

Wind Power Intermittency and Volatility in Electricity Markets

IAN B. PAGE, PHD (IBPAGE@UMD.EDU)

KATHERINE G. SCHUTES

GABRIEL B. CASTRO

UNIVERSITY OF MARYLAND

36TH USAEE CONFERENCE

ENERGY MODELLING - INTERMITTENCY

Motivation

Does wind power increase price volatility?

- Cheap power from wind farms displaces power from conventional, fossil fuel-burning generators
- Large amounts of intermittent power have implications for power system reliability
- No consistent application of “volatility” in existing studies

Market Impacts of Intermittent Renewables

Omit price volatility

- Morthorst (2003), de Miera et al. (2008), Gelabert et al. (2011), Woo et al. (2011a), Hirth (2013), Shrimali et al. (2015)

Mention volatility but do not analyze it

- Cutler et al. (2011), Gil et al. (2011), Katzenstein & Apt (2012), Maggio (2012), Forrest & MacGill (2013), Wurzburg et al. (2013), Suomalainen et al. (2014), Brijs et al. (2015), Cludius et al. (2015)

Explicitly model the relationship

- Chang et al. (2009), Jónsson et al. (2010), Woo et al. (2011b), Mulder & Scholtens (2013), Ketterer (2014), Parachiv et al. (2014), Shcherbakova et al. (2014), Ballester & Furió (2015), Clò et al. (2015), Kyritsis et al. (2016), Rintamaki et al. (2017)

What is Price Volatility?

Erratic and unpredictable price changes

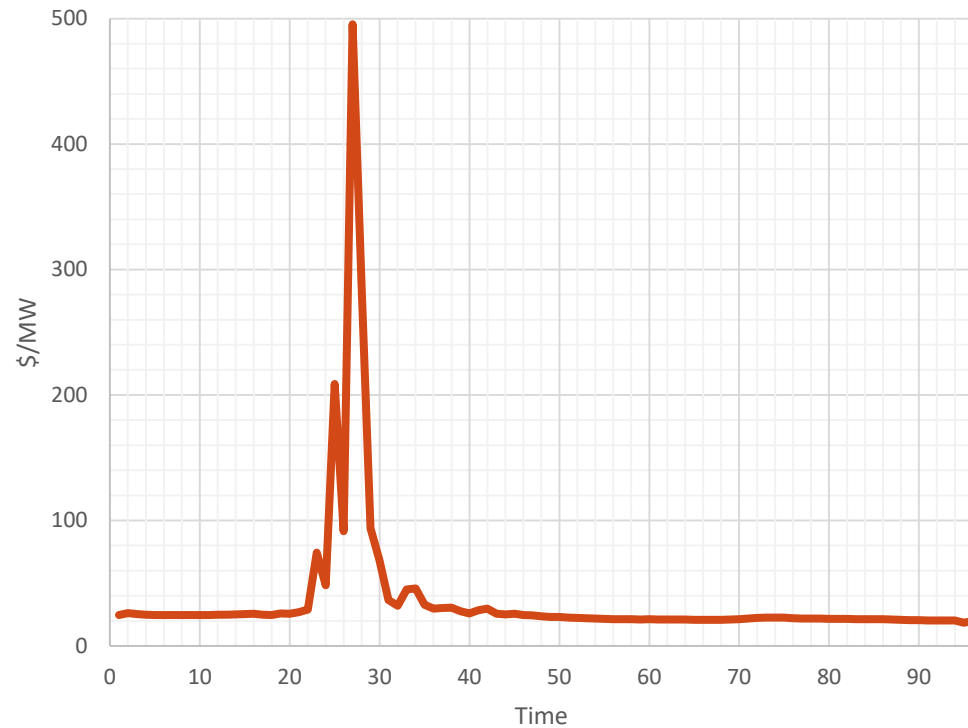
- **Difference in prices** between points in time

Range of prices seen over time

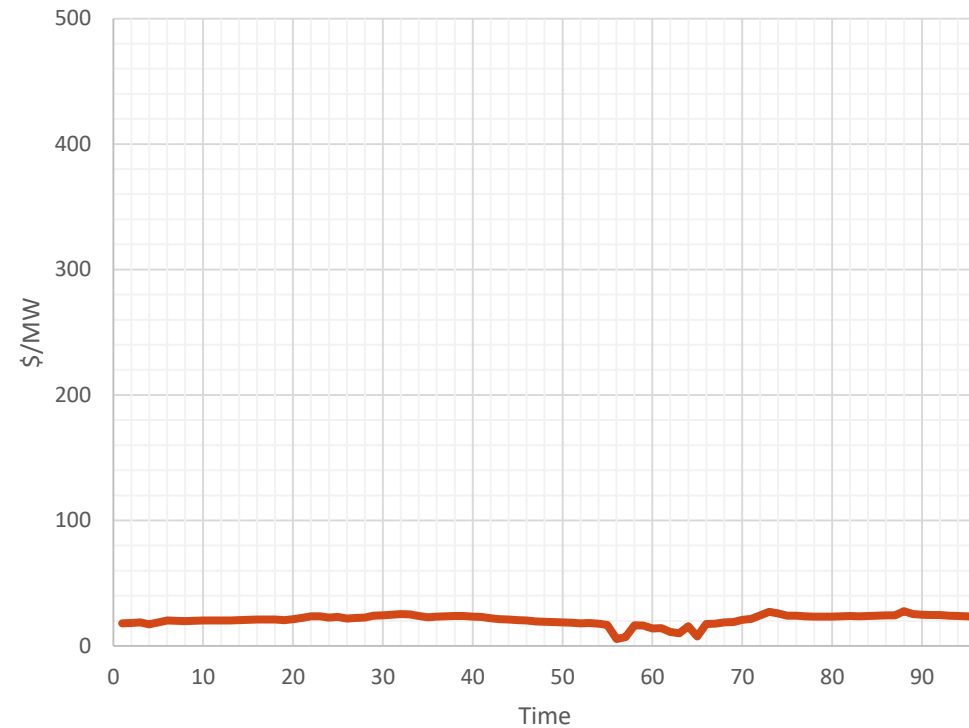
- **Overall variation** of prices over time irrespective of order

Comparing Daily Volatility

WEST TEXAS – 1/16/2015

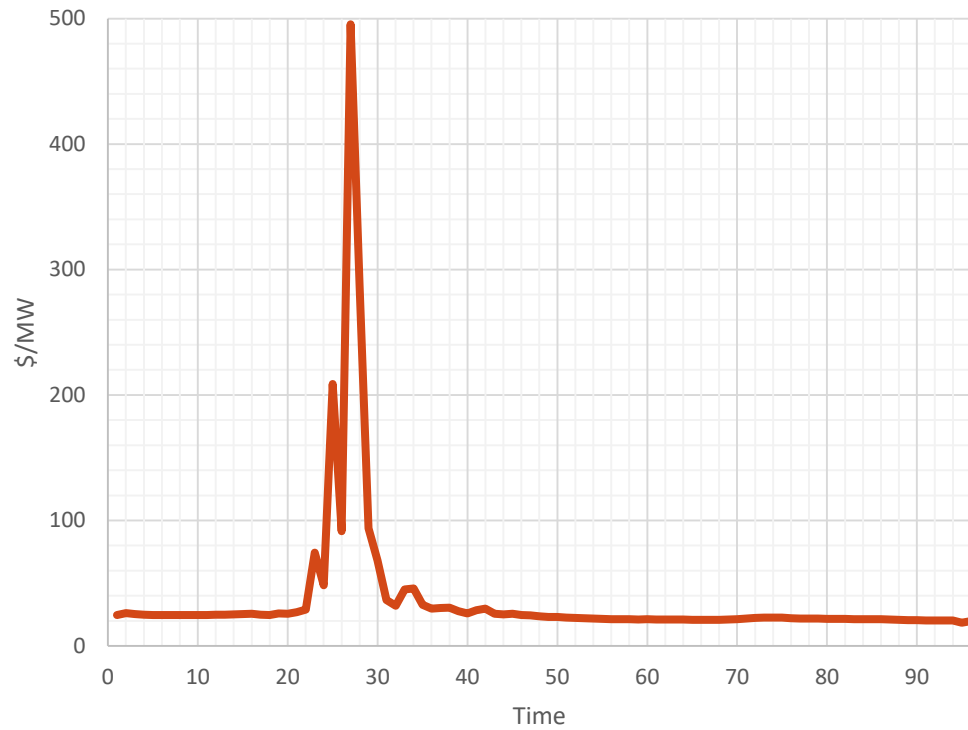


WEST TEXAS – 1/17/2015

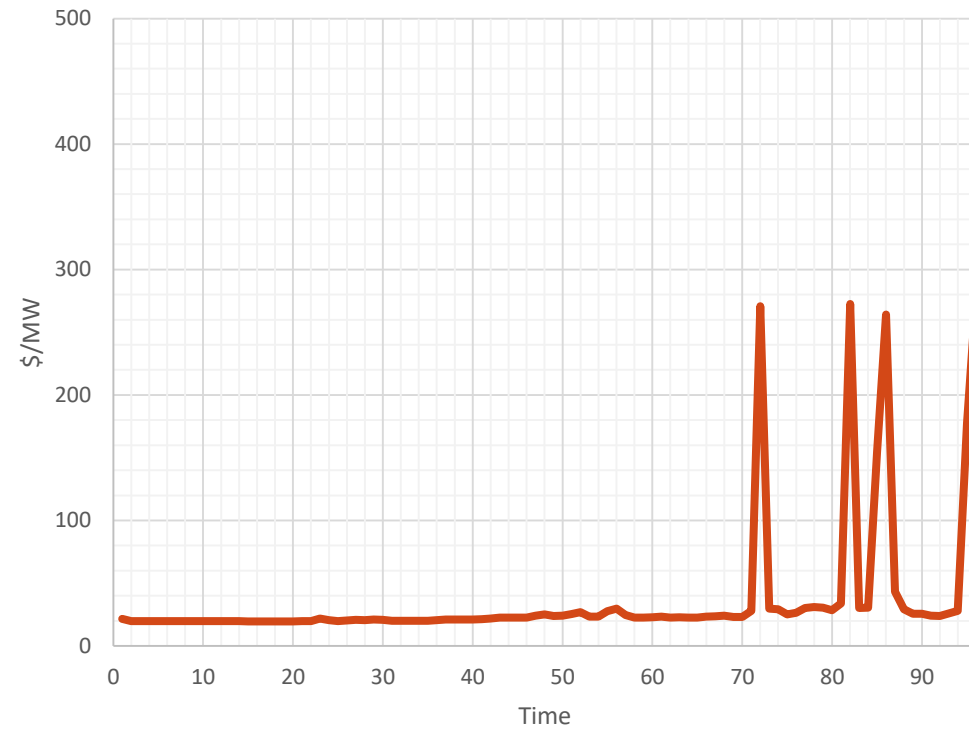


Comparing Daily Volatility

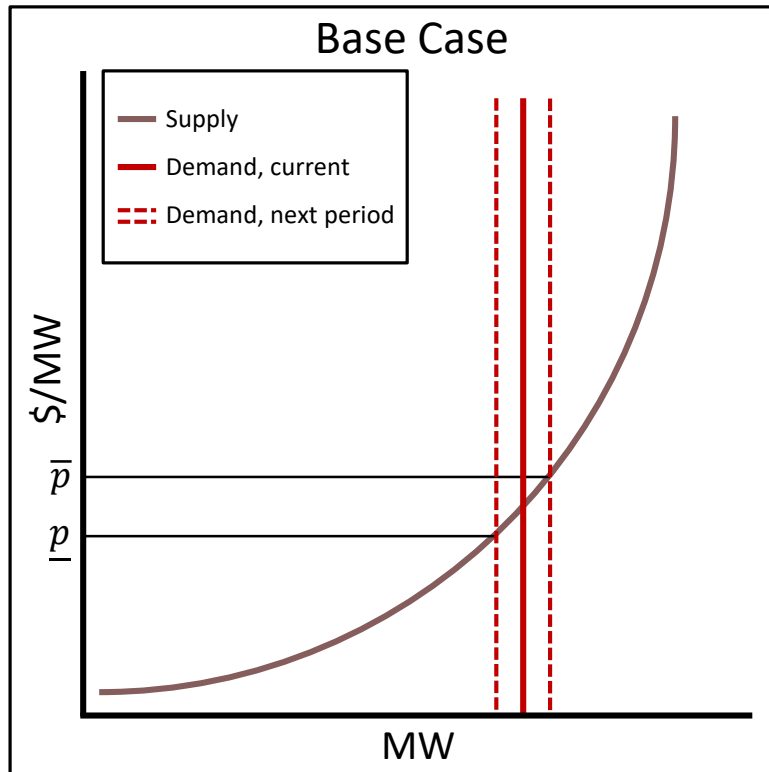
WEST TEXAS – 1/16/2015



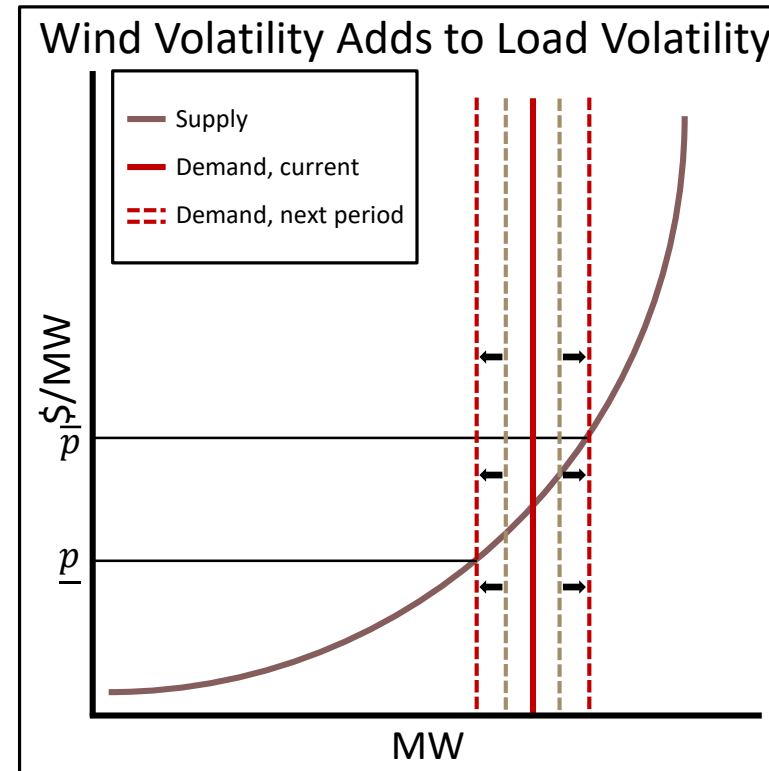
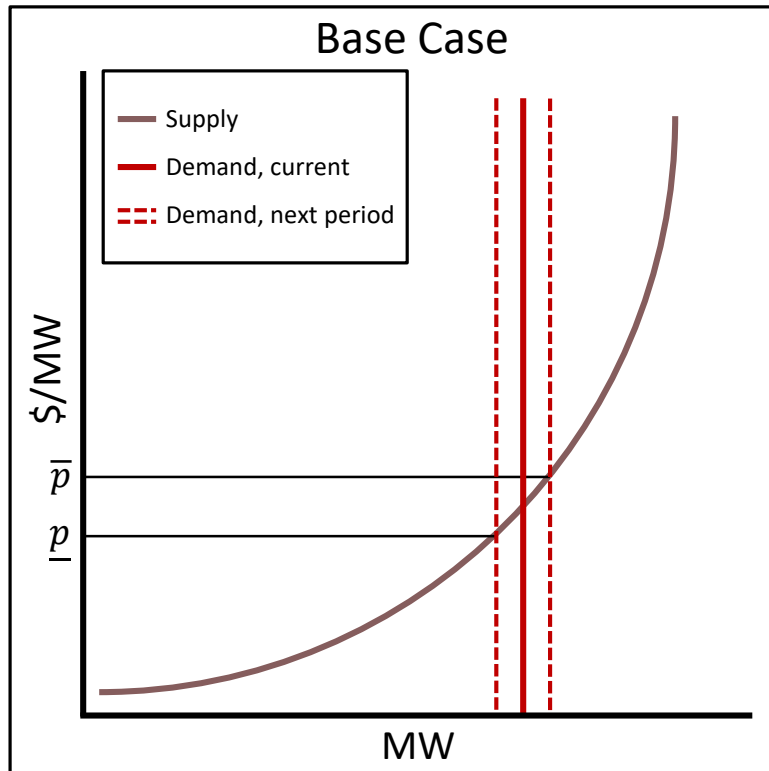
WEST TEXAS – 1/13/2017



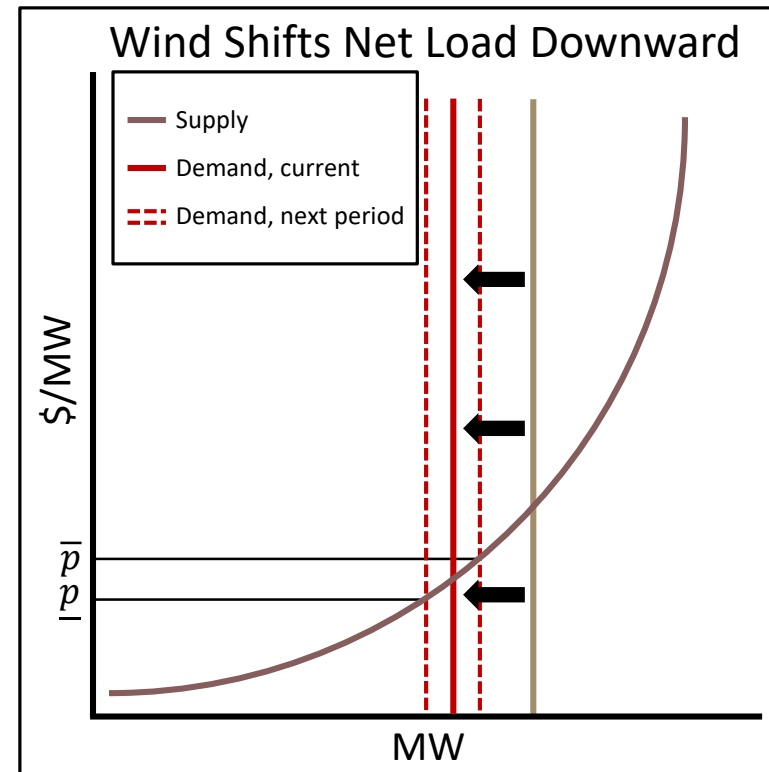
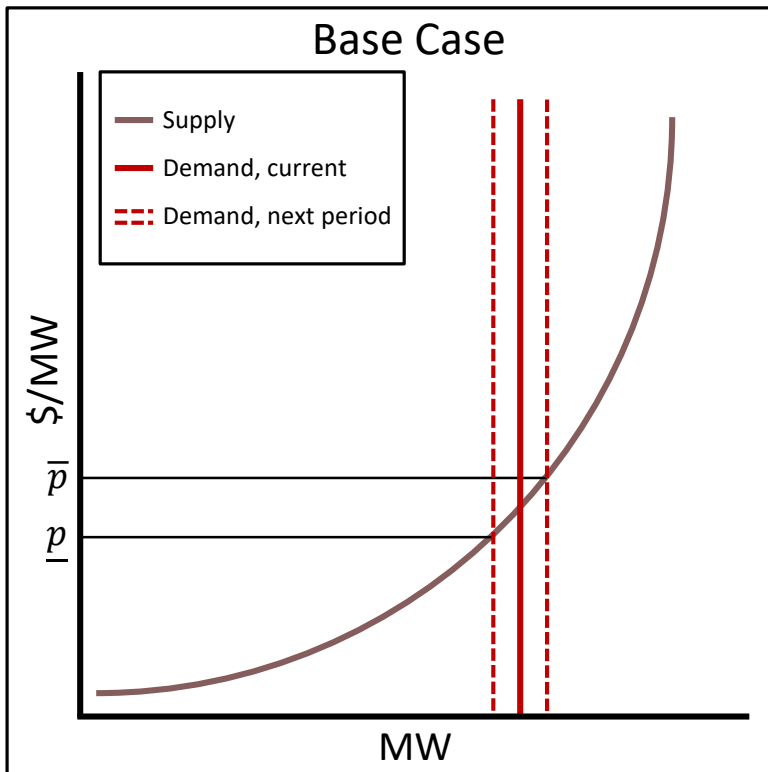
Impacts on Price Volatility



Impacts on Price Volatility



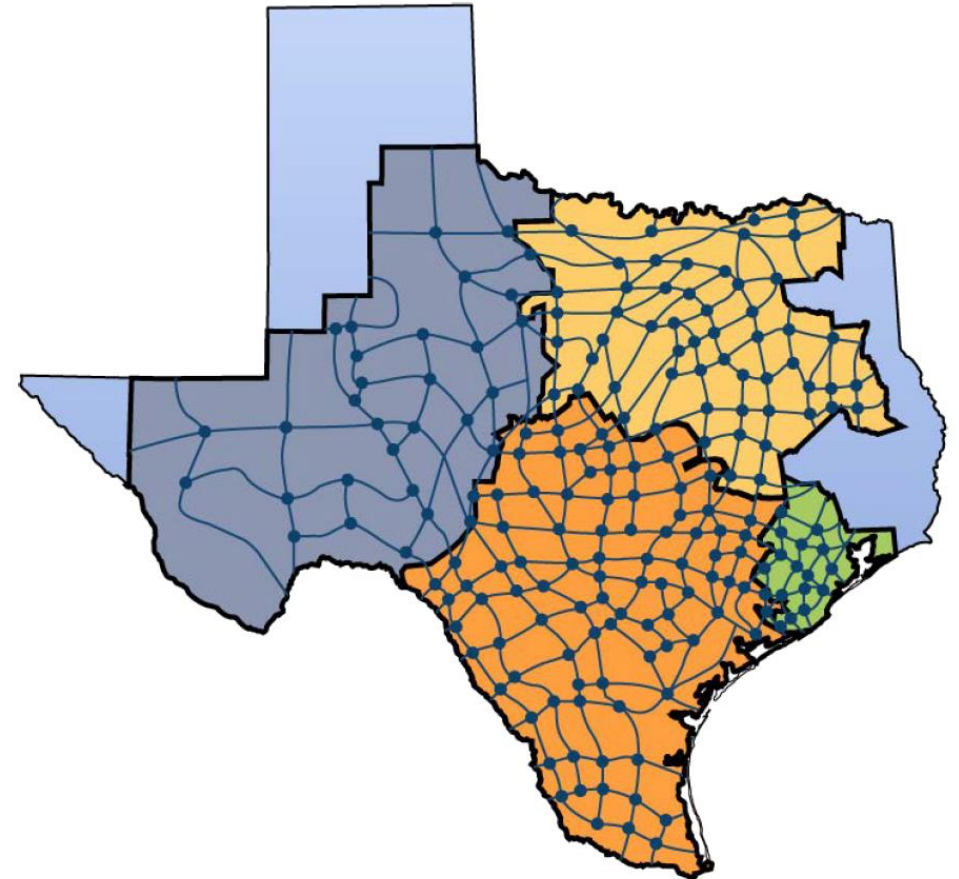
Impacts on Price Volatility



ERCOT Data

Jan. 1, 2015 – Dec. 31, 2017

- Price volatility of West LZ
- Daily wind generation & wind volatility
- Daily load level & load volatility
- Price for natural gas
- Daily nuclear generation



Empirical Analysis

$$\begin{aligned} \text{Volatility}_{it} = & \beta_0 + \beta_1 \text{Wind}_t + \beta_2 \text{WindVol}_{it} \\ & + \beta_3 \text{Load}_t + \beta_4 \text{LoadVol}_{it} \\ & + \beta_5 \text{NGPrice}_t \\ & + \beta_6 \text{Nuclear}_t + \boldsymbol{\varphi}_t + e_t \end{aligned}$$

$$i = \{IR, RV, A, B\}$$

Results

Variable	Volatility - A	Volatility - B	Volatility - IR	Volatility - RV
Intercept	-5211.82	1117.96	-94993.61*	20860.82
Wind	-177.16***	-94.07***	-2979.79***	-6400.48***
Wind volatility	86.72*	-2.59	698.06*	442.05**
Load	123.84**	34.96	2641.39***	2074.03
Load volatility	16.30	12.11	-41.65	85.06
Natural gas price	91.14	-549.77	3118.81	-18981.80
Nuclear generation	116.59	-52.79	-501.88	2370793.24
Month × Year FE	YES	YES	YES	YES

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

Next Steps

Compare IR against A and RV against B

Pick empirical method that accommodates change in volatility

Conclusion

Multiple measures of price volatility

Good predictors of price volatility

- Wind, wind volatility, load
- Stronger predictions for volatility measures A and IR
- Wind & wind volatility have opposite effects

Poor predictors of price volatility

- Load volatility, natural gas price, nuclear generation

THANK YOU

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Volatility Metrics

$$RV_t = \sum_{j=1}^M r_{tj}^2 \quad j = 1, \dots, M, \quad t = 1, \dots, T$$

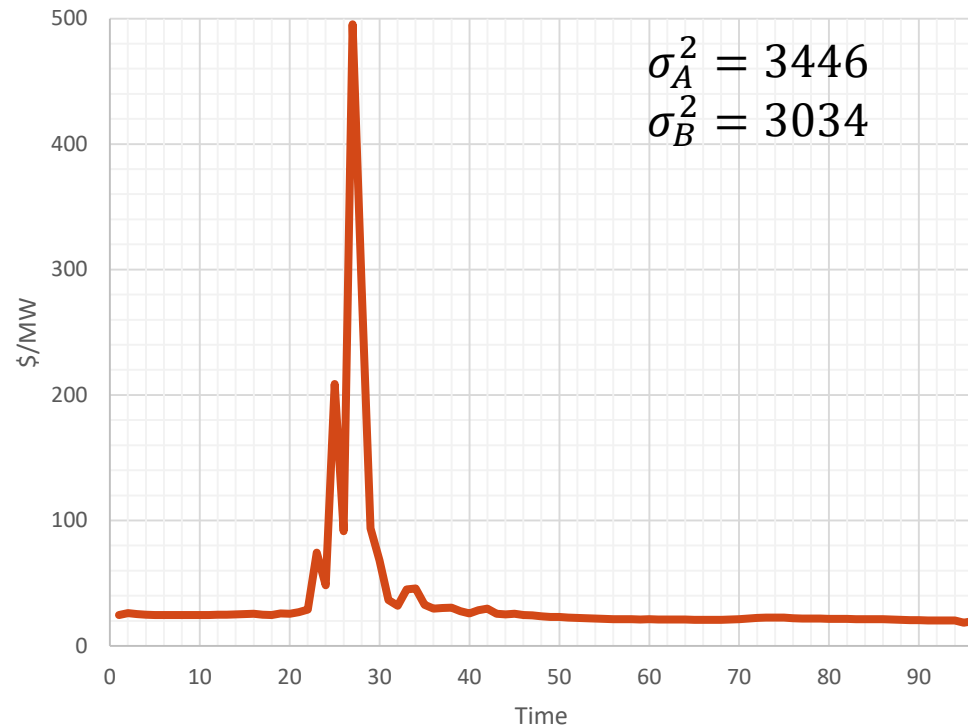
$$IR_t = (\max_j p_{tj} - \min_j p_{tj})^2$$

$$A_t = \frac{1}{M} \sum_j^M (p_{tj} - \bar{p}_t)^2$$

$$B_t = \frac{1}{M} \sum_j^M (r_{tj} - \bar{r}_t)^2$$

Comparing Daily Volatility

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