TRANSITION AND INTEGRATION OF THE ERCOT MARKET WITH THE COMPETITIVE RENEWABLE ENERGY ZONE PROJECT (CREZ)

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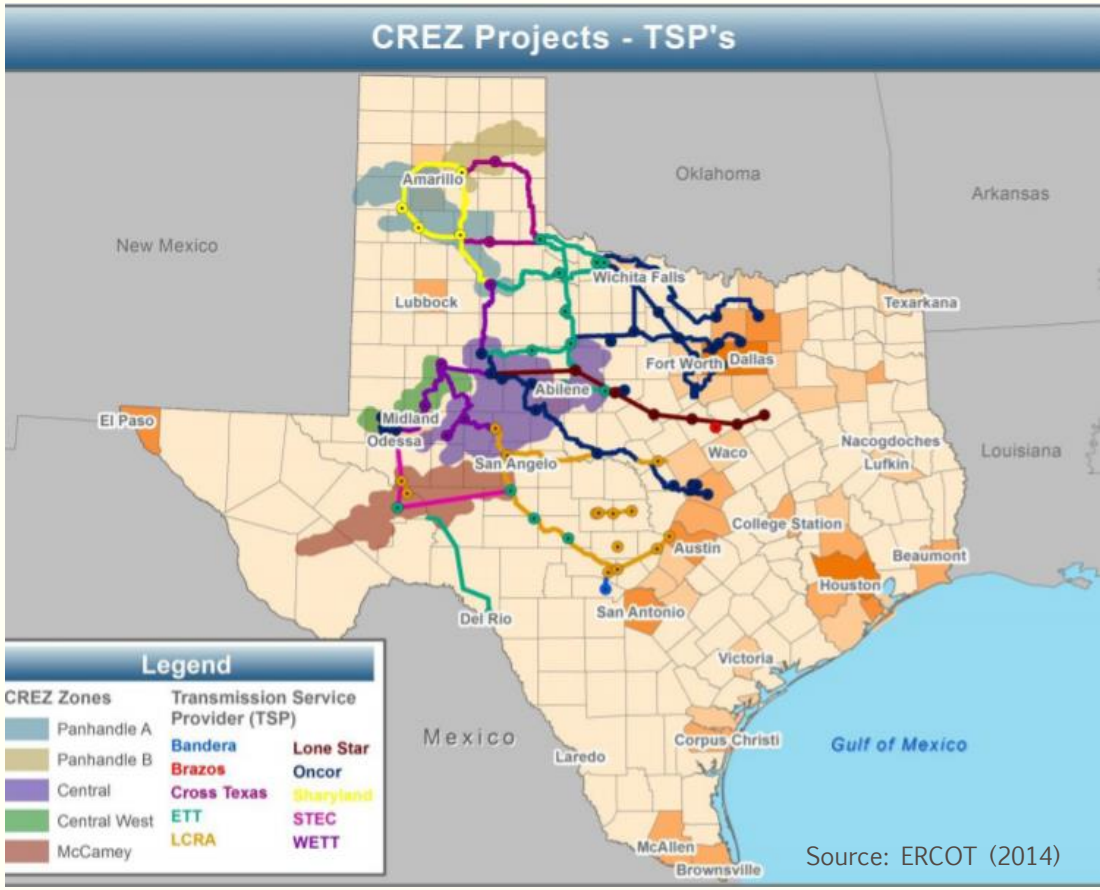

Source: ERCOT (2014)

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  - Overview
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Overview

- Framework: Transmission expansion project to accommodate renewables
- Case study: Competitive Renewable Energy Zone (CREZ)
- Methodology: A variety of empirical analyses of price convergence and volatility
- Contribution: Connecting the expansion of the physical transmission lines with electricity market integration

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Background

- With the increasing penetration of renewable energy, mainly wind and solar, transmission congestion has become a serious challenge for grid operators and planners (DOE 2017)
- In 2016, the power sector experienced the greatest annual increase in renewable energy capacity with 161 GW of new capacity added globally
- In the US, more than 60% of new capacity installations in 2016 were wind and solar, 8.7 GW and 7.7 GW respectively, followed by 33% (9 GW) in natural gas (IEA 2017)

Background

- Recent continues growth and penetration of intermittent capacity require reconsideration of the entire electrical system, for example, additional operating reserves, upgrading of poor infrastructures, expansion of the system to remote locations, and investments in flexible services, safe operations, and power system stability (Milligan et al. 2015; DOE 2017)
- The investments in grid modernization and expansion could be substantial. According to estimates, investment in the grid capacity of the US would require about $100 billion per year between 2010 and 2030 (Andoni et al. 2017)

Background ERCOT

- Provides about 90% of Texas Electricity to approximately 24 million consumers
- Connects more than 46,500 miles of transmission lines and more than 570 units of power generation
- Generation capacity of more than 78 GW (record peak demand of 71.11 GW)

Background ERCOT Wind

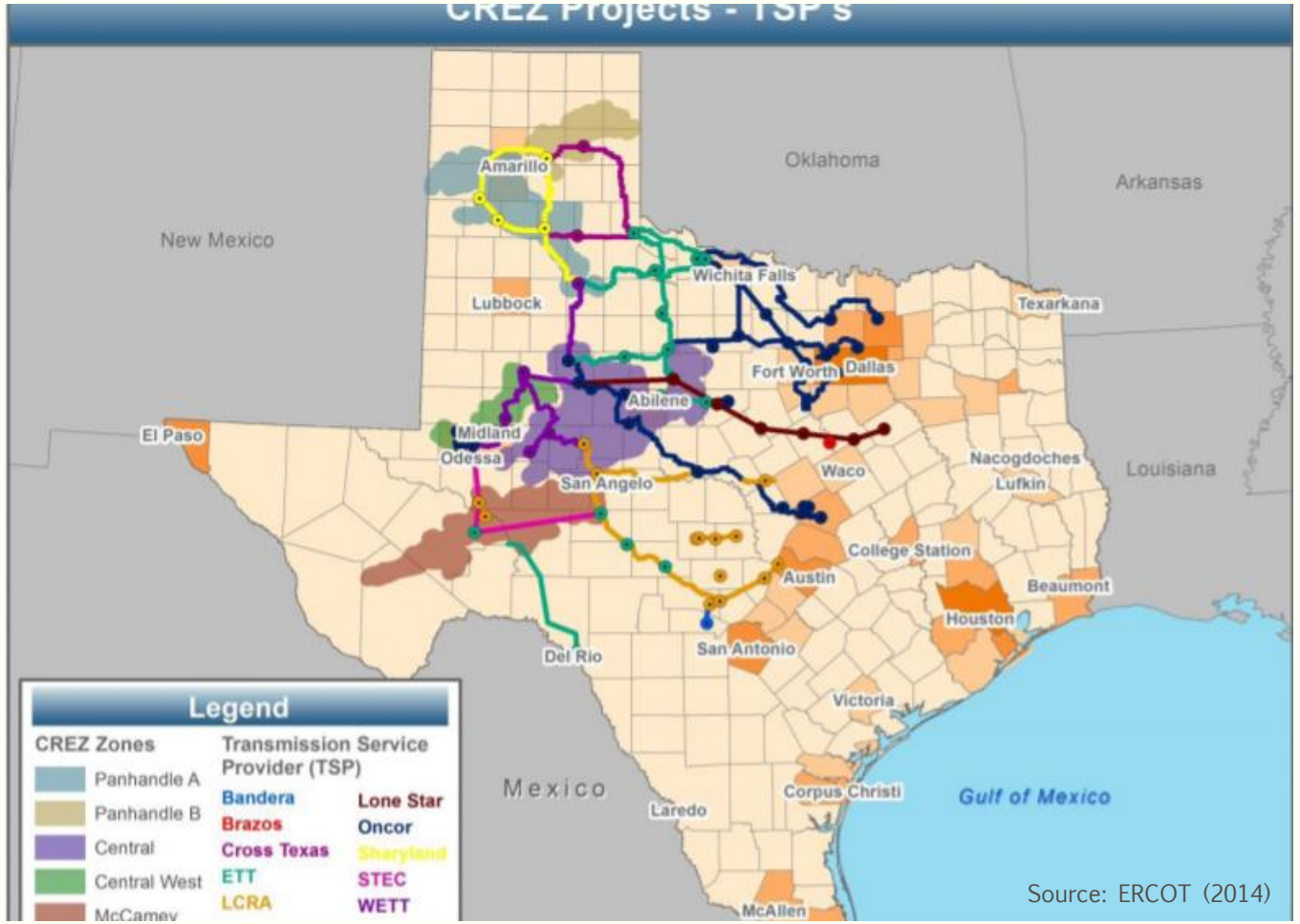
- At the end of 2016, with more than 20 GW of capacity installed, Texas, if it were a country, would have been the sixth largest generator of wind power in the world, after Spain (23 GW) and followed by the UK (14.5 GW) (WWEA 2017)
- In March 2017, ERCOT recorded its highest wind generation of 16,141 MW, which accounted for 80% of the deployment of the wind capacity installed. Earlier that month, energy produced by wind reached a new record when it accounted for 50% of the ERCOT load (ERCOT 2017)
- Wind in ERCOT is mostly available during off-peak hours

Background ERCOT Wholesale Market

- From 2002 and until late 2010 the market operated under a zonal pricing regime with four or five zones
- The transition to nodal pricing took place in December 2010. It involved adopting local marginal pricing (LMP) and the introduction of a day-ahead market
- Prices determined under nodal pricing system reflect not only supply and demand conditions, but also transmission conditions in the local market

Background CREZ

- Construction started in 2009, was completed at the end of January 2014
- $6.8 billion
- 3,600 right of way miles of high voltage transmission lines
- Ability to transmit 18.5 GW of wind power from the West to load centers



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Models

- Rolling correlation coefficient
- Structural break test of relative prices (Bai-Perron)
- Structural vector autoregressive model (SVAR)
  - Structural impulse responses
  - Structural forecast error variance decomposition (SFEVD)
- Price volatility

Data

- Day-ahead wholesale prices
- Hourly prices for trading hubs of the North, South, West and Houston
- Over the period of Dec. 1, 2010 to Dec. 31, 2016 (i.e. a nodal pricing regime)
- We generate three price series, daily average, daily peak, and daily off-peak, which are averages of 24-hours, peak-hours, and off-peak hour prices, respectively

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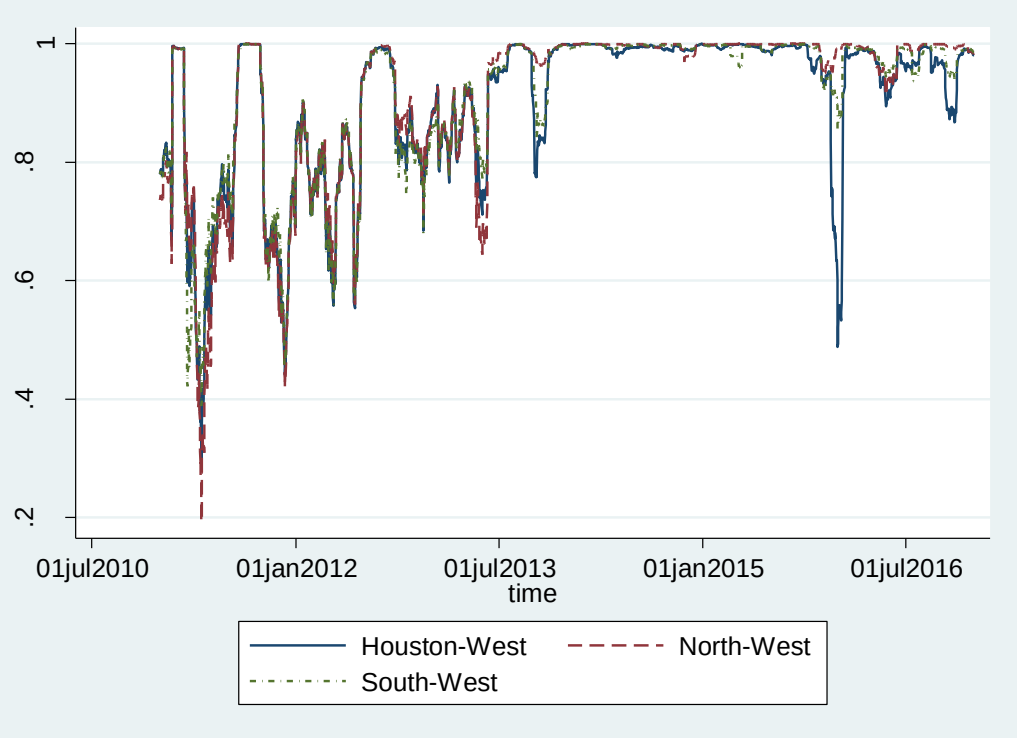
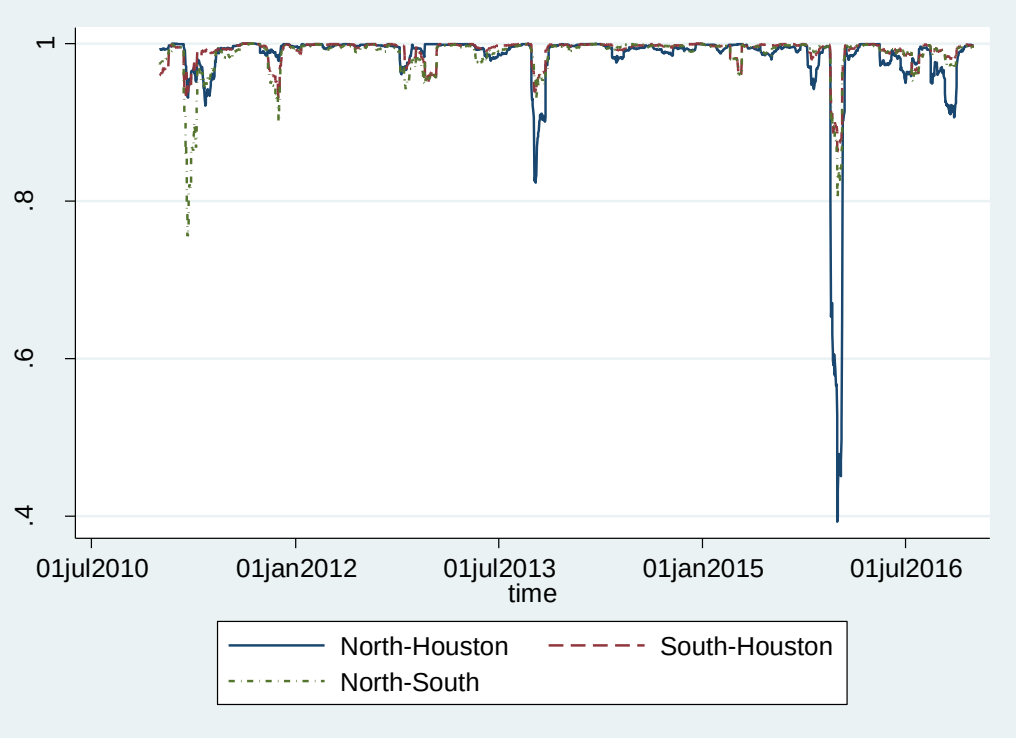
30-day rolling window correlation coefficients, 12/1/2010-12/31/2016

Rolling correlations between West and other ERCOT regions

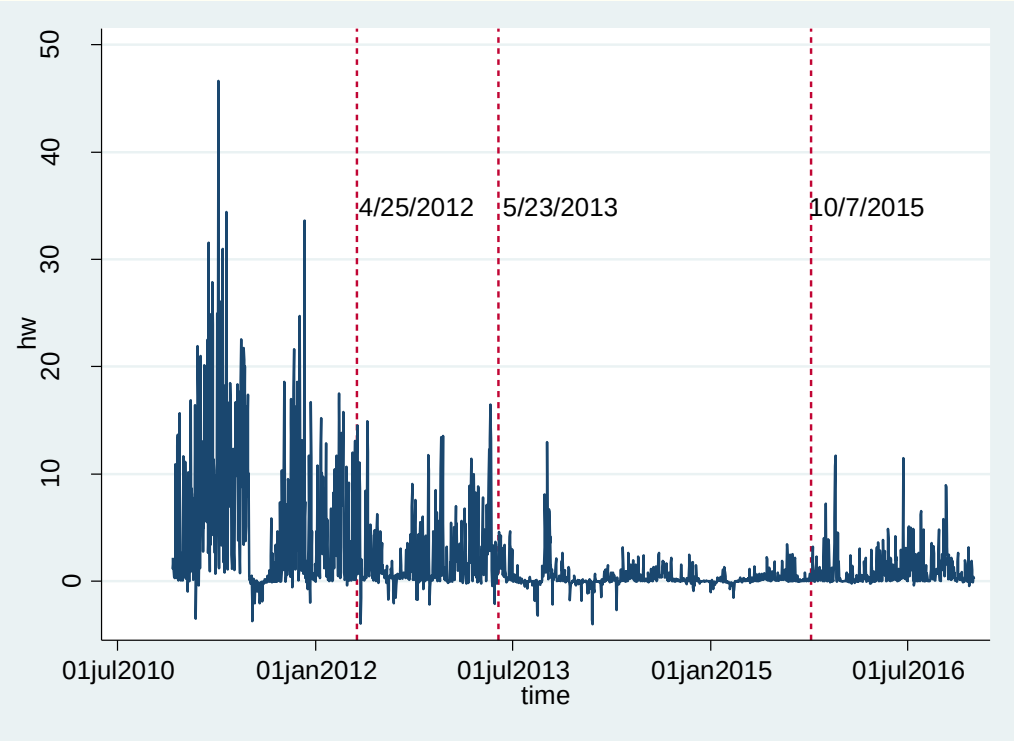


Rolling correlations between other regions except the West

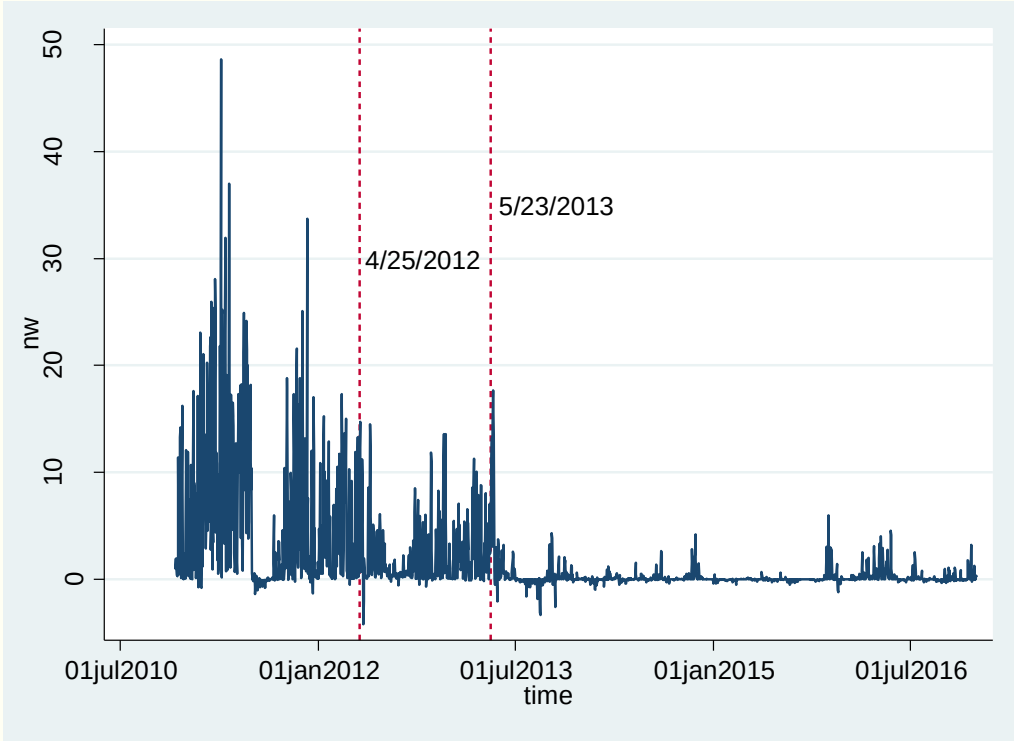


Relative off-peak prices between the West and other three regions, 12/1/2010-12/31/2016 (Vertical lines are structural break points)

Relative off-peak prices of the Houston and West regions

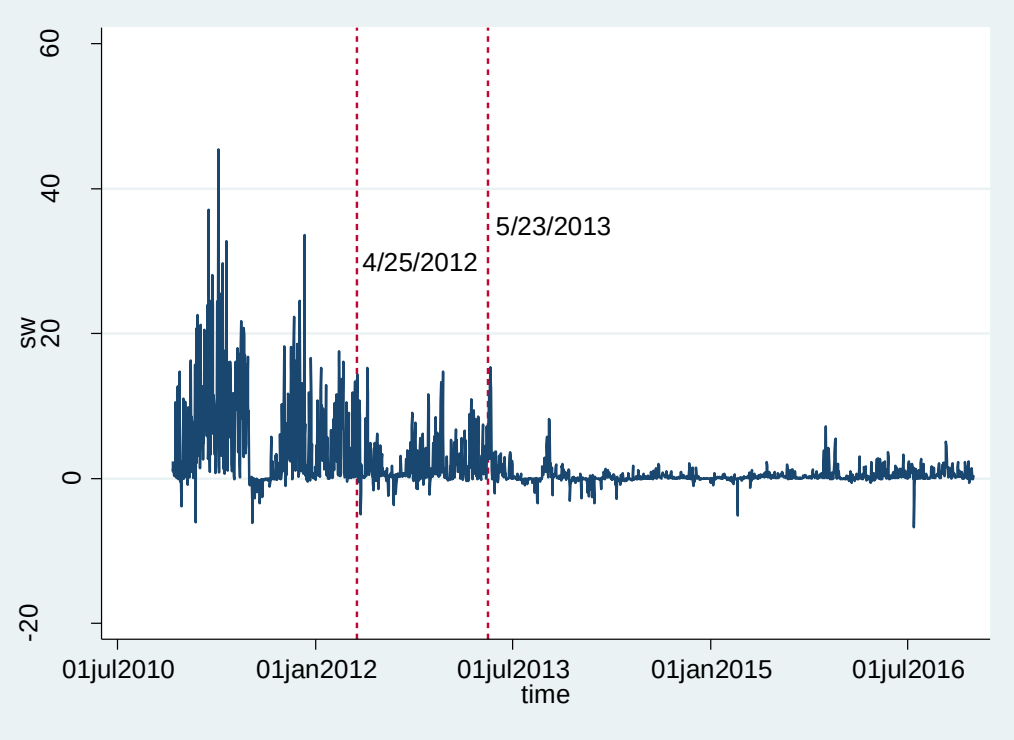


Relative off-peak prices of the North and West regions



Relative off-peak prices between the West and other three regions, 12/1/2010-12/31/2016 (Vertical lines are structural break points)

Relative off-peak prices of the South and West regions

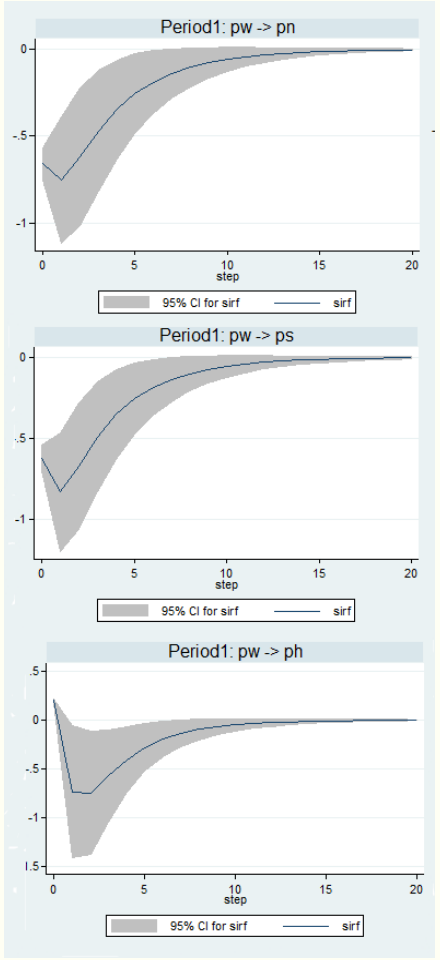


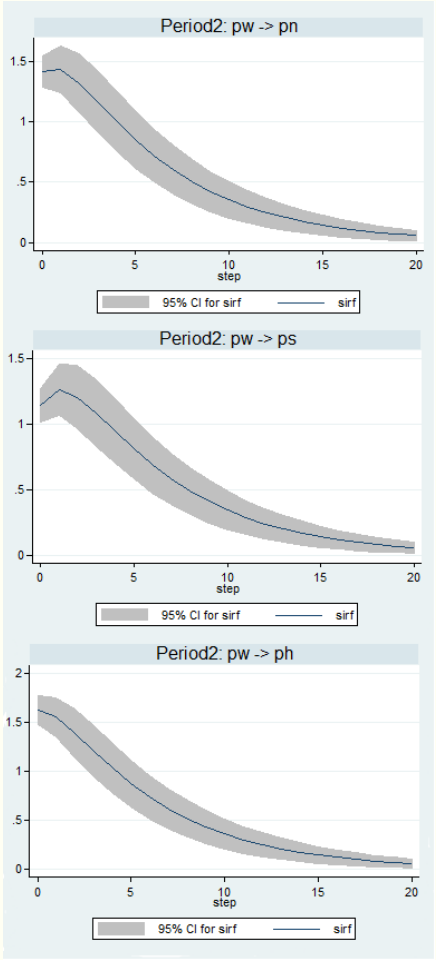
Focal periods:

- Before transition: Dec 2010 – Apr 2012
- Transition: Apr 2012 – May 2013
- After transition: May 2013 – Dec 2016

Structural Impulse Responses -1% increase in Pw

Before transition





After transition

Structural Forecast Error Variance Decomposition (SFEVD) (standard errors are in parentheses)

Shocks	Before-transition				After-transition			
	Pwest	Pnorth	Psouth	Phouston	Pwest	Pnorth	Psouth	Phouston
1 day ahead								
Pwest	32.1 (2.8)	35.0 (2.9)	35.1 (2.9)	2.1 (0.3)	2.4 (0.5)	11.3 (1.1)	7.0 (0.9)	14.9 (1.4)
Pnorth	1.3 (0.2)	0.1 (0.05)	1.5 (0.2)	0.08 (0.009)	2.0 (0.2)	0.2 (0.06)	1.4 (0.2)	2.2 (0.2)
Psouth	2.9 (0.4)	3.2 (0.4)	0.2 (0.09)	0.2 (0.02)	1.3 (0.1)	1.4 (0.2)	0.1 (0.05)	2.4 (0.2)
Phouston	63.6 (3.1)	61.7 (3.1)	63.1 (3.0)	97.6 (0.3)	94.3 (0.8)	87.0 (1.3)	91.5 (1.0)	81.5 (1.7)
20 days ahead								
Pwest	42.6 (5.6)	44.2 (5.6)	44.6 (5.5)	3.6 (1.8)	12.6 (2.9)	20.4 (3.2)	16.9 (3.1)	22.2 (3.3)
Pnorth	1.2 (0.9)	1.1 (1.1)	1.5 (1.0)	1.6 (1.3)	2.6 (1.1)	2.6 (1.4)	2.5 (1.2)	2.6 (1.2)
Psouth	4.4 (2.0)	4.6 (2.1)	1.9 (1.5)	0.3 (0.2)	0.8 (0.4)	1.2 (0.7)	0.4 (0.5)	1.8 (0.8)
Phouston	51.8 (5.7)	50.1 (5.8)	52.1 (5.6)	94.6 (2.2)	84.0 (3.1)	75.8 (3.6)	80.2 (3.3)	73.4 (3.6)

Estimation Results of the Daily Price Volatility

$$y_{it} \equiv \ln(P_{ih}^{\max} - P_{ih}^{\min})$$

	West	North	South	Houston
Daily average				
L(price vol)	0.62*** (0.02)	0.65*** (0.02)	0.67*** (0.02)	0.67*** (0.02)
L2(price vol)	-0.10*** (0.02)	-0.13*** (0.02)	-0.13*** (0.02)	-0.14*** (0.02)
L.week(Price vol)	0.64*** (0.04)	0.66*** (0.04)	0.64*** (0.04)	0.65*** (0.04)
L.month(price vol)	0.12*** (0.05)	0.14*** (0.04)	0.15*** (0.05)	0.17*** (0.05)
Houston-West price difference	-0.02*** (0.003)	-0.02*** (0.003)	-0.01*** (0.003)	-0.01*** (0.002)
Constant	1.08*** (0.18)	0.93*** (0.16)	0.90*** (0.17)	0.81*** (0.16)

Estimation Results of the Daily Price Volatility

	West	North	South	Houston
Daily peak				
L(price vol)	0.54***	0.57***	0.58***	0.59***
L2(price vol)	-0.04*	-0.06**	-0.04*	-0.04*
L.week(Price vol)	0.53***	0.54***	0.50***	0.50***
L.month(price vol)	0.19***	0.18***	0.22***	0.23***
H-W price difference	-0.03***	-0.03***	-0.02***	-0.02***
Constant	1.25***	1.22***	1.22***	1.15***
Daily off-peak				
L(price vol)	0.35***	0.42***	0.42***	0.43***
L2(price vol)	-0.34*	-0.39**	-0.39***	-0.40*
L.week(Price vol)	0.85***	0.86***	0.87***	0.86***
L.month(price vol)	0.03	0.06	0.06	0.08
H-W price difference	0.007**	0.002	0.003	0.004
Constant	0.35**	0.26**	0.23*	0.21*

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Summary

- Strong evidence for price convergence across ERCOT with accordance to the timing of the expansion of major sections of the CREZ
- Cross-correlation coefficients of the West with other regions show an increasing pattern. As wind in the West is not correlated with load centers in ERCOT, this pattern is stronger for off-peak hours
- We use structural break tests to identify focal periods with respect to markets integration
- Structural impulse responses suggest that a price shock after the integration takes double the time to die off compared with the before-integration period
- Regional-specific shocks became more important in terms of driving price change in other regions. Specifically, the impacts of Houston (demand) and the West (wind supply) on each other have increased dramatically
- Lastly, volatility analysis shows that after the completion of the CREZ peak prices become more volatile in all four regions, but less volatile during the off-peak hours when wind is largely available in the West

THANK YOU FOR YOUR ATTENTION
QUESTIONS?

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