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Climate Change and Energy Production: The Effect of Drought on Electricity Prices

Gregory L. Torell and Reid Stevens

AgriLife Research and Deptartment of Agricultural Economics, Texas A&M University

Objectives

This research focuses on two main objectives:

- Determining the effect that drought has on wholesale electricity prices
- Determining the mechanisms of price changes, namely whether electricity price changes are the consequence of:
  1. changes in production costs
  2. changes in production capacity
  3. a combination of both

Introduction

Electricity sales in Texas spiked during a prolonged heat wave and subsequent severe drought in the summer of 2011, and electricity prices increased across the state [1, 2]. The simultaneous supply and demand shocks led to extremely high prices, increased electricity demands, and increased water demands [3].

This paper presents an empirical test of the effect of drought on electricity grid outcomes in the Electricity Reliability Council of Texas (ERCOT) area. We test whether drought conditions have a significant effect on electricity price and quantity bids of electricity plants for the years 2010–2016 using hourly ERCOT data.

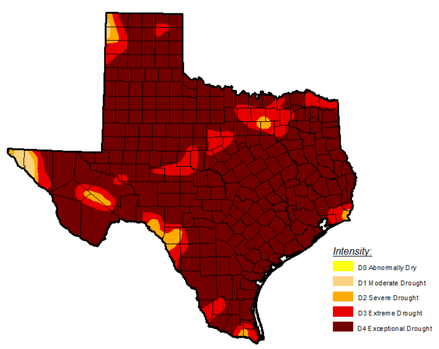

Figure 1: US Drought Monitor Conditions for Texas, September 27, 2011

Data

The following data were used to complete the research:

- ERCOT price and quantity bid data
- EIA Form 860 data
- US Drought Monitor data

These data inform:

1. EIA data were used to inform cooling types and plant type
2. US Drought monitor data was used to inform drought conditions

Important Result

Drought causes **higher electricity price bids** and **lower electricity quantity bids**. The effect varies by plant cooling type. Dry cooling avoids both of these effects.

Mathematical Section

Price Regressions

We use the quantity-weighted average hourly offer prices. These are the price weighted by the share of total electricity offered by producer. Changes in prices explained by drought describe shift in stair-step height in a stair-step electricity dispatch curve.

$$\overline{p}_{it} = \alpha_t + \alpha_i + \beta \text{Drought}_{it} + \gamma \text{Drought}_{it} \times \text{Cool}_i + \beta X_{it} + \varepsilon_{it}$$

where,

- α_t, time fixed-effects
- α_i, generator fixed-effects
- X_{it}, exogenous weather effects
- Drought_{it}, weekly measure of extreme drought severity
- $\text{Drought}_{it} \times \text{Cool}_i$, interaction term between plant cooling type and the drought indicator

Mathematical Section, Cont'd

Quantity Regressions

A similar model is run for quantities offered. Quantity is sum of all quantities in the offer curve for each each generator. Changes in quantity describe a shift in stair-step length for an electricity dispatch curve.

$$q_{it} = \alpha_t + \alpha_i + \beta \text{Drought}_{it} + \gamma \text{Drought}_{it} \times \text{Cool}_i + \beta X_{it} + \varepsilon_{it}$$

Quadratic Terms

Quadratic terms in precipitation, minimum and maximum temperature temperature, and a humidity measure (dewpoint temperature) are tested for both price and quantity specifications.

Results

Table 1: Regression Results: Average Weighted Offer Prices

Dependent Variable: Average Weighted Offer Price			
Explanatory Variables	(1)	(2)	(3)
Dr	1.131***	0.998***	1.279
Dr × DC	-1.133	-1.323	-10.27**
Dr × OC (w/ ponds)	-3.599**	-3.615**	-13.46**
Dr × OC (w/o ponds)	4.619*	4.625	-3.585
Dr^2			-0.00296
Dr^2 × DC			0.0931**
Dr^2 × OC (w/ ponds)			0.108*
Dr^2 × OC (w/o ponds)			0.0917**
Weather	NO	YES	YES
Hour-of-Day FE	YES	YES	YES
Day-of-Week FE	YES	YES	YES
Month, Year FE	YES	YES	YES
R-squared	0.150	0.155	0.155
Observations		36,284,885	
Sample		2010-2017	

Results, cont'd

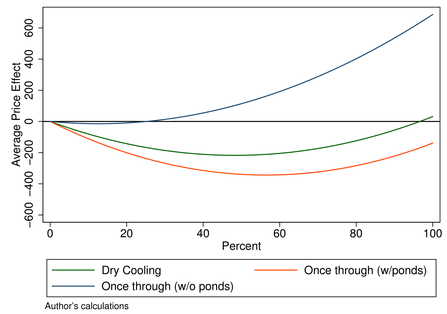

Figure 2: Effect on Average Weighted Price by Percent of County in Drought

References

[1] Energy Information Administration. EIA-923 monthly generation and fuel consumption time series file, 2016 November. Database, January 2017.

[2] Energy Information Administration. EIA-826 monthly electric utility sales and revenue report with state distributions, 2016 November. Database, January 2017.

[3] Bridget R Scanlon, Ian Duncan, and Robert C Reedy. Drought and the water–energy nexus in Texas. *Environmental Research Letters*, 8(4):045033 (14 pp), 2013.

Contact Information

Torell

- Email: gregory.torell@ag.tamu.edu
- Phone: +1 (915) 859 9111

Stevens

- Email: stevens@tamu.edu
- Phone: +1 (979) 847 5805

TEXAS A&M AGRILIFE RESEARCH

TEXAS A&M UNIVERSITY