Electricity Generation Failures and the Capacity Remuneration Mechanism in Turkey

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What we do?

We use the facility outage and maintenance (in particular, power plant failure) notifications provided by the Transparency Platform @Energy Exchange Istanbul [EXIST - EPIAS(TR)] and ask

i. whether we can detect strategic capacity withholding (a market manipulation practice) through failures;
ii. whether the capacity remuneration mechanism affect these failures

Motivation-I

- Electricity markets hardly provide sufficient resources for new generation capacity investments
- Principal reason: electricity markets are highly regulated
  - Electricity plays a significant part in our everyday lives.
  - An affordable electricity price is paramount

Motivation-II

- Price-suppressing actions, such as price caps, ensure that consumers pay a fairer price
- The problem? **"Missing money"**
- Electricity is a necessity
  - Due to the political, social, and economic consequences that power shortages would lead to
    - inadequate investments not tolerable
- Capacity remuneration mechanisms (*e.g.*, capacity payments, capacity auctions, capacity obligations, and strategic reserves) have been introduced to ensure adequate generation capacity.

Motivation-III

- On the other hand, deregulation of electricity markets worldwide led to another concern
- Operators can strategically withhold some generating capacity to increase electricity prices
- This strategy relies on the convex supply schedule in the market (i.e., the merit order) and inelastic short-run demand.

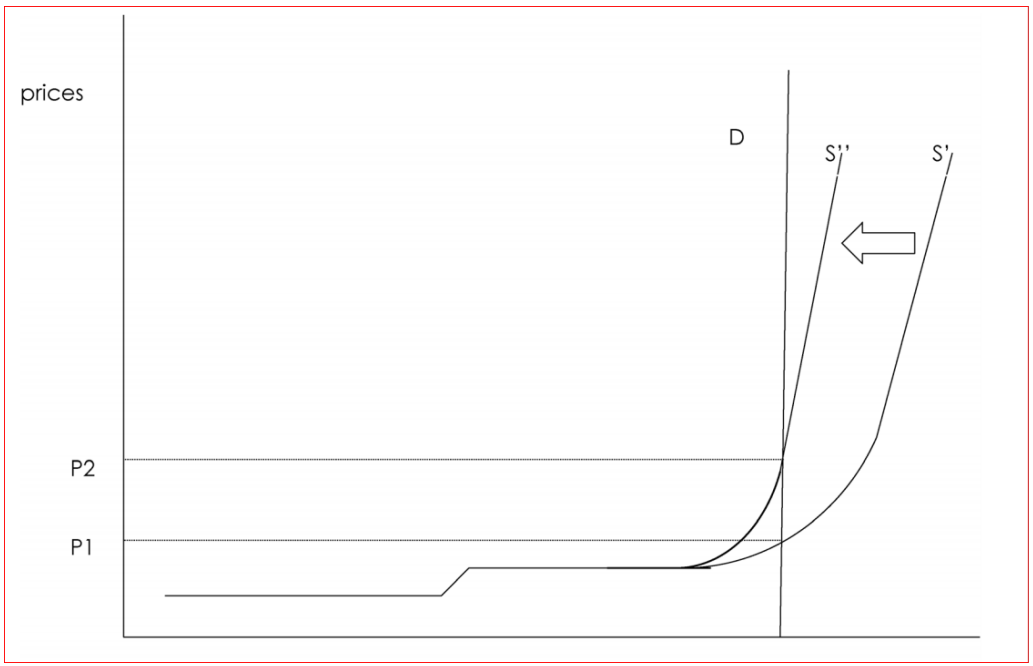

Figure: Wholesale electricity market & capacity withholding

Motivation-IV / Turkish Capacity Mechanism

- Jan 2018: The Regulation on the Electricity Market Capacity Mechanism entered into force
- The Regulation aims to establish a sufficient installed power capacity to assure long-run security of supply
- Coal-fired and natural gas-fired power, as well as hydropower plants, can benefit from the mechanism

Motivation-IV / Turkish Capacity Mechanism

- Payments made to the eligible operators calculated using a formula based on parameters specified by the Energy Market Regulatory Authority (EMRA)
  - Thus, payments are not decided in the market
  - Rather, they are decided by a central authority

Motivation-V / Turkish Capacity Mechanism

- Capacity markets have demonstrated that they can efficiently and effectively meet their objectives and performance expectations as long as they are carefully designed and administered.
- With its parameters determined by EMRA, it is not clear that the Turkish mechanism can achieve its aim of a sufficient power capacity to ensure long-term supply security.

Motivation-VI / Regulation + regulatory mechanisms

Two polar cases: i) Price caps & ii) Cost-of-service approach

- Due to various imperfections in its energy-only market design, price caps worldwide
  - **Turkey also opted for price caps**
- Cost-of-service approach:
  - Firm is compensated for its total cost of production.

Motivation-VII / A glance at the data

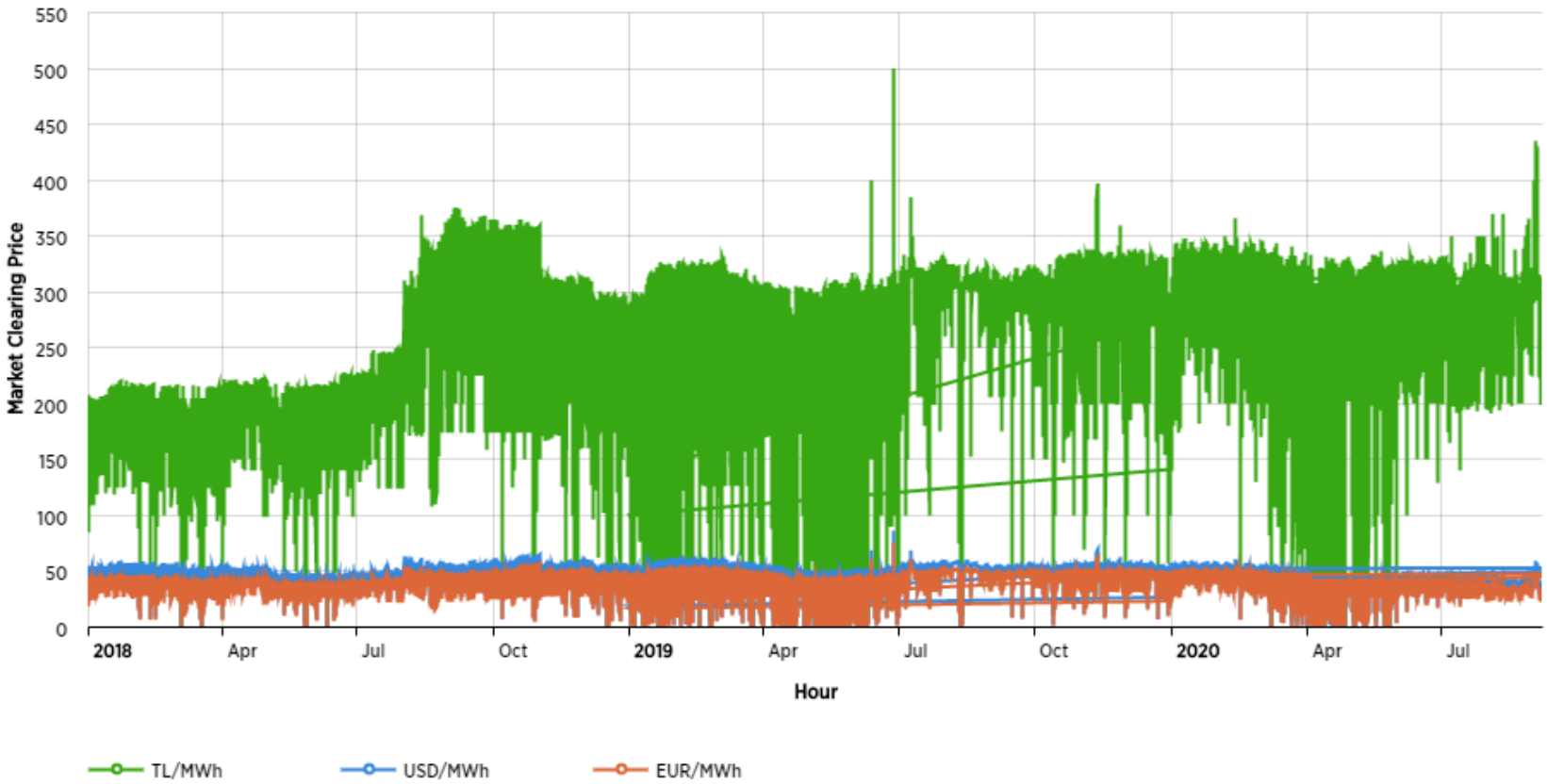

Figure: Market clearing price (Source: EXIST)

- The price cap of 2000 TL/MWh never reached and has not been effective

Motivation-VIII / A glance at the data

- TR Capacity Mechanism shows significant similarities to the Cost-of-Service approach
  - The mechanism can lead to moral hazard problems (*E.g.*, managerial slackness and X-inefficiency) and costs associated with it (Laffont and Tirole, 1993, and Joskow, 2014)

Once again,

We ask

- whether there is strategic capacity holding through failures?;
- whether capacity payments have any influence in this regard?

Literature

- The paper differentiates itself from others in the related literature in several aspects:
  1. Hourly data
  2. Minutes of failure (rather than number of failures)
  3. Hours of affected and therefore lost 'cumulative generation capacity' in the market
  4. TR capacity remuneration mechanism

Data

- Hourly data - starts from September 01, 2018
- The data on capacity payments retrieved from Turkish Electricity Transmission Company's [TETC/TEIAS (TR)]
- The rest of the data obtained from EXIST's Transparency Platform.
    - EXIST started its wholesale activities in the electricity (as well as natural gas) market as of September 01, 2018.

Data

Main variables:

1. **F**: The duration of failures in minutes,
   - Failures that were reported after the incidents took place.
   - We excluded failures that had a duration of more than one day (*e.g.*, maintenance activities).
2. **F_cap**: Affected capacity from the failure $\times$ **F**: How much capacity is withhold/unavailable during the duration of the failure (MWh)
3. **Pr**: Price: market clearing electricity price (TL/MWh)
4. **Wnd**: share of wind energy in the total energy supply
5. **Ld**: load forecast plan (MWh) (the total hourly demand for the next physical day)
6. **Dm**: dummy variable: equals 1 if the utility receives capacity payments in the corresponding data point

Data - Summary statistics

	Mean	SD	Min	Max	Obs
F	175.2539	237.8497	14	1399	34,350
F_cap	278.1637	1235.214	0	27870	34,350
lPr	5.4443	.8629803	-4.60517	6.214608	34,350
Wnd	.0737497	.042435	.0012621	.2191754	34,350
lLd	10.41841	.1373918	9.798127	10.71664	34,350
Dm	.1491121	.3562041	0	1	34,350

Figure: Summary statistics. lPr and lLd stand for the logarithms of Pr and Ld, respectively.

Empirical strategy

- As prices can directly affect how generators are operated an OLS regression would give biased estimates.
- Thus, to estimate a causal effect of prices on generation failures, we
  - use a linear two-step model,
  - instrument for prices using natural gas price.
- Natural gas price was chosen as an instrument because Turkey is a major importer of natural gas and in light of their significant shares in the energy mix, natural gas power plants are the price-setting units in the market

Empirical strategy

- Due to the simultaneity of failures and price, we apply instrumental variable techniques (IV) and instrument for day-ahead prices through the following equation:

$$lPr_t = \theta_0 + \theta_1 lPr_{ng\,t} + \theta_2 Wnd_t + \theta_3 lLd_t + \theta_4 Dm_t + \varepsilon_t \quad (1)$$

$Pr_{ng\,t}$: natural gas price

- In the second stage, we apply an IV GMM estimation approach using the following structural equation:

$$F_t = \beta_0 + \beta_1 l\hat{P}r_t + \beta_2 Wnd_t + \beta_3 lLd_t + \beta_4 Dm_t + \epsilon_t \quad (2)$$

Regression results (1)

Dependent variable: F	(2SLS)	(LIML)	(GMM)
lPr	58.61254** (26.81281)	58.61254** (26.81281)	58.61257** (27.20796)
Wnd	150.8176** (62.16724)	150.8176** (62.16724)	150.8177** (63.91069)
lLd	-281.9723*** (73.45716)	-281.9723*** (73.45716)	-281.9724*** (74.74996)
Dm	151.7554*** (4.610466)	151.7554*** (4.610466)	151.7554*** (5.69784)
C	2760.1*** (617.2341)	2760.1*** (617.2341)	2760.101*** (628.5597)
N	34,350	34,350	34,350

Note: Standard errors are in parenthesis for 2SLS and LIML, and robust standard errors are in parenthesis for GMM regression analysis. ***,**,* indicate significance at the 1, 5 and 10 percent level.

Figure: Single-equation instrumental-variables regression

Regression results (2)

Dependent variable: F_cap	(2SLS)	(LIML)	(GMM)
lPr	507.2714***	507.2714***	507.2707***
	(142.762)	(142.762)	(146.2772)
Wnd	1055.163***	1055.163***	1055.161***
	(331.003)	(331.003)	(344.59)
lLd	-1382.537***	-1382.537***	-1382.535***
	(391.115)	(391.115)	(401.6237)
Dm	864.6599***	864.6599***	864.66***
	(24.54795)	(24.54795)	(37.99358)
C	11713.51***	11713.51***	11713.49***
	(3286.399)	(3286.399)	(3378.011)
N	34,350	34,350	34,350

Note: Standard errors are in parenthesis for 2SLS and LIML, and robust standard errors are in parenthesis for GMM regression analysis. ***,**,* indicate significance at the 1, 5 and 10 percent level.

Figure: Single-equation instrumental-variables regression

Testing for the "Relevance and Strength of the Instruments" + "Endogeneity"

First-stage regression summary statistics

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	F(1,34345)	Prob > F
lPr	**0.2041**	**0.2040**	**0.0037**	**128.223**	**0.0000**

Minimum eigenvalue statistic = **128.223**

Critical Values
Ho: Instruments are weak

\# of endogenous regressors: **1**
\# of excluded instruments: **1**

	5%	10%	20%	30%
2SLS relative bias		(not available)		

	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	**16.38**	**8.96**	**6.66**	**5.53**
LIML Size of nominal 5% Wald test	**16.38**	**8.96**	**6.66**	**5.53**

Conclusion & Discussions

- Our results suggest strategic withholding through failures ("market manupulation") in the electricity market
- The current setup of the capacity mechanism adds to the duration of the failures in the market

i. Strategic capacity withholding suggests that a verification mechanism may be required to verify the failures
ii. The positive effect of the capacity payments on the number of failures suggest that the mechanism may need to be redesigned/updated

Thank you!

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