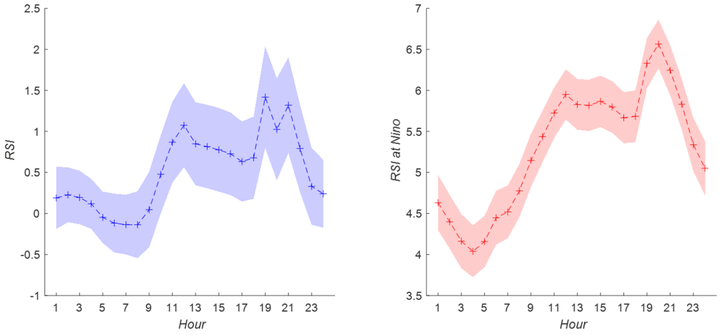

Figure: Hourly econometric estimation when Market Power = RSI. Confidence intervals at 95%

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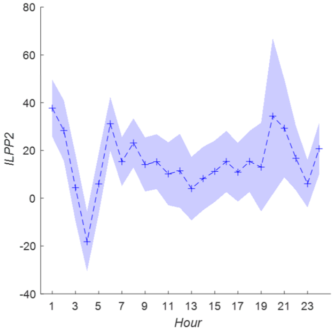

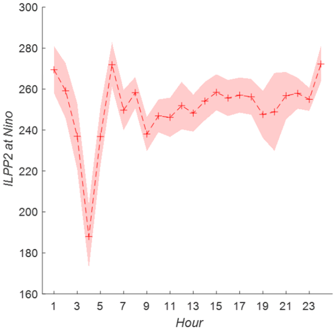

Figure: Hourly econometric estimation when Market Power = Lerner's Inx. Confidence intervals at 95%

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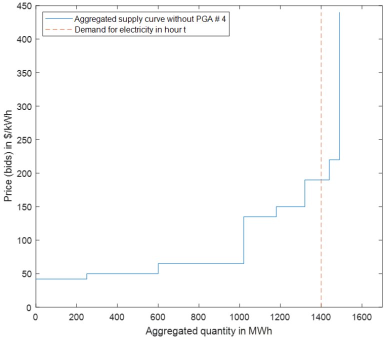

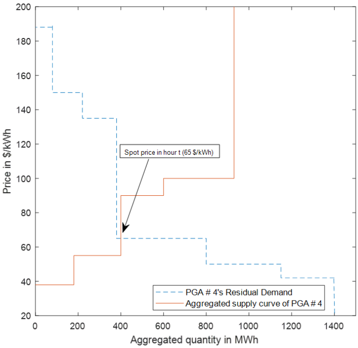

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$$\varphi_i + \underset{p_k}{Max}\left\{\pi_{id}\left(p_k\right)\right\} = \sum_{t=1,k\Omega i}^{24}\left[RD_{it}\left(p_k; p_{-k}^*\right) - FrwdCt_{kt}\right] \cdot P_{spot,t}$$

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$$p_k \geq MarginalCost_{k,t}$$

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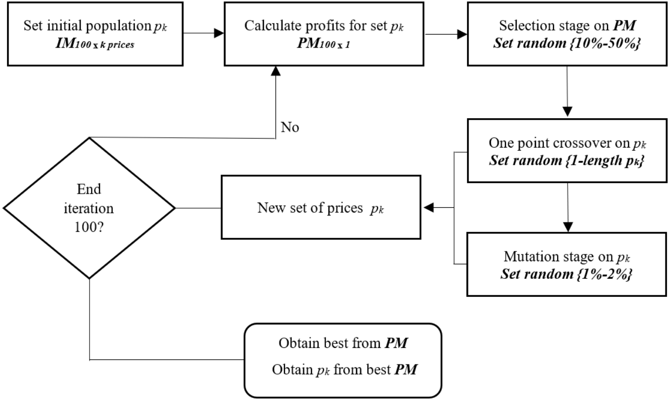
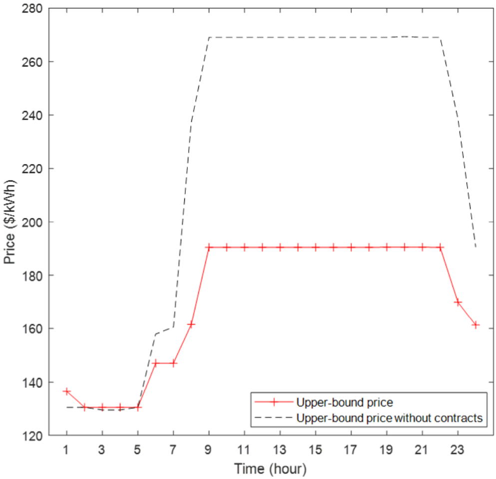


Figure: Algorithm structure

Results

Test for the four biggest PGA in colombia. They occupy 70% of the total generation capacity.



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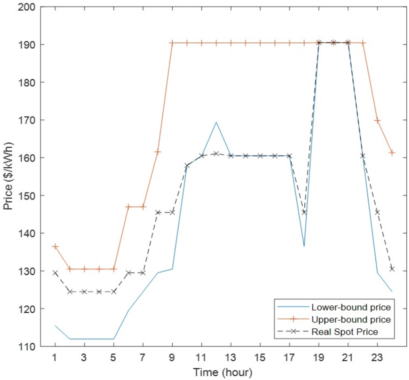

Figure: Results - PGA 'Emgesa'

Mark-up construction

- Lower-bound

$$\mathcal{L} = max\left\{p_{k\Omega i}\right\} \cdot \left(\sum_{t=1,k\Omega i}^{24} FrwdCt_{kt} - RealGen_{kt}\right)$$

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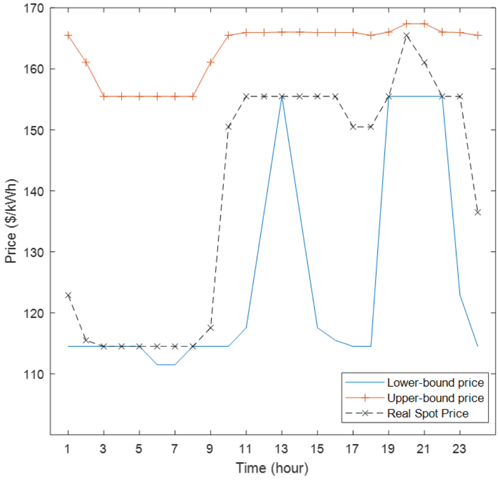

Figure: Results - PGA 'EPM'

Thanks!

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