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The Effect of Carbon Pricing Mechanism on Australia's Electricity Markets

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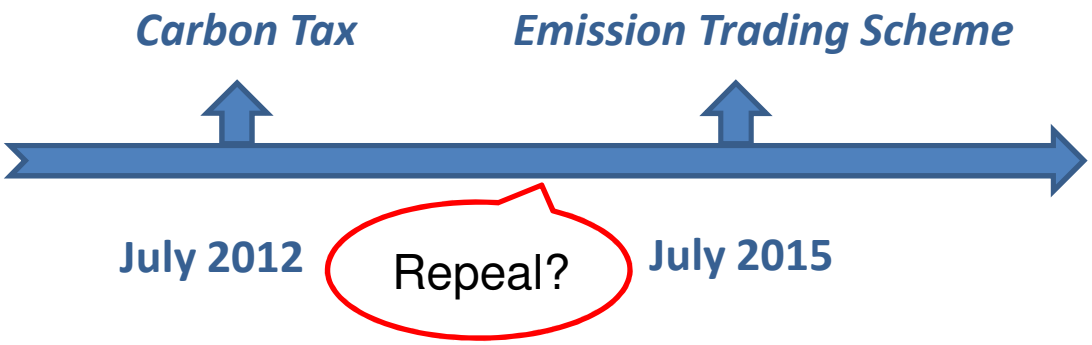
Outline

- Background
- Motivation
- National Electricity Market
- Electricity Derivative Market
- Electricity Derivative Market Modeling with STAR Model
- Conclusion

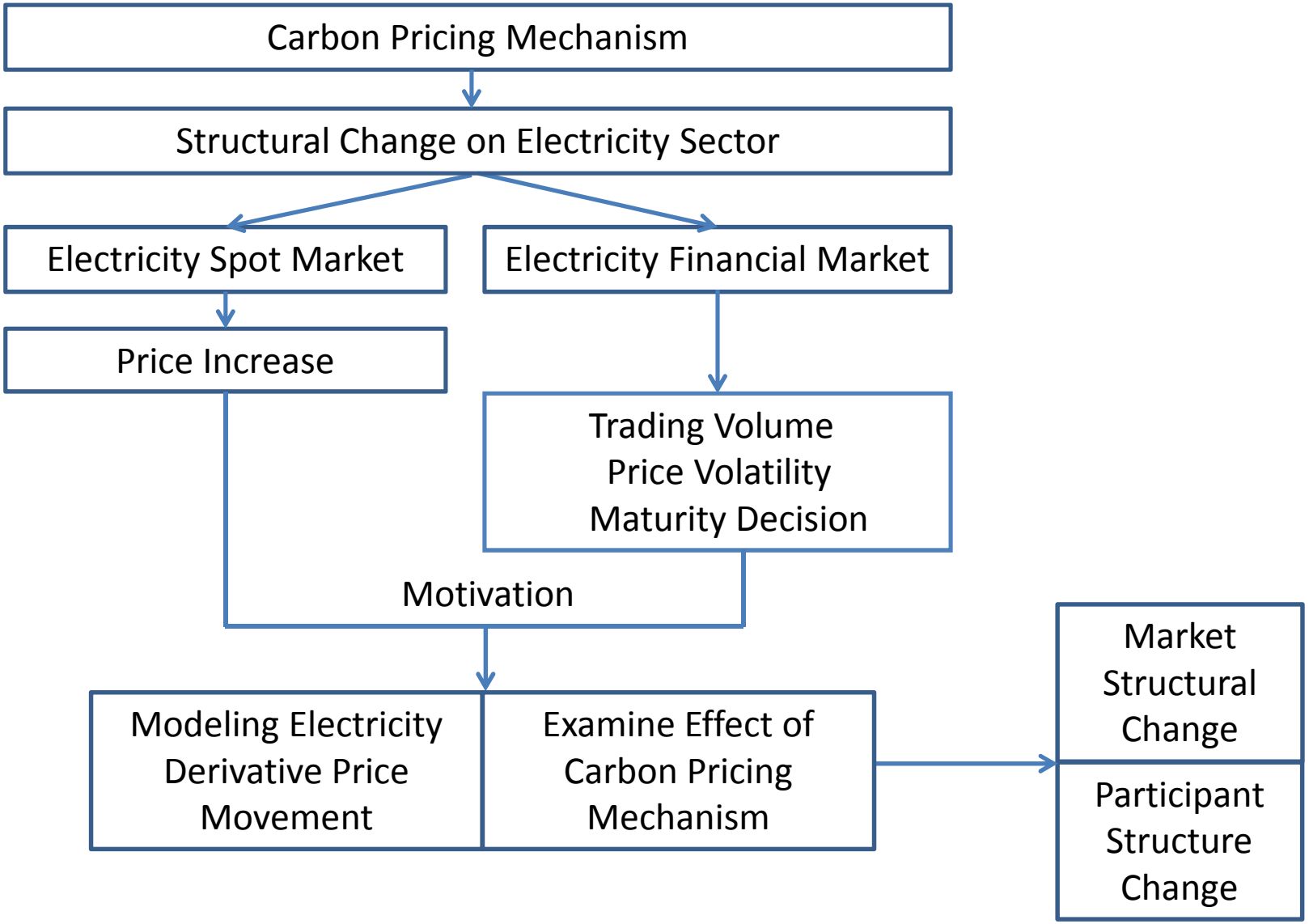
Background

- **Threat due to Global Warming and Climate Change**
- **37 Kyoto Protocol Parties (2012) aiming reducing GHG emissions by 18% below 1990's level by 2020**

  (Source: Framework Convention on Climate Change. United Nations)
- **Two stage Carbon Pricing Mechanism in Australia (Clean Energy Future Plan)**



Motivation

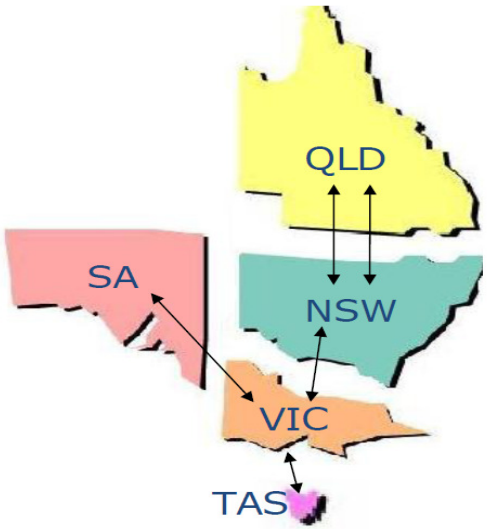

Carbon Pricing Mechanism
Structural Change on Electricity Sector
Electricity Spot Market
Electricity Financial Market
Price Increase
Trading Volume
Price Volatility
Maturity Decision
Motivation
Modeling Electricity Derivative Price Movement
Examine Effect of Carbon Pricing Mechanism
Market Structural Change
Participant Structure Change

National Electricity Market

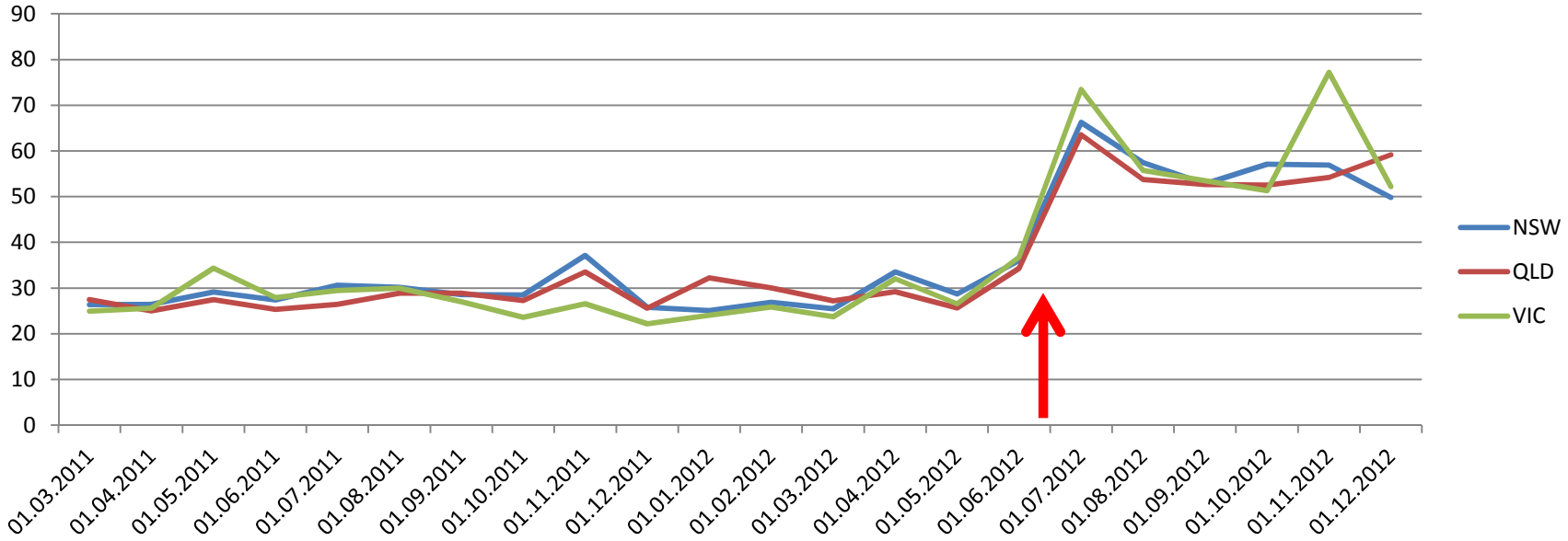
- **National Electricity Market**

  (Source: AER. 2013)

Participating Regions	NSW, QLD,VIC, SA, TAS, ACT
Installed Capacity	48.321 MW
Registered Generators	317
Turnover 2012-13	$12.2 billion
Electricity Generation 2012-13	199 TWh
Network Distance	4500 km
Carbon Emission Intensity 2012-2013	0.875 t/MWh



National Electricity Market



(Source: AEMO. 2013)

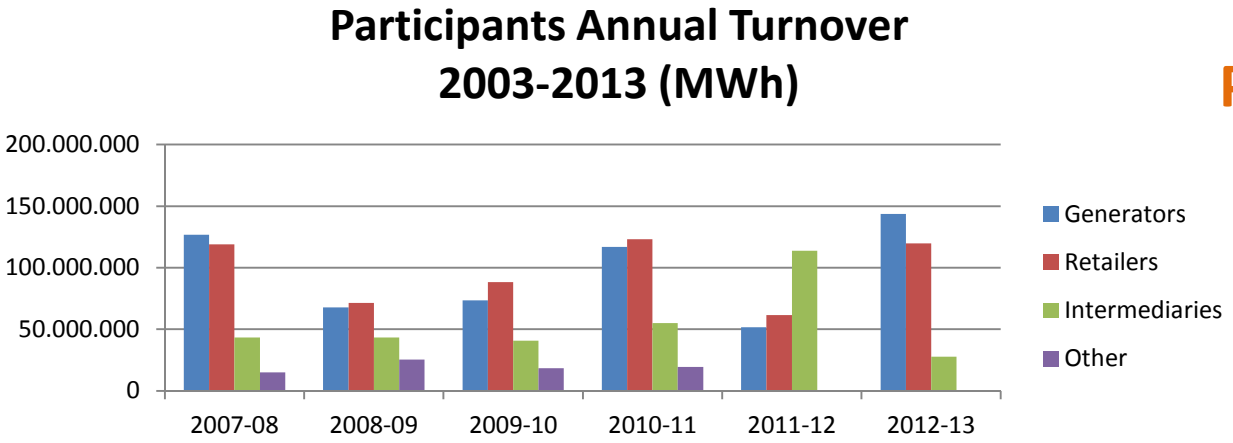
	Mean NSW	Mean QLD	Mean VIC
Before July 2012	29.11	28.41	27.53
After July 2012	53.73	52.87	57.15
Price Increase	24.62	24.46	29.62

- **Imposing carbon tax since 1 July 2012**
- **$23 per tonne of carbon dioxide equivalent**

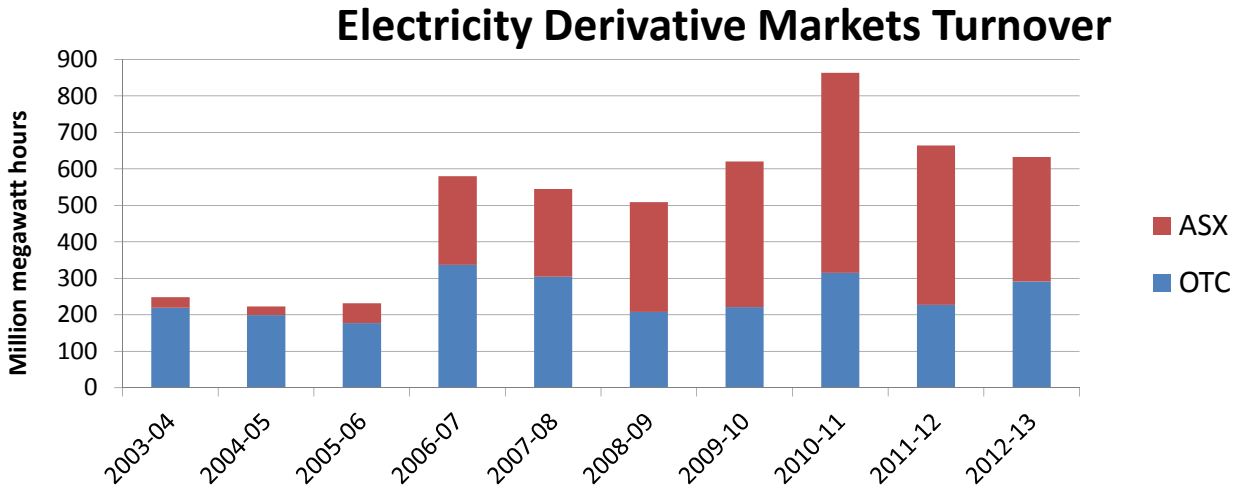
Electricity Derivative Market

- **Electricity Financial Market- ASX Energy**

  (Source: AER. 2013; AFMA. 2013)



Participating Regions	**NSW, QLD VIC, SA**
Turnover 2012-2013	**342 mio. MWh**



Electricity Derivative Market

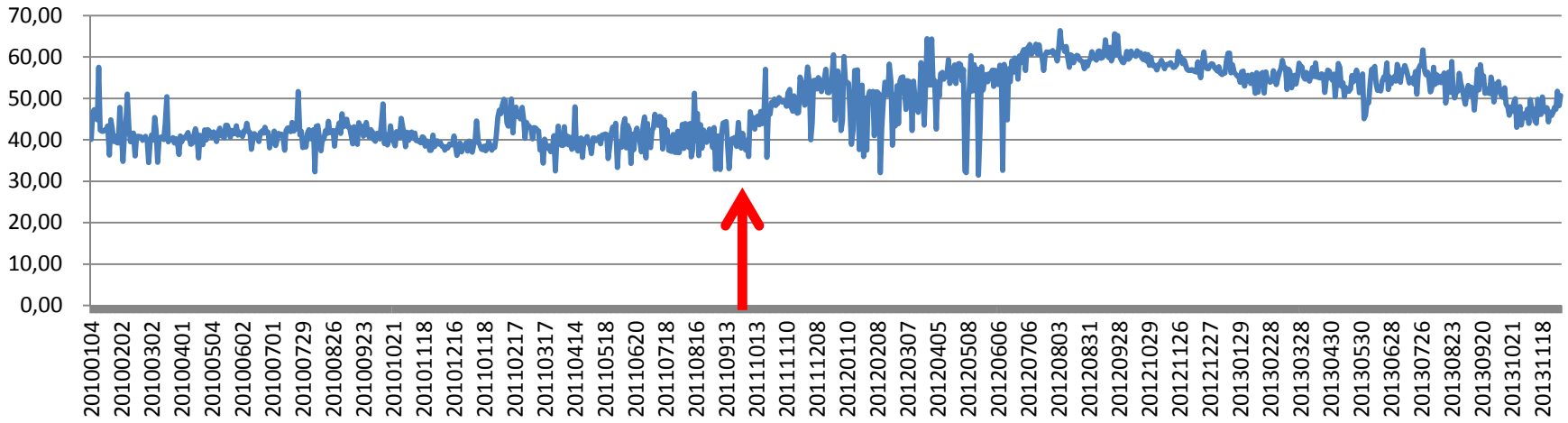
Product Turnover

- Futures (54%)
- Options (27%)
- Cap(14%)
- Peak Futures(3 %)

Non-Zero Volume ASX derivatives Price (2010 -2014)

Sample size	NSW	QLD	VIC
Quarterly Base Load Futures	973	942	955
Quarterly Peak Load Futures	556	325	440
Quarterly Base $300 Cap	760	528	728
Strip Futures	470	400	287
Base Strip Option	395	279	268

NSW Quarterly Base Load Futures Price 2010-2014



(Source: AER. 2013; AFMA. 2013)

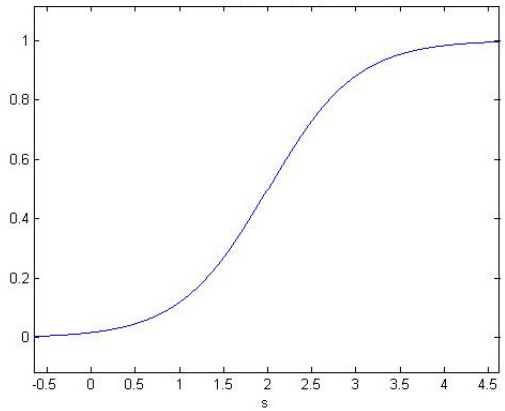
Smooth Transition Autoregressive Model

$$y_t = \pi_{10} + \pi_1' w_t + (\pi_{20} + \pi_2' w_t) F(y_{t-d}; \gamma, c) + u_t$$

Linear Part Nonlinear Part Smooth Transition Function

Nonliear time series model with regime swithcing characteristic

$F(y_{t-d}; \gamma, c) \in [0,1]$ **a continuous transition function**



y_{t-d} **delayed transition variable**

c **location of transition**

γ **slope of transition function**

STAR Model-Transition Function

Transition Function Forms

Logistic

$$F(y_{t-d};\gamma,c)=\frac{1}{1+e^{-\gamma(y_{t-d}-c)}}$$

Exponential

$$F(y_{t-d};\gamma,c)=1-e^{-\gamma(y_{t-d}-c)^2}$$

Tangent Hyperbolic

$$F(y_{t-d};\gamma,c)=\frac{2}{(1+e^{-2\gamma(y_{t-d}-c)})-1}$$

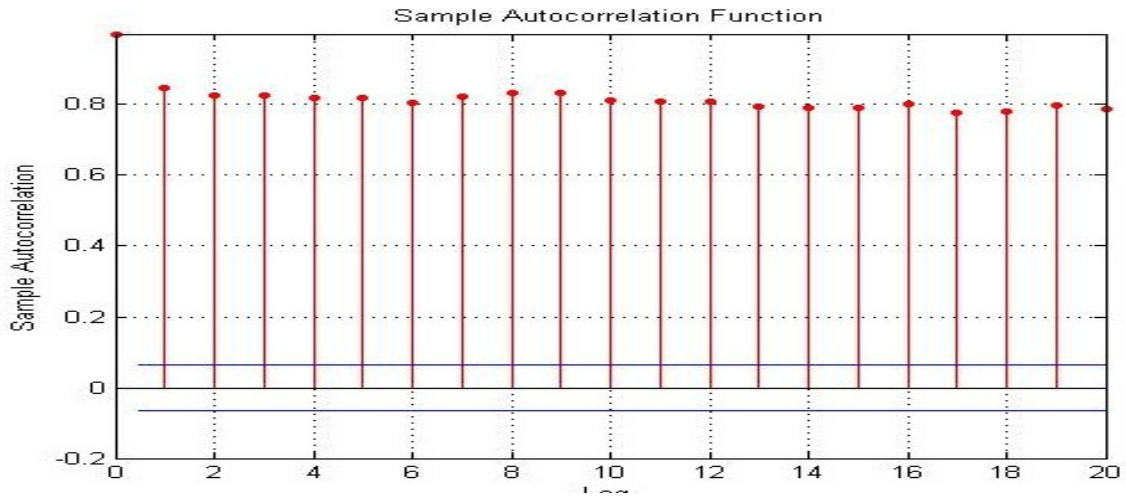
Generalized Bell

$$F(y_{t-d};\gamma,c)=\exp\left[-\left(\frac{y_{t-d}-c}{r}\right)^{2b}\right]$$

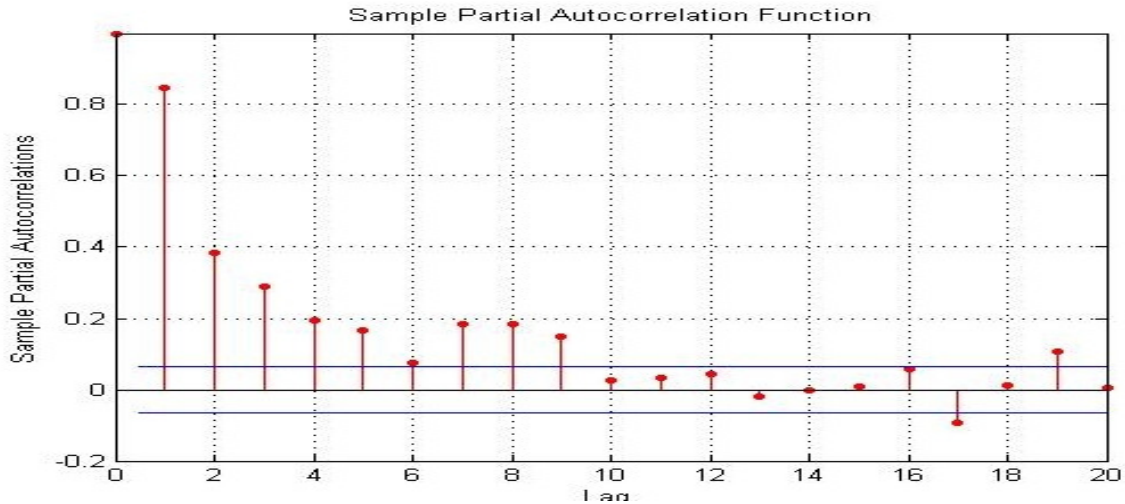
STAR Model-AR Test

1 Detecting autocorrelation and AR order with Ljung–Box test & AIC test

Result Example- *NSW Quarterly Base Futures*



Lag	AR bounds	Ljung-Box-Test Result (h)
1	0.064117	1
2	-0.06412	1
3		1
4		1
5		1
6		1
7		1
8		1
9		1
10		1



Lag	AIC
1	5591.328
2	5437.252
3	5353.758
4	5318.135
5	5292.898
6	5289.59
7	5258.149
8	5227.073
9	5207.99
10	5209.399

STAR Model-Nonlinearity Test

2 Detecting data nonlinearity with BDS test

BDS nonlinearity statistics result (all beyond critical value)

w

125.8709	0	0	0	0	0	0	0	0
0	146.5159	0	0	0	0	0	0	0
0	0	168.2327	0	0	0	0	0	0
0	0	0	196.9875	0	0	0	0	0
0	0	0	0	235.5821	0	0	0	0
0	0	0	0	0	286.981	0	0	0
0	0	0	0	0	0	355.7222	0	0
0	0	0	0	0	0	0	449.2468	0
0	0	0	0	0	0	0	0	575.2326

3 Determining delay (self-exciting) parameter

Lag	P-value	yd
1	1.74E-26	47.725
2	2.72E-45	46.86
3	0	46.85

Specific-to-General Approach

- Regress y on x
- Regress y on x and xy_{t-d}
- Compute LM-Test on ssr0 & ssr1

STAR Model-Estimation Result

4 Determining parameters and STAR Model estimation

$$y_t = \alpha_{10} + \alpha_1' x_{t-p} + \left(\alpha_{20} + \alpha_2' x_{t-p}\right) F\left(y_{t-d}; \gamma, c\right) + u_t$$

LSTAR	22.3904	0.436	6.5297	0.0933
ESTAR	24.3573	0.405	4.4071	0.1195
TSTAR	25.6552	0.483	3.2648	0.0466
GbellSTAR	0.0534	27.7	0.5899	-2.2605

mean	skewness	kurtosis
48.20	0.1235	1.6841

	yd	C	Gamma	b
LSTAR	2	50.78	0.2074	
ESTAR	2	38.63	0.0049	
TSTAR	2	50.78	0.1037	
GbellSTAR	2	38.92	2.9686	-0.2142

$$F(y_{t-d};\gamma,c) = \frac{1}{1+e^{-\gamma(y_{t-d}-c)}}$$

$$F(y_{t-d};\gamma,c) = 1-e^{-\gamma(y_{t-d}-c)^2}$$

$$F(y_{t-d};\gamma,c) = \frac{2}{(1+e^{-2\gamma(y_{t-d}-c)})-1}$$

$$F(y_{t-d};\gamma,c) = \exp\left[-\left(\frac{y_{t-d}-c}{r}\right)\right]^{2b}$$

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Conclusion

- Price level increase in NEM after imposing carbon tax
- Dynamic change on electricity derivative market
- Market weight swtich from OTC to ETD
- Intermediaries were active in FY 2011/12
- Regime-switching phenomenen with different thresholds
- Changing transition speeds and transition locations with choice of different transition function forms

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